

**Elements of chemistry / being the annual lectures of Herman Boerhaave ...
Translated from the original Latin, by Timothy Dallowe.**

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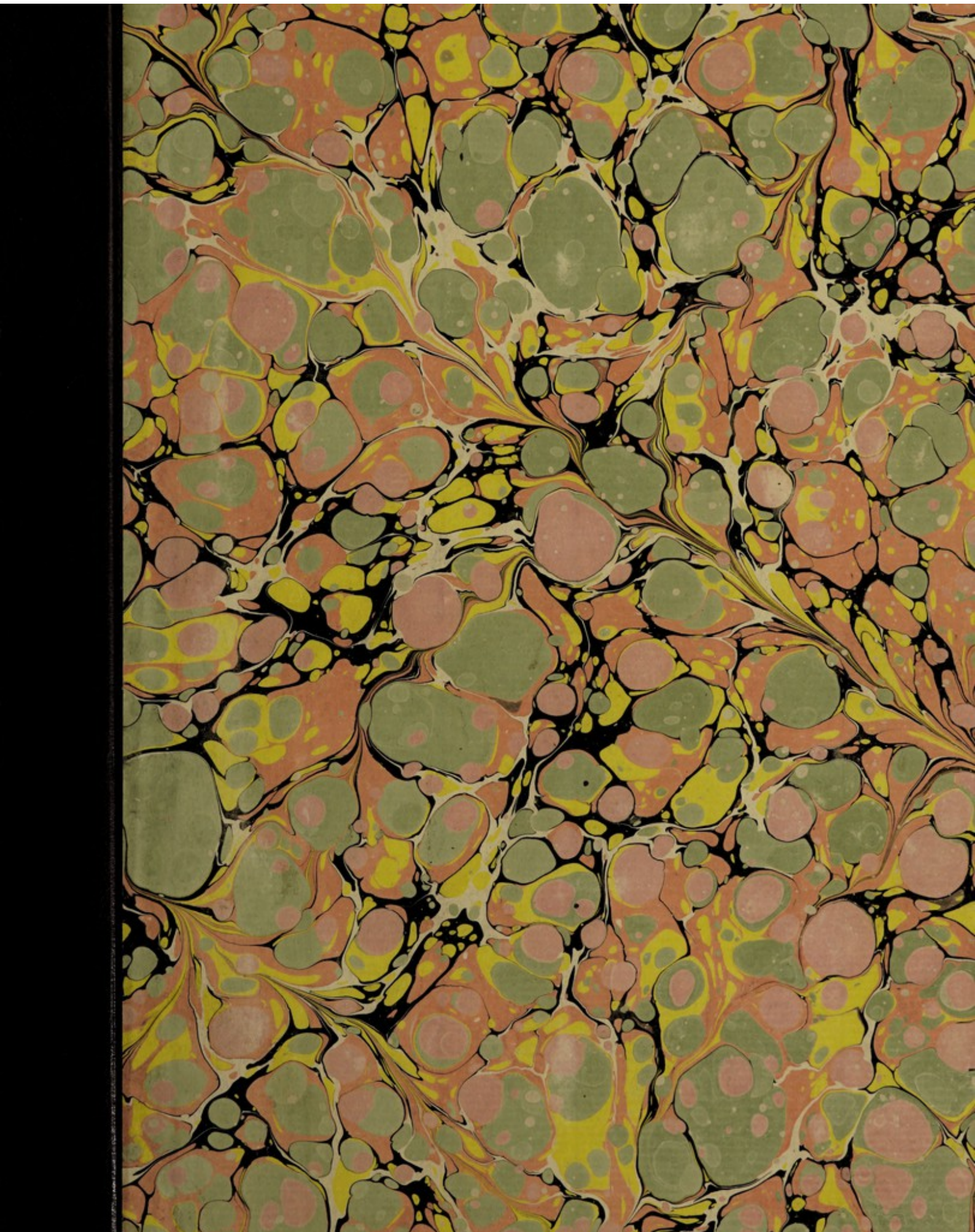
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Elements of Chemistry :
BEING THE
ANNUAL LECTURES
OF
Herman Boerhaave, M.D.

Formerly PROFESSOR of

CHEMISTRY and BOTANY,

And at present,

PROFESSOR of PHYSICK

IN THE

UNIVERSITY of LEYDEN.

Translated from the ORIGINAL *LATIN*,

By *TIMOTHY DALLOWE, M.D.*

VOL. I.



L O N D O N :

Printed for J. and J. PEMBERTON, in *Fleetstreet* ; J. CLARKE, under the *Royal Exchange* ;
A. MILLAR, in the *Strand* ; and J. GRAY in the *Poultry*. MDCCLXXXV.

Elements of Chemistry:

BEING THE

ANNUAL LECTURES

OF

Herman Boerhaave, M.D.

PROFESSOR OF

CHEMISTRY AND BOTANY

IN THE

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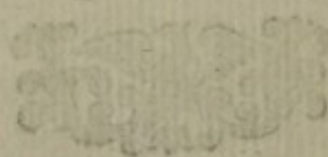
IN THE

UNIVERSITY OF LEIDEN

Translated from the Original Latin

By TIMOTHY DALLON, M.D.

VOL. I



LONDON:

Printed by J. and J. Parnerton, in the Strand; and J. Gray in the Strand; and J. Gray in the Strand; and J. Gray in the Strand.

THE
TRANSLATOR
TO THE
READER.

AS the Reader, in this Translation, may observe several Variations from the Original, it is necessary to inform him that the Alterations are made with the Author's Approbation. I am very sensible that, upon the whole, I shall be challenged for following the Original too minutely : but I was willing rather to err on this hand, than to leave out any thing, that might have a Meaning and Propriety that I was not aware of. It must be confessed however, that our Author is evidently, in many places, pretty prolix ; nor in reality, considering these as Publick Lectures, could this possibly be avoided : For as we had nothing to depend upon but our Memories, and the short Hints we could take in Writing from the Professor's Mouth, it was necessary for him to dwell longer upon Things, and set them in various Lights, in order to make them appear with more Evidence, and fix them upon the Mind with greater Certainty. It were to be wished, indeed, that when he came to printing them, he had had Time sufficient for retrenching these Superfluities ; but I have a great deal of Reason to think this was not the case ; and yet he was under a kind of Necessity of putting them out as soon

To the READER.

as possible, to justify himself from the monstrous Absurdities published in a Course of Chemistry with his Name to it, which some of his Pupils ungenerously printed without his Knowledge, as you will find taken notice of in the Preface. Had this Work, at first, been designed purely for the Press, or had the Author had Leisure to have put a finishing Hand to it in the Form it stands at present, it would, without dispute, have appeared much more to Advantage, both in point of Elegance, and Correctness. As the Substance of the Performance, however, is still the same, and it contains abundance of curious and valuable Observations and Experiments, both in Chemistry, and Natural Philosophy, the Reader no doubt will readily overlook any Inaccuracies he may meet with, and think himself obliged to the worthy Author, who has so candidly communicated the Result of many Years indefatigable Application.

T. Dallowe.

London
* March 1734-5.

THE

THE
AUTHOR'S DEDICATION

To his BROTHER

JAMES BOERHAAVE.

AS I could not avoid publishing the Work which I now address to you, I have been obliged in my old Age to review the Labours of my Youth. And whilst I have been thus engag'd, I could not help, I confess, being sometimes surpriz'd, when I consider'd both the number of them, and the remarkable Dangers that frequently attended them. The grateful Reflection, however, of your having been my constant faithful Companion and Partner in both, gave me at the same time a very sensible Satisfaction. You know very well, nor is the Remembrance, I flatter myself, disagreeable, how many whole Days and Nights we have spent successively together in the chemical Examination of Natural Bodies. At that time, indeed, your Thoughts were turned chiefly to Physick, mine to Divinity: But Providence ordered otherwise; so that altering our Designs, you devoted yourself intirely to Sacred Things, making it your whole Concern to promote the true Worship of God, by the Plainness of your Preaching, and the Integrity of your Life; whilst I, conscious of my weaker Abilities, and not daring to attempt any thing higher, was content to apply myself to the Study of the Healing Art.

Who,

The DEDICATION.

Who, therefore, has an equal Right to this Work with yourself, to whom it in some measure owes its being what it is? Accept it, therefore, I entreat you, with the same kind Repentments, with which I offer it; and let it stand as a public Token of a grateful Acknowledgment, and a lasting Memorial of Fraternal Affection. I have always esteem'd it my particular good Fortune to be favoured with such a Brother, whose happy Genius, and vertuous manner of Life, render him not unworthy of that great Office he is entrusted with, the noble End of which is purely to recommend the Terms of Reconciliation, offered by God to Mankind, by Precept and Example, without a vain Affectation of any thing more. If in my Province, I have been so happy likewise to behave in such a manner, as to meet with your Approbation, I shall have wherein to rejoice. Adieu; and whilst you are now and then amusing yourself with Things of this Nature, don't forget those joint-labours we were formerly so agreeably engaged in.

Leyden, 1. July 1731.

THE

T H E

A U T H O R's

P R E F A C E.

NOTHING was formerly farther from my Thoughts, than that I should ever trouble the World with any thing in Chemistry. There are so many Books already upon this Subject, and many of them wrote so well, that it is hardly possible for me, either to represent things in a better Light, or to offer any thing that has not been said before. My Academical Office however made it necessary, that I should annually give a Course of Lectures in this Art; but this was with no other View, than just to lay down the Rudiments of it, and give some Examples of the Operations, for the sake of those Gentlemen, who were pleased to put themselves under my Tuition. And so far it is possible, the Method I have made use of in digesting the Subject, and the great Simplicity I have constantly and carefully studied, may not have been without their use. And in these two Particulars, indeed, there seemed still some room left for farther Application; that at last Chemistry too might deserve to be introduced among the Academical Sciences. This, therefore, I endeavoured to the best of my Abilities; and having done this, I thought I had discharged my Duty, and that nothing farther could reasonably be expected from me. It has happened, however, very different from what I was aware of: For the Ingratitude of some of my Pupils, the promoting whose Interest was always my Study; and the insatiable Avarice of some Booksellers, who will not stick at the basest Actions, if they can make any Advantage of them, sufficiently sowered my Chemistry-Professorship. For these Persons, under a false pretence of doing Service to Learning, published, without my Knowledge, a Course of Chemical Institutions and Experiments, and prefixed my Name

to it; and thus did an Injury both to the Publick and me, in a manner certainly very dishonourable, and that ought to be taken notice of by the Laws. The false Notions, Absurdities, and Barbarisms, that are imputed to me in every Page of that Work, are so abominable, that they will not bear mentioning. It happened, however, to the Misfortune of the present Age, of which by this means they have left an instance to the succeeding, that this sorry Book met with too many Buyers, very much to the Loss and Disgrace both of them, and the Persons who recommended it. By this means I had the daily Mortification of seeing my Pupils before me with this Book in their Hands, whilst I was giving my Lectures; and could plainly perceive, that every Word I said must be examined by the Text of that miserable Performance. Quite tired with this, I applied myself for Relief to some Persons in Authority, who had Power to restrain and punish such Enormities as these; and I had almost gained my point, had not some others designedly delay'd, put off, nay and opposed it too, though I had deserved much better things at their Hands, and had received from them so many fair Promises in my favour, as, I think, would have deceived the most cautious Man living. Thus then I was satisfied by an uncomfortable Experiment, that there are some Persons in the World, who take Pleasure in triumphing over Learning, by every method that lies in their Power. These, and other Considerations, determin'd me to give Lectures in Chemistry no longer; and therefore I immediately resigned my Professorship. But this was no sooner over, than I was again engaged in new Difficulties; for my Friends were all of opinion, that in my own Defence I ought to publish my Chemical Institutions and Experiments myself, that by this Means the World might have an Opportunity of judging in what manner I did in reality teach Chemistry, both in the publick and private Schools. It was to no Purpose for me to object, that these Institutions were designed only for my private Use, and calculated purely for Beginners, to lay before them the first Elements of the History and Method of Chemistry, and of consequence would be of no manner of Service to the Publick. Nay I insisted farther, that as these only laid down the Rudiments of the Chemical Art, and had nothing else to recommend them, they must necessarily be disagreeable to any Reader that was ever so little versed in it. They on the other hand urged, that the spurious Work met with general Approbation, was mightily wanted, grew dearer, and would be very soon reprinted, if I did not take care to prevent it. This I confess gave me some Uneasiness, and brought to my Mind the great Petrarch, who lamented the Misfortune of his Contemporaries, when he saw them set such a value upon his Works, as to think him worthy to be rank'd amongst the famous Poets. How much more then, thought I, ought I to be ashamed, should I, who am conscious of my own poor Abilities, and am an Admirer of other Authors, dare to intrude myself among

among the Chemical Writers. Not able, however, to stand out any longer, I at last undertook the disagreeable Task; and I publicly declare, that the Book with which I now trouble the World, was forced from me much against my Inclination. As for the Work, I have wrote it in as concise a manner as the Subject would admit of; and have avoided as much as possible pure Terms of Art. That this might be done, I saw evidently in the Example of the incomparable George Agricola, in that immortal Work, *De Fossilibus, Re Metallica, & Subterraneis*. I heartily wish, indeed, I had had so much Time at command whilst I was composing this Treatise, as was necessary for the sufficient Imitation of so great an Author. For want of this, and being hurried with a Variety of Business whilst this large Work was in Hand, I am sensible, many Expressions have escaped me, that are not so elegant. I am aware too, that some Persons will think I very often insist too particularly upon things that seem but of little Consequence: But this I have done with Design, on purpose to caution sufficiently against those Inconveniencies, that in these kind of Inquiries continually surround us. I have constantly had Beginners in my view; and therefore thought myself obliged to point out every thing doubtful, or dangerous. For the same reason you'll find I every where proceed chiefly upon particular Experiments, not laying down any general Rules, without a great deal of Caution. By this Example, young People may learn the Method that Beginners should pursue in their philosophical Inquiries; a laborious one, I confess, but certainly a just one, and that will lead us most securely to true Knowledge. In the first part of this Work I had those Lectures to insert, which I had given at particular times upon Chemical Subjects in the publick Schools: And as I thought it necessary to relate them again, and confirm them by new Observations, it has happened, that I have sometimes repeated things I had said before; which it was not possible to avoid. And thus the Size of the Book insensibly grew upon my Hands, though at the same Time I was too much engaged in Business of another Nature. How happy, under these Difficulties, did I count those Authors, who have Time enough to study, digest, and put a finishing Hand to the Works they are employed in. For my part, amidst a thousand Avocations, I have been obliged to dispatch these things in a rude manner, and very different from what I should have done, had I been Master of that Leisure and Retirement which I have long wished for: Especially, as I have a great Desire to confirm and improve some particular Parts by new Experiments. Those which are now contained in this Work, are what I made in publick many Years ago: And this I think proper to mention, lest any body should suspect I borrowed them elsewhere, without making mention of the Author's Name. But to detain my Reader no longer, please to accept this Performance, such as it is, in a favourable manner; excuse the

The AUTHOR'S PREFACE.

Trouble I by this means give you; and impute the Liberty I take of appearing in Print upon this Subject, to the very good Reception the spurious Copy, which was worse, met with from the Publick. Upon this Occasion, too, give me leave to inform you, that I never published any thing besides what follows; which I confess I am ashamed to mention.

Oratio de commendando Studio Hyppocratico. *Spoken and printed at Leyden 1701; for Abrah. Elsevier.*

—— de Ufu Ratiocinii Mechanici in Medicina, 1703, *for John Verbeffel.*

—— quâ repurgatæ Medicinæ facilis asseritur Simplicitas, 1709, *for John Vander Linden.*

—— de comparando certo in Physicis, 1715, *for Peter Vander Aa.*

—— de Chemia suos errores expurgante, 1718, *for Peter Vander Aa.*

—— de Vita, & Obitu Clarissimi Bernardi Albini, 1721, *for Peter Vander Aa.*

—— de Honore Medici Servitute, 1731, *for Isaac Severinus.*

An Oration, which I delivered when the Curators of the University honourably gave me leave to resign my Professorships of Botany and Chemistry, 1729, for Isaac Severinus.

Institutiones Medicæ in Usus annuæ exercitationis domesticæ, 1708, *for John Vander Linden, Father and Son.*

Which was afterwards reprinted several times, with Additions in 8vo.

Aphorismi de Cognoscendis, & Curandis Morbis in usum Doctrinæ Domesticæ, 1709, *for John Vander Linden.*

Of which there were afterwards several Editions, with Additions, in 8vo.

Index Plantarum, quæ in Horto Academico Lugduno-Batavo reperiuntur, 1710, *for Cornelius Boutestein, in 8vo.*

Materia Medica, & Remediorum formulæ, 1719, for Isaac Severinus, in 8vo.

Afterwards reprinted in 8vo.

Index alter Plantarum, quæ in Horto Academico Lugduno-Batavo aluntur, 1720, for Peter Vander Aa, in 4to.

Atrocis nec descripti prius morbi Historia, secundum Medicæ artis leges conscripta, 1724, for Boutestein, in 8vo.

Atrocis rarissimique morbi Historia altera for Samuel Luchtman, and Theodore Haak in 8vo.

A medicinal Treatise de Lue Venerea, prefixed to the Collection of Authors upon the Venereal Disease, 1728, for John Arn. Langer, and John and Herm. Verbeek, in Folio.

Epistola pro sententiâ Malpighianâ de Glandulis ad Clariss. Ryiscium, 4to for Peter Vander Aa.

Every thing else printed in my Name, except a few Prefaces, is spurious, and published without my Knowledge.

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THE DESIGN.

GENTLEMEN,

AS you have put your selves under my care, to instruct you in the know-
ledge of Chemistry, I shall think it my duty to endeavour as much
as possible to answer your expectations. The Design.

And in this, as far as I can judge, I shall most effectually succeed, if I clearly and methodically explain to you every thing you will have occasion for, either to understand the most valuable Authors, in this Art, from whom you may gain a knowledge of it purely as it stands founded upon Experiments; or, to enable you to perform the principal operations in Chemistry; that by this means you may be ready in the exercise of the Art, as well as thoroughly understand it.

This, however, is not so easy to accomplish, in an Art cultivated by men taught rather by accidental discoveries, than acting according to rules of Art, and who for the most part wanted intirely the knowledge and assistance of the more liberal Sciences. Difficulty of the Design.

For hence it came to pass, that they have given us only a confused collection of the things they observed, just in the order they happened, without any regard to a methodical disposition of them.

And this difficulty was still farther increased, by an almost constant neglect of those things which came very frequently under their observation: for these they did not think worth taking notice of; and yet without them, to a reader not versed in the Art, the causes of many things must be unintelligible.

But then this Science became most perplexed, when these Artists began to introduce their disputations into it; came to coining their general principles; and went about to explain the causes of the different appearances they met with.

These difficulties however may in some measure be removed, by collecting together the genuine Experiments, which have been performed in this Art; from thence deducing some general rules; and then disposing those rules the most to advantage.

Especially, if the person who sets about it, has the happiness of having his mind formed to the work, by a long and careful exercise in the practical part of the Art; which I hope without vanity I may lay a small claim to. Method proposed.

With some hopes therefore of success I undertake writing these Institutions; which I shall divide into three parts. Distribution of the works.

The first of which will contain the rise, progress, culture, and fate of Chemistry; will give an account of the principal Authors in this Art, according to the times in which they lived, briefly hinting at the things in which they agreed, Part the first.

and wherein they differed; and hence will make mention of the different sects, and what they have contributed towards the advantage or prejudice of the Art: And here (which caution may be of service for guiding your conduct in this Science) giving to every one the glory due to their merit, I shall candidly commend those who on account of their services to the Art distinguish themselves above the rest; and through the whole shall carefully proceed according to those rules, and with that integrity, which Histories ought religiously to observe.

Second part.

The second part will lay down certain, indisputable, chemical Positions, collected from such evident physical truths, as have been discovered by the Chemists; and these will be chiefly of a general nature, and so contrived, that by the help of them may be performed all the operations, that truly belong to the chemical Art.

Theory of Chemistry, what?

Nor indeed in this Art do we allow of any other Theory, than what is built upon such general Propositions, as have first been deduced from many common undoubted Chemical Experiments, from which, as they always succeed in the same manner, some general truth may be fairly inferred.

Limits of this Chemical Theory.

We must take care, however, not to carry even this rule any farther, than simply to apply it to such particular bodies, as we evidently discover to be perfectly of the same nature.

The reason of this cautious proceeding.

For it is certain, that the powers of some particular bodies, frequently produce such effects, as could not possibly have been foreseen from any general Theorem, in as much as they depend purely upon the peculiar nature of those bodies, which perhaps may be different from all others.

Physico-Mathematics, and Physics made use of in Chemistry.

We shall farther, in forming this Theory, take the liberty to make use of such truths, as are demonstrated in Physics, Mechanics, Hydrostatics, and Hydraulics; since the properties, which belong to all bodies in common, must hold good in chemical ones too: but then, we must in this affair proceed with a great deal of caution; as we find, that by the application of some particular bodies to one another, from the singular nature of those bodies effects are often produced, that are quite contrary to the demonstrations which are true of bodies in general. An instance will make this plain: *Galilæo* has ingeniously demonstrated the law by which a body will descend from a fixt point above to a point on the earth perpendicularly under it, supposing it to move in a spiral, or elliptical line, and with a certain degree of acceleration. Let us now only imagine the falling body to be a loadstone, and another to be so disposed, that the former in its descent shall come within the sphere of its activity; and then his Demonstration will appear to be false. In like manner, the things which *Archimedes* has proved in his Hydrostatics, though they are strictly true when applied to bodies in general, yet do not always hold so, when applied to particular ones; as we see that gold, which sinks in all other fluids, is dissolved, and suspended in so light a one as *Aqua regia*.

Under these limitations then, the truths discovered by the Philosophers, and others abovementioned, will always be of service to this Art; nor can ever possibly do it any prejudice.

The last part of the Design.

In the third and last part of these Institutions, I shall actually exhibit to your view the methods made use of in Chemistry, in order to change natural bodies in such a manner as this Art directs, and to the end which it likewise had before determined.

And

And here I shall take care, that the most common things, if it is of any consequence to know them, shall not be omitted; nothing shall be unnecessarily repeated; and that, shall be always treated of first, of which there will be occasion in the process that follows.

The order in which the chemical Operations are digested.

In the prosecution of which, the Theorems explained in the second part, will be made great use of; by the help of which all the operations in Chemistry will be easily understood, and both the head and the hand fitted for the exercise of the Art: At the same time also, every one of these Processes will be a Demonstration of the truth of the particulars, from which the general Theorem was at first constructed. By this method, Gentlemen, I propose to lead you into the most perfect knowledge of Chemistry; nor have I loaded with difficulties a Science, which in its own nature is sufficiently troublesome. Without this, all the labours of the Chemists, which they call Processes, indeed are of no real service, but waste our time, and instead of being an advantage, are really a prejudice to those that are fond of them.

The use of the chemical Theory in the Operations.

COURSE of CHEMISTRY.

PART I.

The History of the ART.

The name
of the Art.

THE word, which in the Greek Language signifies *Chemistry*, is *χημία*, or *χημεία* : and this is of so very ancient a date, that it is supposed to have been in use before the flood.

This certainly was the opinion of *Zosimus the Panopolitan*, whose Greek manuscripts, which *George Agricola* had seen in the year 1550, and *Joseph Scaliger*, and *Olaus Borrichius* perused afterwards in the King of France's Library, have a remarkable passage in confirmation of it.

For in the book intitled *χεῖσις Ζωσίμου τῷ πανοπολίτῃ φιλοσόφῃ ἐν τῇ πρὸς Θεοσέβειαν ἐν τῇ θ' τῆς ἰμυθ' βίβλῳ*, he expressly says, that the Art which was revealed to the daughters of men by Dæmons, as an acknowledgment of their favours, (*χημίαν καλεῖσθαι*) was called *Chemistry* : For this is the sense of the text, as it was read by *Joseph Scaliger*, and inserted by him in his notes upon *Eusebius*, p. 243, 258. N. 38 ; And by *Borrichius* against *Conringius*, p. 49. *The sacred Writings tell us, that there is a sort of Dæmons that are familiar with women. And Hermes mentions the same thing in his Physics ; and almost all our learning both open and occult, take notice of it likewise. This then the ancient and sacred Scriptures inform us, that the Angels were enamoured of women, and came and taught them all the Works of Nature. Now the first tradition they gave concerning these Arts was called ΧΗΜΑ ; and the book likewise that contained it, they called ΧΗΜΑ ; and hence also the Art obtained the name ΧΗΜΙΑ. Now this very ancient fiction arose from the misunderstanding those words of Moses, Gen. vi. 2. for from this passage they concluded, that by the sons of God were meant Dæmons, consisting of a spiritual part, and a corporeal one, that was visible only, like the image or phantom reflected from a looking glass ; that these beings were endued with a universal knowledge, were conversant with men, were very fond of women, were great with them, revealed secrets, and appeared to mankind. Compare with this, Luke xxiv. 37, 39. Matt. xiv. 26. And this fable probably gave rise to this story of Σίβυλλα, (Σιβ, that is in the Æolic Dialect, Δισβύλλα, or βελλή,) on whom *Phæbus* in return for her favours conferred the gift of Divination, so that she could discover the will and counsels of the Gods. Thus is the mind of man, whilst in a state of uncertainty, apt to run into very strange conceits, which it afterwards idolizes and regards with veneration.*

But farther, the land of *Egypt* was likewise very anciently called by the same name as *Plutarch* observes, (*Is. & Osir. p. 364. C.*) Besides, the soil of *Egypt* being of an exceeding black colour, like the black of the eye, they call it *χημία*. And the same country went also by the name, *ἐρμοχήμεος*, as *Steph. Byzant.* takes notice

rice under the word *ἀγνῶστος*. But the word *χημᾶ* too, as *Bochart* informs us, among the *Arabians* signifies *to hide*.

If we now lay all these things carefully together, we may easily perceive that this name was made use of before the flood; that it continued in use in the succeeding ages; and that in those days it signified,

It is very ancient.

1. A knowledge of the works of nature, *διδασκαλίαν πάντων τῶν φύσεως ἔργων*.
2. A book containing the Tradition of such a Science.
3. That *Hermes* in his book of Physics had made mention of it.

The meaning of this very old name.

The word now, if it is wrote *χημᾶ*, according to *Bochart* signifies *to hide*, as we took notice just now: And hence if *χημῖα*, as *Plutarch* will have it, (*de Is. & Os.* p. 364. C.) expresses the black of the eye, or any thing exceeding black, there will be no great difference betwixt them, as used by the hieroglyphical writers; for among them the pupil of the eye denotes something hidden, and precious.

Especially, if we consider that the same *Egypt*, called in the sacred Writings the land of *Cham*, (*Psalms* cv.) stiled their God *Αμῶν*; which according to *Manetho* the *Sebennite* signifies *somewhat concealed*. *Plut. de Is. & Os.* p. 354. C.

Nay, and that the same country even to this day is called in *Coptic* the land of *Cemi*; as we learn from the same *Samuel Bochart*.

This name therefore signifies something hidden, occult, mysterious, secret; and the Art which it expresses is called likewise, *Chemi*, *Chemia*, *Alchemia*, *Alkumia*, *χημᾶ*, *χημῖα*, *ἰμᾶθ*, *ποιητική*, the *Spagarite* and *Hyssopic Art* separating the pure from the impure.

And by it, the Authors who first made use of the word meant, a universal knowledge of Nature.

The word therefore was used originally in a very pure sense, though it was afterwards perverted to a very different one; which misfortune likewise, by means of illiterate persons, befel the word *Magic*.

But as Metals now comprehend a large and very beautiful part of natural bodies; hence the same word came likewise to signify Metallurgy.

The word used to express Metallurgy.

And this Art also was cultivated to great perfection by the Antidiluvians: for *Tubal-cain*, the true *Vulcan* of the Ancients, son of *Lamech* and *Zillah*, and the eighth person from *Adam*, understood how to prepare copper, and iron in such a manner as to work it into utensils, *Gen.* iv. 22.

But fossil copper as it is dug in the ore requires both exquisite art and labour to make it fit for use; no less than twelve fusions being necessary to render it sufficiently malleable; as both *Agricola* and *Erker* inform us.

The difficulty of the metallurgic Art.

And iron in like manner must be managed with a vast deal of skill and pains, before it can be applied to the same purposes; as we learn from the same faithful Authors, who were the top masters in this Art.

Hence therefore we see that the original of Chemical Metallurgy is exceeding ancient, as well as that of the name itself.

The country which is first celebrated for the cultivation of this Art, is that which was inhabited by the first people, as the History of *Tubal-cain* evinces (*Gen.* iv. 22): Especially, if you compare this with the Fables and Histories of the *Vulcan* of the Ancients, who was the same with *Tubal-cain*, (*Voss. Id. g.* l. 65.) And indeed the very name of the Arts seems by it original to confirm the same thing, as you have seen already.

Chemical Metallurgy first cultivated in Asia.

From

Then in
Egypt.

From hence as its source, this, like other Arts, began to spread, and was next carried into *Egypt*; and there it was practised with a vast deal of application. For *Moses* who was skilled in all the learning of the *Egyptians* (*Acts* vii. 21.) knew how by the help of fire to reduce gold to a powder, so as to render it miscible with water, and by this means potable, (*Exod.* xxxii. 20;) and this is what is certainly one of the top performances of the Art, and what even the greatest Adepts of the present age are not masters of. *Vulcan*, the son of *Jupiter* and *Juno*, was the first who reigned in *Egypt*, and was deified after his death for the invention of fire (*Diod. Sic.* l.) or rather for the first application of fire to making utensils of metals, as the same Author says expressly (γ.) *They tell us, that Vulcan was the Inventor of all works in iron, brass, gold, silver, and other bodies that require the management of fire. He found out likewise all the uses of fire, which he discovered both to the workmen and every body else.*

But *Egypt* itself in the sacred language of the Priests is called *χημία*, (*Plut. Is. & Osir.* 364. C.) and *ἑμποχήμιος*, *Steph. Byz.* in the word *ἄιγυπτος*.

The same country likewise went by the name, *Ἡφαισία*, or the land of *Vulcan*, (*id. ib.*) The great *Scaliger* indeed asserts, that the Art *χημία*, was by the *Egyptians* called *ἰμβθ*. And yet in the book entitled, *Minerva mundi*, taken out of *Stobæus*, it is said, *ποιητικῆς τ' Ἀσκληπίου τ' ἰμβθς*, (*Conring. b. m. c. III.*) i. e. That *Æsculapius* the son *Imuth*, was the inventor of Chemistry; for *ποιητικῆς* is the same as *Chemia*, (*Reines. var. lect. lib. II. c. v.*)

Vulcan it is certain had Priests at *Memphis* (*Herod.* II. 3.) A very beautiful temple was erected to him there (*Herod.* II. 99.) with portico's (*id. ib.* 102.) and images (*id. ib.* 176. III. 37.) And his symbol there was a Vultur (*Vof. id. g. III.* 573.) viz. a bird of prey. But *Zeno* tells us that *Jupiter* too was called *Ἡφαισος*, on account of the extension of his influence to artificial fire (*Diog. Laert.* VII. 147.); which name plainly appears to be derived from *τὸ ἡφθαί*, to be set on fire, or to burn. Agreeable to which opinion, *Horace*, who is remarkable for the elegance of his Epithets, expresses himself,

—dum gravis Cyclopum

Volcanus ardens urit officinas. *Carm.* I. 4. 7.

as *Plautus* indeed had done before him (*Amphitr.* I. I. 1885.)

Quo ambulas tu, qui vulcanum in cornu conclusum geris?

All these observations then seem to make it plain, that the part of Chemistry called Metallurgy, or the Art of Metals, was by the ancients cultivated chiefly in *Egypt*. Nor do I think there can be the least doubt about the antiquity of this very old Art, in this sense; or about the name itself.

The origin
of the word
as applied to
the Art of
making
gold.

A considerable time after, the same word first came to be used to express that Art, by which the purest gold might be procured from any sort of metal; either by a true transmutation, maturation, or some peculiar kind of separation, that was not commonly known.

Afterwards, the *Arabians*, who principally cultivated this Art, altering the sound a little, called it *Alchemia* in the sense just now mentioned; and with a little more variation, *Alchimia*, *Alchemy*.

Very uncer-
tain.

Suidas, who lived in the tenth century, tells us (under the word *χημία*) that *Dioclesian*, who reigned the twenty last years of the third century, gave orders that all the books of this Art should be inquired after, and burnt, because the *Egyptians* were plotting against the *Roman* Government. *χημία*, (*Chemistry*)

or the Art of preparing gold or silver. The books concerning which, Dioclesian got together and burnt, because the Egyptians rebelled against him. He used them cruelly and without mercy, when he sought after their books that were written by their forefathers concerning the *χημεία* of gold and silver, and burnt them, lest by the help of this Art they should grow rich, and so be tempted again to oppose the Roman government.

But under the word *δέσας* he carries the affair still a great deal higher, expressly and positively asserting, that the Golden Fleece, which Jason and the Argonauts brought away when they sailed thro' the Pontic Sea to Colchis, was nothing but a book written upon parchment teaching the method of making gold (*διὰ χημείας*) by the Chemical Art. This now, had he confirmed it by sufficient authority, would have advanced the antiquity of this Science to thirteen centuries before Christ, that is, before the time of the Argonauts. And yet upon this supposition we see the Art even at that time was known, practised, committed to writing, and was the motive to the Argonauts to undertake that fatiguing and dangerous expedition. If this was the case however, it must be confessed it is pretty extraordinary, that neither Moses, the Sacred Writers, Sanchoniatho, Orpheus, Homer, Hesiod, Pindar, Herodotus, Thucydides, Hippocrates, Aristotle, Theophrastus, Dioscorides, Galen, or Pliny should mention one word of it: Especially, as every body who is acquainted with their works must allow, that both the capacities of the Authors, and the design, subject, and times of their writing, must necessarily have led them to have taken notice of it.

Nor is this difficulty at all removed by that passage in Pliny (xxxiv. 25.) concerning flexible Glafs; or by that of Dion Cassius (lvii. p. 617.) concerning the same project's being rejected by Tiberius; nor yet by the other of Pliny (xxxiii. 4.) where he tells us, that Cajus, by a very intense fire, procured from orpiment a small quantity of very choice gold: For supposing these things to be true, they in reality prove nothing more, than that they were at that time excellently skill'd, both in the docimastic Art, and that of Glafs.

It must, however, be acknowledged, that Julius Maternus Firmicus, in the beginning of the fourth Century, writes of the Science of Alchemy, as a thing perfectly well known (3 Matthes. lv.) if this is the genuine text of the author.

And Æneas Gazæus, towards the close of the fifth Century, discoursing upon the same subject, as a common thing, tells us, in his Theophrastus, or treatise *De Immortalitate Animæ*, that those Persons who were thoroughly versed in this Art, take silver and tin, and perfectly destroying their original nature, transmute them into the most beautiful gold. *Biblioth. Patr. vol. 2. pag. 373.*

But Anastasius the Sinaïte, about fifty years after, as Vossius thinks (*Id. G. l. 1. pag. 25.*) or rather towards the latter part of the seventh Century, as upon weighing the matter carefully, Fabricius is of opinion, (*Biblioth. gr. v. pag. 313.*) writes still more expressly; *ὃ δὲ χρυσοχόος ἡμᾶς, καὶ λιθεύων, καὶ χημείας, χρυσοκαλλήτων λίθων ἀπεργάζεσθαι, ἢ γεωφὴν βελομένην, καὶ παιδίδεσθαι τὰ ταυτα φησιν.*

And lastly, in the seventh Century, Georgius Syncellus, wrote professedly upon the same subject.

Soon after him, there sprung up a whole tribe of Alchemistical Writers, whose manuscripts at Rome, Venice, and Paris, by their Greek Idiom, make it plain what age they liv'd in; and by their style make it very probable, that

'Tis ancient however, chiefly amongst the Greek divines.

Christian Greeks the principal Alchemistical Writers.

Were they
the first
too?

A Catalogue
of these.

they were of religious orders. A Catalogue of these Works, which are not yet printed, we have in *Borrichius*, and others (*de Hermetis, Ægyptiorum, & Chemicorum Sapientia*, pag. 78. & seq.)

Σωέσιμ^{ος}, whose treatise of the Philosophers Stone, is in the Library of the University of *Leyden*.

Συνέσι^{ος} φιλόσοφ^{ος} εἰς βιβλίον Δημοκρίτου. The whole treatise is in *Fabric. Bibl. Gr. L. v. cap. 22. p. 232. Gr. & Lat.*

Σώσιμ^{ος} ὁ μέγας, ὁ θεῖος, ὁ Πανοπολίτης, of πανάπολις a city of *Egypt*. xxiv. books ἱμαῖθ to Θεοσέβεια. The title is Σωσίμ^{ος} τῷ παναπολίτῃ γνησία γράφῃ, περὶ τῆς ἱερᾶς, καὶ θείας τέχνης τῷ χρύσει, καὶ ἀργυρεῖ ποιήσεως. and Σώσιμ^{ος} περὶ ὀργάνων, καὶ καμίνων.

Ἐλυμπιόδωρ^{ος} ὁ Ἀλεξάνδριν^{ος}.

Ἡλιόδωρ^{ος} περὶ χρυσοποιήσεως.

Ἰωάννης Ἀρχιερεὺς, τῷ ἐν ἀγίᾳ πόλει περὶ τῆς ἀγίας τέχνης.

Στέφαν^{ος} ὁ φιλόσοφ^{ος} ἀλεξανδρῶς οἰκονομικὸς περὶ τῆς ἱερᾶς, καὶ θείας τέχνης τῷ χρυσοῦ ποιήσι^{ος}. The Manuscript of this also is in the University Library at *Leyden*.

Ωρ^{ος}. χημικὰ.

Σοφᾶρ ἐν περσίδι.

• Ἐρμης handed about in the sixth Century, and commended by *Zosimus*.

Διόσκωρ^{ος} ὁ ἱερῶς μεγάλῃ Σεραπίδ^{ος} ἐν Ἀλεξανδρίᾳ.

Ὁσάνης ἀπ' Αἰγύπτου πρὸς Πετᾶσιον περὶ τῆς ἱερᾶς καὶ θείας τέχνης.

Μώσης προφήτης περὶ χημικτικῆς σωλᾶξεως.

Μαρεία Ἐβραῖα.

Πελάγιος φιλόσοφος περὶ τῆς θείας, καὶ ἱερᾶς τέχνης.

Πορφύριος.

Ἐπιθύχιος. ὁ Ἐπιθήχιος.

Κομάριος φιλόσοφος, καὶ ἀρχιερεὺς, διδάσκων τὴν Κλεοπάτρεν τὴν θεῖαν καὶ ἱερὰν τεχνίῳ τῷ λίθῃ τῆς φιλοσοφίας.

Κλεοπάτρα ἡ γυνὴ Πτολεμαίῳ τῷ βασιλεῶς. The same περὶ σαθμῶν καὶ μέτρων.

Κοσμᾶ ἱερομονάχ^{ος} ἐρμηνεία τῆς χρυσοποιίας.

Ἀγαθοδαίμων εἰς τὸν χρησιμὸν Ὁρφέως σωμαγωγῇ, καὶ ἐπόμνημα.

Πάππ^{ος} φιλόσοφ^{ος} ἔργον.

Ἡρακλεῖος ὁ βασιλεὺς.

Σαλμανᾶ Ἀραβ^{ος} μέθοδος.

Χελσίανος περὶ τῆς θείας ὕδατος.

Θεόφραστος φιλόσοφος περὶ τῆς θείας τέχνης.

Ἀρχέλαος φιλόσοφος περὶ τῆς θείας τέχνης.

Κλαυδῖανος.

Σέργιος.

Ἀνεπίγραφος φιλόσοφος περὶ χημείας.

Μιχαὴλ ψέλλος περὶ χρυσοποιίας. He lived in the time of *Constantine Ducas*, in the year of our Lord 1060. *Borrich.* 79.

Ἰσις προφήτις τῷ ῥῶ ὥρῳ.

Βλεμμίδας ἔργον χημικτικόν.

Νικέφορος.

Δημοκρίτης βίβλος προφωνηθεῖσα λαοκήπων.

Δημόκλειος φυσικὰ καὶ μυστικὰ.

Ἱεροθέος φιλόσοφος περὶ λίθου τῶν φιλοσόφων.

Ἰσαακ Μόναχος, ὅπως δὲ εὐρίσκειν μεθοδὸν ἀργύρου.

Concerning these Greek Alchemistical Writers, consult in particular, *Andreas Libavius* throughout all his Works; but especially against *Guibertus Conring. de Med. Herm. pag. 21, to 31. Borrich. Ort. Ch. 97.* and against *Conring.* from pag. 66, to 95. *Joann. Albert. Fabric. Biblioth. gr.* in various places. And the Catalogue of the University Library at *Leyden*.

Is it not surprising now, that the incomparable *George Agricola*, should have been acquainted with these Authors? For those elaborate Books of his, *De Re Metallica*, which the great *Erasmus* so highly extoll'd, he wrote, and perfectly finish'd, before the year 1550; and yet, in a very elegant Preface prefix'd to these Works, he recites in order, almost all the Writers we have just now mention'd. For your intire satisfaction on this head, I'll beg your patience, whilst I give you the passage in the very words of this noble Author. Of Chemistry (Χημειτικά) wrote *Osthanes*, *Hermes*, *Chanes*, *Zosimus of Alexandria* to his Sister *Theosebia*, *Olympiodorus of Alexandria* likewise, *Agathodæmon*, *Democritus*, not of *Abdera*, but another, *Oris Chrysoirichites*, *Pebechius*, *Comerius*, *Joannes*, *Appuleius*, *Petadius*, *Pelagius*, *Africanus*, *Theophilus*, *Synesius*, *Stephanus* to *Heraclius Cæsar*, *Heliodorus* to *Theodosius*, *Geber*, *Calides*, *Rachaidibus*, *Verdianus*, *Rhodianus*, *Canides*, *Merlinus*, *Raymond Lully*, *Arnaud de Ville Nieuve*, *Augustinus Pantheus a Venetian*; three of the female sex, *Cleopatra*, the *Taphnuttian* maid, *Maria the Jewess*; these all wrote in prose; one only, *Joannes Aurelius Augurellus of Merrechia*, in verse.

All these Authors, however, made use of the Word Chemistry hitherto, to express the Art of converting the baser Metals into pure Gold; and don't seem so much as ever to have thought of any universal Medicine for all the diseases of the human body. See *Conring. de Med. Herm. 15, 16.*

The meaning of Alchemy.

But after the *Arabians* began to cultivate Chemistry in the sense hitherto described, viz. as it relates to Metallurgy, and the Art of making Gold, they seem by their metaphorical and hieroglyphical style, to have given occasion to the Materials made use of to perfect their Metals, going by the name of Medicines; the impure Metals being called sick Men; and Gold, a Man in perfect health and strength. Hence, in time it came to pass, that persons, who were unacquainted with this way of writing, imagin'd these expressions were to be understood in the literal sense; especially, when they saw the impurity of the baser Metal called a Leprosy, which of all distempers is particularly incurable.

The origin of medicinal Chemistry, from the misunderstanding the Expressions of the Chemists.

And this is supposed to have given rise to that report, which afterwards spread so far, and grew so common, that the impure Metals might be transmuted into pure Gold, by the very same chemical instrument, by which the bodies of sick persons might be restored to health.

And this instrument they call'd the *Philosophers Stone*, and the *Gift of Azoth*; and to the persons that were possess'd of it, they gave the name of *Adepts*.

And this prejudice a few simple Experiments afterwards rooted still deeper; for by these, they saw the healing virtues of Medicines might be extracted from them by the Chemical Art. Of this *Rhazes* had given some instances. *Avicenna* too, in the eleventh Century, had in his book, *De Viribus Cordis*, exhibited

The Authors in Alchemy after the Greeks.

hibited the same thing in the Julab of the *Arabians*, or the distill'd Water of *Roses*; and it was afterwards confirm'd likewise by *Mesue*.

Among these, the Authors of the greatest character are *Geber*, called the *Arab*; tho' *Leo Africanus* will have him to be a *Greek*: He was at first a Christian, but afterwards renounc'd his Religion. He wrote in *Arabic*, and liv'd in the seventh Century. The Library of *Golius* furnish'd us with his Works, which have been translated into *Latin* by various hands. See *Leo Afric.* L. III. p. 136. *Conr. b. m.* 369. 372, 373. He wrote chiefly

De Alchimia, vel Chimia; aut de investigatione perfectionis Metallorum.

De Summâ Perfectionis Metallorum.

De Claritate Alchimicæ.

De Lapide Philosophico.

De Testamento.

De Epitaphio.

De inveniendâ arte Auri & Argenti.

Morienus Romanus, a Hermit of *Jerusalem*: He wrote concerning this *Arcanum*, in a very elegant manner, and is reckoned among the purest Authors. His Works were translated out of *Arabic* into *Latin* the 11th of *February* 1182.

Albertus Magnus, a German, Bishop of *Ratisbon*, born at *Laving* in *Schwaben*, about the year 1200. He wrote

A Treatise *De Mineralibus.*

Lilium floris de spinis evulsum.

Speculum Alchemicæ de compositione Lapidis, &c. See *Borellus*.

Roger Bacon, a Briton, who was a Monk of *Westminster*, and resided at *Oxford*. He was famous for his knowledge in Alchemy, Chemistry, natural Magic, Mechanics, Metaphysics, Physics, and Mathematics; and was in vast reputation about the year 1226. Those of his Works that are come to our hands, are

Two Treatises, *De Chimia*, wrote in a plain style enough, without any design'd obscurities.

Speculum Alchemicæ, and another different from the printed one, the Manuscript of which is in the University Library at *Leyden*.

Thesaurum Chemicum.

De secretis artis, atque naturæ operibus, & de nullitate Magiæ. Specula Mathematica.

His Works *De Arte Chymicæ*, printed at *Francfort*, 1603. 12°. which contain a great many very beautiful observations in Mechanics, natural Magic, and various other Arts, the honour of which is unjustly given to modern Authors; and which were falsely imputed to Magic and Heresy. *Borrich. Ort. Ch.* p. 122. and *Borellus*.

George Ripley, a Briton, Canon of *Bridlington*, liv'd about the same time. He wrote *Duodecim portæ. Medulla Chymica. Alchemy*, the Manuscript of which is in the Library of the University of *Leyden*, in *English* verse. All his Works were printed at *Cassell*, in 8v°. 1649.

Hermesius, the Philosopher. He wrote a Treatise, *De Mercurio Philosophorum*. The Manuscript, in the Library of the University of *Leyden*.

Arnoldus, or *Arnaud de Ville Nieuve*, who liv'd in the thirteenth Century. His Writings are *Rosarium. Testamentum novum præticum. De Alchimia. Semita Semitarum,*

Rosa

Rosa Novella. A Letter to Pope Pius.

Novus Splendor, vel Lumen. Flos Florum. De Furno Philosophico. De Secretis Naturæ. De nova compositione Lapidis vitæ Philosophorum. De Principiis naturalibus to Pope Clement. *Opus in Arte Majore.* All these Treatises are in Manuscript, in the University Library at Leyden.

Raymond Lully, of Majorca, descended from a family of Barcelona. He was born in the year 1235, was a Scholar of *Arnaud de Ville Nieuve*, and died in Africa in 1315. He was one of the principal Writers of the universal Remedy for all diseases of the human Body, and of the *Lapis Aurificus*, in his Treatise *De Quintâ Essentiâ*. He wrote likewise, *De Secretis Naturæ, seu de Quintâ Essentiâ, & de Accurtatione Lapidis Philosophorum. Codicillum, seu vade mecum, de formatione Lapidum pretiosorum*; Manuscripts in the University Library at Leyden. *Claviculam de L. P. Testamentum Apertorium.* Some Letters to Edward, King of England. *Lux Mercuriorum. De Mercurio Speculum magnum. Testamentum Novissimum.* A Letter to *Robert King of England. *Aphorismi. Epistola Accurtationum. De investigatione occulti secreti. Exempla Accurtationis.* The Manuscripts of all these Treatises are in the Library of the University of Leyden. He is said to have wrote upon chemical Subjects, to the number of sixty Volumes.

* So in the original.

Joannes de Rupefissa a Franciscan Monk; he died in prison about the year 1375. He wrote various Treatises of Alchemy. See *Conr. H. M. Borellus.* *Paracelsus* said of him, that he asserted things that were both trifling and false.

Isaacus Hollandus, and *Joannes Isaacus Hollandus*, of Stolk, a little town in Holland. They wrote a good many things on Alchemistical Subjects, in which there are a great many very curious Experiments. *De Lapide Philosophorum. Scientia Chimiæ. De projectione infinitâ. De Mineralibus, & vera Metallorum Metamorphosi. De Vino. De Vegetabilibus*, and other things.

Basil Valentine. It is commonly reported, he was a Monk of the *Benedictine* Order at *Erffurt*; tho' it is confidently affirm'd, that there never was any such Monastery there; and indeed, both names seem to be a fictitious composition from the *Latin* and *Greek*: This however is certain, that he was a most expert Artist in every Branch of common Chemistry. That single Treatise of his, intitled, *Currus triumphalis Antimonii*, is a sufficient proof of this Assertion; for that alone contains an exact description of almost all the chemical Artifices that are now-a-days unfairly put upon the world for new discoveries: In the more abstruse parts of the Art too, he discover'd a profound knowledge. His very great fault was, that he extolled every Preparation of Antimony, without exception, for its medicinal vertues; than which, nothing can be more weak, fallacious, or mischievous. And this fatal error has infected all the Schools of the Chemists, from that time, quite down to the present age. It appears by his writings, that he was both a Monk and Physician; and seems by his learning, to have gain'd a very great reputation in the Courts of several Princes. He is supposed to have flourished in the Century before *Paracelsus*. He was the Inventor of the three chemical principles, which *Paracelsus* afterwards made great use of. He wrote a great many things in a pretty prolix manner, and some of them upon medicinal Subjects.

After these last five Authors had publish'd their Works, the opinion, as we just now took notice, every where got ground among the Chemists, that it was

Chemists
and Alchemists become
Physicians.

possible, by one alchemistical Medicine, perfectly to root every distemper out of the human body, to restore absolute health, and prolong life to a great series of years, without being impair'd by any diseases.

Who being puffed up with some good effects of their Art, especially in the venereal Disease by the influence of Mercury,

Puffed up therefore with these expectations, and grown vain with the success they had had from some of their strong chemical Medicines, in a short time they were for engrossing the Art of Physic intirely to themselves.

At the same time too, the Art of Physic had for a good while, by the subtle sophistry, and jargon of the Schools, been become intirely *Galenical*, and given up to the doctrines of the *Arabians*: Hence bleeding, purging, and a few efficacious Medicines, being the sum of the practice, and these not being sufficient to encounter with the venereal Disease that then made havock among them, it was forc'd to give way to the more powerful Preparations of the chemical Art; for *Carpus*, by the assistance of his Mercury, easily out-did the Shoolmen, and thus afforded the Chemists fresh occasion of triumph.

promised new and incredible cures.

By this means, the condition of the old Physicians seem'd now to grow very uncomfortable; for after they had taken a vast deal of pains to search into nature, in order to discover the origin, and cure of diseases, these boasting Alchemists condemn'd all their labours in *Ætiologies*, *Diagnostics*, *Prognostics*, *Dietetics*, and *Therapeutics*, as trifling, and of no manner of service; whilst they, without any regard to diet, or the cause and nature of the disorder, could intirely remove all manner of distempers, by the simple application of one and the same Medicine.

But perform very little.

This extravagant error, however, by sweeping away great numbers at the first onset, made it appear, upon maturer consideration, that the bold pretensions of those practitioners were not only vain, but did likewise a great deal of mischief.

This we learn plainly from the life and writings of *Paracelsus* and *Van Helmont*, as may be fairly collected from the hints they have given us.

History of Paracelsus from himself.

Aureolus Philippus Paracelsus Theophrastus Bombast de Hohenheim, was the Son of *William Hohenheim*, a man of Letters, and Licentiate in Physic, tho' not much noted for his practice, who had a very fine Library, being himself a natural Son of a Master of the *Teutonic Order*.

He was born in the year 1493, in a village called *Einsidlen*, which signifies a Desert, two German miles distant from *Zurich* in *Switzerland*: And hence he came to be called the Hermit; which appellation *Erasmus* gave him, in the letters he wrote to him.

He is said to have had his testicles bit off by a hog when he was but three years old; and from that time he was looked upon as an Eunuch. This is certain he always behaved with the greatest aversion to the female sex; and yet a picture of him drawn from the life when he was grown up, represents him with a beard. Under the advantage of the faithful instructions he received from his father, he made great progress, both in medicine and surgery; but having whilst he was very young a vast fondness for Alchemy, his father committed him to the care of *Trithemius*, abbot of *Spanheim*, who was at that time in great reputation. Under him he got an insight into a good many *Arcana*, and then quitting him applied himself to *Sigismund Fuggerus*, who at vast expence and with a great many servants, was then strenuously prosecuting the chemical Art in *Germany*; which he had very much improved by abundance of new Discoveries.

And

And here it was, as he himself confesses, he learned both the Theory and Practice of the Spagairite Art.

Afterwards he tells us, he sought out, and studied under all the tutors, that bore the greatest reputation at that time of day, and were deepest skilled in the adept Philosophy; and they, he says, concealed nothing at all from him, but revealed to him all their *Arcana*.

However not being satisfied with this, in order to get a better knowledge of Physic, he visited all the Universities in *Germany, Italy, France, and Spain*; and travelled into *Prussia, Lithuania, Poland, Walachia, Transylvania, Croatia, Portugal, Slavonia*, and in short into all the Kingdoms of *Europe*; and wherever he went he made it his business to inquire among Physicians, Barbers, old Women, Conjurers, Chemists, rich and poor, for the best and surest remedies, and was always very well pleased to be informed by any person whatsoever.

From the writings of *Basil Valentine*, he learned the doctrine of the three Elements, *Salt, Sulphur, and Mercury*, which he afterwards, concealing the Author's name, published as his own.

When he was twenty years of age, he took a view of a great many mines in *Germany*; and whilst he was on this expedition, wandering quite up into *Muscovy*, he was upon the borders taken prisoner by the *Tartars* and carried before the *Cham*, who sent him with the Prince his son to *Constantinople*: and here in the eight and twentieth year of his age, he is said to have become master of the *Philosophers Stone*.

In the character both of Surgeon and Physician he was often in camps, battles and sieges.

He had a high esteem for *Hippocrates*, and the ancient Physicians: as for the Doctors of the schools he made very little of them; and had a particular aversion to the *Arabians*.

Mercurials and Opiates he used plentifully and boldly, and with these he cured the Leprosy and Venereal Disease, the Itch, Ulcers, the lighter sorts of Dropsies, and acute pains; which Distempers were at that time of day beyond the reach of the Physicians; as they knew nothing of Mercury, and were afraid of Opium, from an idle notion of its being cold in the fourth degree.

By the cure of such distempers he grew bold and famous; but particularly by that which he performed upon *Frobenius* at *Basil*, which brought him acquainted with our great *Erasmus*. The Magistrates of *Basil* being on this account very well pleased with him, courted him with a very handsome salary to the Professorship of Physic and Philosophy in their University; which he accepted in the year 1527, and gave public Lectures for two hours every day, in the *Latin* tongue sometimes, but chiefly in the *German*.

He took this opportunity to explain his own books, *de Compositionibus, Gradibus, and Tartaro*; in which, as *Van Helmont* observes, there is a great deal of trifling, and very little of any real service. And here he burnt the works of *Galen* and *Avicen* publicly from the chair; and declared to his pupils, that if God would not assist him, he should not scruple to consult even the Devil himself.

At this place he got a great many Scholars, with whom he lived in a very friendly intimate manner. Three of them at his own expence he furnished both

The first public professor of Alchemy.

both with diet and apparel, and let them into some of his *Arcana*; but they deserted their master, wrote reproachful things against him, and injudiciously making use of the observations he had communicated to them, did their patients a vast deal of mischief. He maintained in his family likewise, Surgeons and Barbers, to whom too he communicated some of his secrets; but these likewise soon forsook him, and became his enemies. As his proper faithful scholars, he only speaks handsomely of Doctor *Peter*, Doctor *Andrew*, Doctor *Ursing*, Licentiat *Pangratius*, and Master *Raphael*. When he had been in his office two years, with three Pills of his *Laudanum* he cured *Liechtenfessius* a noble Canon of most terrible pains in his stomach, which had brought him so low that his Physicians had given him over. The Canon like other sick folks had from the beginning promised him an hundred Louis d'ors, if he restored him to health, but refused to pay it when he had got well; upon which *Paracelsus* in a merry manner told him, he had given him nothing else but three pills made of mouse dung; for which he was cited to appear in court by *Theophrastus*. The Judges proceeding according to their common law, and hence having regard not so much to his skill, as to the charge and trouble he had been at, decreed him but a trifling acknowledgment. This so provoked *Paracelsus*, that according to his custom he could not help accusing the Judges both of ignorance and injustice; and thus knowing himself guilty in some measure *læsæ majestatis*, he made what haste he could home, and by advice of his friends got privately out of the city, leaving his whole chemical *Apparatus* to *John Oporinus*. He did not however retire to any great distance, but for two years wandered up and down *Alsace*, *Oporinus* all the while bearing him company, and waiting upon him: And during this time he was as happy in his practice, as he was dissolute in his life. This *Zwinger* informs us (*Theatr.* 1422), who at that time lived at *Basil*, and frequently heard the story from *Oporinus* himself.

He had then taken *Oporinus* for his *Amanuensis*, and servant. He was a famous man, and master both of the *Greek* and *Latin* tongue, but was led away by the vain expectation of being let into *Paracelsus's Arcana*. After rambling about with him however for two whole years, he found he could get nothing at all out of him, though he had left his own family purely on that account. Being quite tired therefore, and grown wiser at last, he left *Paracelsus*, and returned to *Basil*.

The immediate occasion, however, of his leaving him was the following accident. One evening as *Paracelsus* was merry making with some country fellows, he was sent for to a Peasant, that lay dangerously ill near *Colombaria* in *Alsace*; but he being set in for drinking, and not caring to break company, put off going to see him that night. In the morning however he went, and when he came into the room, with a stern countenance asked whether the sick man had taken any thing, having some of his *Laudanum* ready to give him. The persons about him answered, that nothing had been given him but the Sacrament, as he was now just upon the point of expiring. Upon which *Paracelsus* flew into a passion, and told them, if he had sent for any other Physician, he had no occasion for him, and left the house immediately. This impious behaviour so shocked *Oporinus*, that he was afraid, he himself should some time or other suffer for the monstrous inhumanity of his master, and therefore resolved to

take a final leave of *Paracelsus*, though he had a very particular value for him. *Zwinger, Theatr.* 2275.

Paracelsus had now lost what knowledge he had of the *Latin* tongue, and never after this settled in any place, but kept rambling about; never sober, neither changing his clothes, nor so much as going to bed; till at length after a few days illness, in which he held perfectly sensible to the last, he died through extreme weakness at a publick inn at *Saltzberg*, on the four and twentieth of *September* 1541, and in the seven and fortieth year of his age, though by the assistance of his *Elixir Proprietatis* alone, he had flatter'd himself with the years of *Metbusalem*.

Some of his works he publish'd himself, viz, The fourth part of his *Chirurgia Magna*, which he dedicated to *Hieronymus Bonerus* chief magistrate of the city of *Colmar*, the second day of *June* 1528. His Treatise *de Apostematibus*, which he presented to *Conrad Wiseram*, Consul at *Colmar* the 5th of *July* 1528, His books *de Gradibus*, *Compositionibus*, and *Tartaro*. *Chirurgia Magna*, which he addressed to *Ferdinand Cæsar*, from *Munich*, *May* the seventh 1536. The second part of this, which he inscribed to the same person the eleventh of *August*, 1536. In these he quotes those works of his, that were already published; *De Archidoxis*, *De Sanationibus*, *De Sanitate Microcosmi*, & *Elementorum*. *De Generatione Naturalium*. *De Suppuratione*. *De Signis*. *De Characteribus*, & *Adeptis*. *De Phlebotomiâ*. *De Origine novorum Morborum*. *De Magia*.

This whole History of *Paracelsus* I have extracted from his own writings, from *Oporinus*, *Zwinger*, and *Helmont* in particular; nor has it cost me a little trouble. See *Van Helmont*, (p. 187. § 3. p. 324, 325, 698, 699.) As for the accounts given of him by other Authors, I was afraid to subjoin them, as a mixture of ill nature or prejudice in his favour seems too evidently to appear amongst them.

John Baptist Van Helmont, descended from a noble family at *Brussels*, was born in the year 1577, six and thirty years after the death of *Paracelsus*. In the year 1580, he lost his father, being the youngest of all the children, and then without the knowledge of his friends, and contrary to the inclination of his mother, he applied himself to the study of *Physic*, p. 833.

The life of
Van Hel-
mont from
his own
Writings.

In the year 1594, he had gone through a Course of *Philosophy*, being then but seventeen years of age, (p. 12. § 1.) He was a prodigious lover of books, and had carefully read over *Galen* twice, *Hippocrates* once, other *Greek*, and all the *Arabian* Physicians; and whatever he thought worthy of notice in them he had collected into a common place book. And hence, at this time, he gave publick Lectures in *Surgery* in the College of Physicians at *Louvain*, being appointed to that office, by the Professors, *Thomas Fyenus*, *Gerard Villers*, and *Stornius*, (p. 833.)

Who was
learned in
the liberal
Sciences,
Philosophy,
and *Medi-*
cine.

In the year 1599, he was made a Graduate at *Louvain*, in the two and twentieth year of his age, (p. 11. § 7.); and began to see the insufficiency of the schools, long before he was master of any good Medicines, (p. 423. § 2). In himself he experienced the unsuccessful method of cure of the schoolmen, being troubled with a slight Itch, which was happily removed by the assistance of *Sulphur*, (p. 256, 257). He then began to grow uneasy, that he being of a noble descent should be the first of the family, that had ever applied himself to the study of *Physic*; and for this reason he quitted his Profession, divided his effects among his relations, and went out of the country with a resolution never to return again, (p. 833). He threw away his library which cost him two hundred

Was made
Doctor of
Physic.

despaired of
doing any
thing in
Physic.

hundred Pistoles, (p. 666. § 12), and wandered about for ten whole years, (p. 11. § 7). He then, by the assistance of an illiterate person, got a notion of *Purotechny*, and applied himself intirely to Chemistry. Within two years after he made himself master of certain Chemical Medicines, by which he was able to cure some Distempers, (p. 833).

In the year 1609, he married a wealthy virtuous wife, of a noble family; and with her he retired to *Vilvorden*, where he gave himself wholly up to the Chemical Art, (p. 41. § 7. p. 833, 838.)

At first setting out, by making some very dangerous Experiments, he frequently run a risque of his life, p. 719, 948.

He neither visited any patients, or followed his Profession with views to advantage, (p. 693. § 3.)

Practised
Physic.

And yet he tells us he relieved myriads of sick persons every year, (p. 835.)

He spent fifty whole years in distillations, (p. 241. § 1.) He was in great esteem with the Bishop and Elector of *Cologn*, who was vastly fond of Chemistry, and exceedingly well skilled in it. He was sent for by the Emperor *Rudolphus*; and invited to Court by two Emperors: but he would not accept their favours, (p. 833, 835.)

Could not
cure many
diseases.

He was not able to cure his two sons of the Plague, but lost them both, (p. 873); nor his eldest daughter of the Leprosy, though he spent two whole years about it, (p. 714. § 27); nor his wife, or maid, (p. 469); nor himself when somebody had given him poison, *Ibid*.

In the year 1624, he published a little treatise, *de Aquis Spadanis*, at *Liege*; and afterwards some other pieces.

Was ill
himself, and
endeavours
his cure by
the com-
mon me-
thods,

* In the sixty fifth year of his age, (p. 720, 721.) after he had passed his sixty third, on the third of the Kalends of *January*, 1640, he was seized with a Fever, accompanied with a slight *Rigor* that made his teeth chatter. He had a pricking pain about his *Sternum*, attended with a difficulty of respiration. What he spit up, was at first streaked with blood, and afterwards pure blood itself. He took the *Penis* of a Stag scraped, and his pain abated. Afterwards he drank one drachm of goat's blood. In four days time the bloody *Sputum* left him; but he was still at times troubled with a slight cough, with some discharge. His Fever still continued, and a pain in his *Spleen* succeeded, which he removed by drinking some wine made hot with Crabs Eyes: And in a short time all the symptoms disappeared, (p. 322. § 35.) In the year 1643, being exposed to the fume of burning charcoal, he fell into a Syncope, (p. 242. § 19.) from the inconveniences of which he relieved himself by Sulphur of Vitriol, *ibid*. On the eighteenth of *November*, 1644, he was attacked by an Asthma and two Paroxysms of a Pleurisy: Under this disorder he laboured seven weeks, and then died of a slight Fever from extreme weakness, on the thirtieth day of *December*, 1644. See his son's Preface, who after his father's decease published all his works.

But without
success,

thence sinks
under his
distemper.

Hence therefore it appears evident beyond dispute, that neither of these Authors, who were the most famous of the Chemists that practised Physic, were masters

* The account given us here of *Van Helmont's* age don't agree with the preceding one of his birth: for if he was born in 1577, he could not on the third of the kalends of *January*, 1640, be in his sixty fifth year. This, among other things, I mentioned to the learned Author, who is sensible of the disagreement, but says it stands so in the places quoted from *Van Helmont* himself.

of such a universal Medicine as they every where boast of; tho' where the *Viscera* of their Patients were found enough to bear the shock of their violent Remedies, it must be confess'd, they perform'd a great many noble cures.

And here we may likewise remark, that neither of these vain men, with all their pretensions to longevity, arrived in reality to that stage of life, that one can properly call old age.

Afterwards the celebrated Physicians, *Franciscus de le Boe Sylvius*, *Otto Tachenius*, and their followers, introduc'd the chemical Art into Medicine, and made this every where dependant upon it, both in Theory and Practice.

Chemistry
and Medi-
cine united,
and made
one Acade-
mical
Science.

These things then being thus slightly gone through, it will be of service to a beginner, at his setting out, to examine carefully those Authors, who have digested the operations of Chemistry themselves into a regular system; and of these, the following are the most valuable.

Oswald Crollius. Basilica Chemica cum notis Jo. Hartmanni. Genev. 1658. 8vo.

Beguinus Tirocinium Chemicum, often reprinted. 8vo. and 12mo.

John Hartmann. Opera Medico-chymica. Francf. 1690. folo.

Glafer. Traité de la Chymie. Bruffels 1676. 12mo.

Le Febre. Traité de la Chymie. Leyden 1669. 12mo, 2 vol. Paris 1660. 2 vol. 8vo.

A catalogue
of Authors
for the Prac-
tical part.

Le Mery. Cours de Chymie. Leyden 1716, 8vo.

Le Mort. Chymia Medico-Physica, &c. Leyden 1696, 4to.

Barchausen. Purosapia. Leyden 1698. 4to.

In the metallurgic part of the Art, the most celebrated are

Geber, often printed in various sizes.

George Agricola. De Re Metallica, Lib. xii. &c. Basil, 1657.

Lazarus Erkern. Beschreibung aller furnemisten Mineralischen ertz, und bergwerks arten, &c. Francf. 1629. folo. The same in 4to. *Francf. 1694*, intitled, *Aula subterranea, alias Probirbuch Lazari Erker.*

John Rudolphus Glauber, throughout all his works publish'd separately, at different times, and in various sizes.

Joachim. Becher. Metallurgia Becheri. Francf. 1660. 8vo.

John Kunkel. Philosophia Chymica, experimentis confirmata. Amsterdam 12mo.

Olaus Borrichius. Docimastica metallica. Copenhagen 1680. 8vo.

In Alchemy the following are of greatest repute.

Geber, who *Bernardus* reckons amongst the *Sophists*.

Alchemists

Morienus.

Roger Bacon.

George Ripley.

Raymond Lully.

Bernardus, Count of *Trevisan*. He wrote in the year 1453.

Joannes Isaacus Hollandus, and who perhaps is the same

Isaacus Hollandus, who is more modern than *Arnaud de Ville Nieuve*, but anterior than *Paracelsus*. *Penotus* had such a value for him, that he imagin'd him, lying conceal'd in *Paracelsus's* time, to be *Elias* the Artist, the promis'd revealer of secrets. *Libav. Alchimia Pharmaceut. 122.*

Basil Valentine. Chymische Schrifften. Hamburg 1694. 8vo.

Artephius.

Theatrum Chemicum.

Turba Philosophorum.

Paracelsus. Opera omnia, in Latin, Genev. 1658. 2 vol. fol°.

————— *High-Dutch*, Strasburg, 1603. 2 vol. fol°.

————— *High-Dutch*, Strasburg, 1616. 2 vol. fol°.

Ireneus Philaletha.

Michael Sendivogius.

John Baptist Van Helmont. Opera omnia. Amsterdam, 1652. 4to.

For Chemistry apply'd to Medicine and Natural Philosophy.

The same *Van Helmont.*

Robert Boyle. In all his writings.

John Bohn. Dissert. Chymico-Physicæ, Leips. 1698.

Dr. Cox and Dr. Slare. In several of the *Philosophical Transactions of the Royal Society.*

Messieurs Homberg, Geoffroy, and Le Mery, the younger. In the *Memoirs of the Royal Academy of Sciences.*

Georg. Ernest. Stahl. In his *Fundamenta Chymicæ.* Norimb. 1723. 4to.

But above all, the very ingenious *Frederic Hoffman*, in his *Observationes Physico-Chemicæ selectiores, libris tribus comprehensæ*, publish'd at Hall, 1722; a Gentleman, who has done a vast deal of service to the chemical Art, and enriched both Chemistry and Physics, with abundance of beautiful observations.

Chemical
Authors in
Medicine
and natural
Philosophy.

COURSE

COURSE of CHEMESTRY.

P A R T II.

Which delineates the Theory.

CHEMISTRY is an Art, that teaches us how to perform certain physical operations, by which bodies that are discernible by the senses, or that may be rendered so, and that are capable of being contained in vessels, may by suitable instruments be so changed, that particular determin'd effects may be thence produced, and the causes of those effects understood by the effects themselves, to the manifold improvement of various Arts.

Chemistry
defined.

And certainly, it very justly deserves the name of an Art ; inasmuch as it directs us to the performance of such actions, as the understanding certainly knows will produce such and such effects.

The objects, in observing or changing of which this Art is conversant, are all sensible bodies ; and that whether they are so in their own nature, or such, as tho' they were before imperceptible, yet by the help of this Art, either in themselves, or by their effects, may be brought within the reach of our senses ; especially, if they are naturally capable of being contain'd in vessels ; or by the power of this Art, may be so managed, as to be confin'd therein.

The objects
of the Art.

Now, from an accurate consideration of these bodies, it appears, that they may commodiously enough be distributed into three Classes ; and these have obtain'd the names of Kingdoms.

Dispos'd into
three Clas-
ses.

The first Class comprehends Fossils, or, as they are vulgarly called, Minerals ; which are defined natural bodies, generated in the bowels, or on the surface of the earth, whose texture is so simple, that the most accurate observers, assisted by the nicest microscopes, have never been able to discover any difference in them of vessels and contained fluids, nor any part of them, but what is perfectly uniform, and similar to the whole ; tho' at the same time we certainly know, that most of them are compounded of parts, both solid and fluid : These the Chemists call the Mineral Kingdom.

The first in-
cluding Fos-
sils.
Character of
Fossils.

Of METALS.

And among these, the first place in order is given to Metals ; whose character is, that they are the most ponderous Fossils, melting in the fire, uniting again in the cold, and then being ductile under the hammer.

The first
place given
to Metals.
Marks of
Metals.

Now of these, if we consider them simply, there have never yet been discovered more than six, *viz.* Gold, Silver, Copper, Tin, Iron, and Lead.

The ancient Philosophers indeed, added Mercury; but as that has neither Hardness, Ductility, or Fixity, it must certainly be of quite a different nature: The place however where it is found, its weight, simplicity, and easy union with Metals, naturally led them to think in this manner; and indeed, 'tis a very ancient, and has been a very prevailing opinion, that Mercury constitutes the principal part of all Metals.

The ancient
characters
of Metals.

The most ancient among the *Persians*, which is pretty remarkable, in their religious affairs, constantly made use of the same Names, for the seven Metals they saw produced in the Earth, which they had given to the Planets in the Heavens.

The Astronomers too, and Astrologers, have distinguished the heavenly Planets by the very same Characters ☉, ☿, ♀, ♁, ♂, ♃, ♄, as the Chemists do their Metals.

The mean-
ing of these
characters.

Which of them made use of these Marks first, it is not easy to determine; but this is certain, that the Chemists, by their hieroglyphical manner of writing, have aptly express'd the Bodies they design'd to represent, as upon examination will easily appear.

- ✕ Denotes every thing that is sharp and corrosive, Vinegar, Fire; and hence it has those sharp points which you see all round it.
- ☉ — whatever is perfect, immutable, and most simple: Such is Gold, in which there is nothing corrosive, or heterogeneous.
- ☿ — half-gold; whose inward part turn'd outwards makes pure gold, without any thing foreign, or corrosive. This the Alchemists have observ'd in Silver.
- ♀ — the inmost part pure Gold; but that at top there appears the colour of Silver, whilst underneath there is something sharp and corrosive; both which being remov'd, there will remain pure Gold, but *Aurum vivum*. This the Adepts assert to hold good in Mercury.
- ♂ — the greatest part to be gold; but that there is still a considerable quantity of a crude, sharp, corrosive matter join'd with it, which being separated from it, the remainder will have the properties of Gold. This also the Adepts declare the truth of.
- ♃ — that this too is intimately Gold; but that it has with it a great deal of the sharp, and corrosive; tho' with but half the degree of Acrimony as the former, as you see it has but half the sign that expresses that quality. And what the Alchemists assert, the Physicians observe to be true: Indeed, it is almost the universal opinion of the Adepts, that the *Aurum vivum*, or *Philosophorum*, does lye conceal'd in Iron; and that here therefore we must seek for metalline Medicines, and not in Gold itself.
- ♄ — that Tin is half Silver, the other half a crude corrosive Acrimony: And this every one who is used to docimastic trials experiences the truth of; for the Cupel shews, that it has pretty near the same fixedness in the fire with Silver; and that it contains abundance of crude Sulphur, well known to the Alchemists.
- ♅ — that it is nearly all corrosive, with some resemblance of Silver; which to the skilful is sufficient.

♄ — Chaos,

♂ — Chaos, τὸ πᾶν. The world. The one in which are all things. Gold, and a large quantity of an arsenical corrosive.

The individual proper character of Metals, is their extraordinary weight, which far exceeds that of all other bodies: And this, as it is of all properties the most difficult for Art to produce, affords us a certain mark of Metals.

A catalogue of them, as they have been examined in the purest water, I have here inserted from the *Philosophical Transactions* N°. 169, p. 926. N°. 199, p. 694.

⊙	19636.	♂	7852.
♂	14019.	♀	7321.
♂	11345.	Granate	3978.
♂	10535, 11087.	Glass	2805.
♀	8843.	Pump Water	1000.

Weight, the principal, and certain mark of Metals.

Weight, the true mark that distinguishes Metals from one another. And from other very heavy bodies. The rules drawn from the weight alone certain, and of great use.

If we want therefore to be satisfied, whether bodies that we are not acquainted with, have any quantity of Metal in them, the consideration of their weight furnishes us with the best method of trial.

Nay, and by this means it often appears too, of what sort it is.

How great therefore must be the difficulty of increasing the weights of bodies to such a degree, as to condense other Metals into Gold, or to convert other bodies into Metals?

Hence again we see farther, what substance comes nearest to Gold, in respect of its weight, and of consequence, is most likely to be transmuted into it.

And lastly, that the demonstration from weight is infallibly certain.

⊙. 1. Of all bodies is the heaviest.

2. The most simple, or homogeneous.

3. The most fix'd, both in Air and Fire: Nay, it is so to such a degree, that an ounce of Gold has been kept in fusion for two months together, in the Eye of a Glass-house furnace, without losing one Grain of its weight. Hence it appears to be incorruptible.

4. It is the only body that is capable of resisting the power, both of Antimony and Lead; nor when it is melted with them, does it run into *Scoriae* with 'em, like other Metals, but sinks to the bottom. Hence it is the most durable of all bodies we are hitherto acquainted with; nay, perhaps immutable, by any physical power: And for this reason, the wisest among the Alchemists, have unanimously agreed, that it is easier to produce Gold by Art, than it is to destroy it.

5. Of all bodies 'tis the most ductile. The workmen can hammer out a grain of Gold, between skins made of Ox's guts, into a leaf, that shall contain $36\frac{1}{2}$ square inches, and 24 square lines. Forty-eight ounces of Silver shap'd into a cylindrical form, may be gilt with one ounce of Gold; from this, Wire may be drawn so fine, that 2 ells of it shall weigh no more than one grain; and consequently, in the surface of these 2 ells, there must be extended $\frac{1}{48}$ of a grain of Gold; and yet upon examination with a Microscope, the Gold is found to be spread so thick, that there is not, in any part of the surface, the least appearance of Silver under it. Hence therefore it follows, that $\frac{1}{100000}$ of a grain of Gold may be discern'd by the naked Eye; and that the thickness of this visible Foliage, is no more than $\frac{1}{134500}$ of an inch. Halley. *Philosoph. Transact.* N°. 194. p. 549.

The true marks of Gold.

And

And in the *Mem. de l' Acad. Roy. des Scien.* 'tis demonstrated, that the gilding on the smallest Silver wire, is but $\frac{1}{1030000}$ of a line thick. A single drop of a Solution of Gold in *Aq. Reg.* will give a metalline taste to a pint of rectify'd Spirit of Wine; and will change some quarts of Water, that have two grains of Tin dissolv'd in it, to a dark purple colour. *Hoffman.* A workman at *Ausburg*, by a particular Art of his own, could draw one grain of Gold into a wire of 500 feet long. *Cassius de Auro*, pag. 77.

6. It is soft, scarcely elastic, or sonorous.
7. When it is once red hot, it presently melts; but in *Madagascar* there is a very soft sort, which runs like Lead with a gentle Fire. *Flacourt. Hist. Inf. Madagasc. Borrich. Ort. Cb.* 49.
8. Nothing will dissolve it, except Sea-Salt, or some *Menstruum* prepared from it, all other Salts having no effect upon it; and hence it comes to pass that it never rusts, as there is no such thing as *Aq. Regia*, or Spirit of Sea-Salt in the Air.
9. It very readily unites with Mercury, if it is pure; but not so easily with crude Mercury, as people generally imagine; no, not even by the assistance of Fire.
10. If it is dissolv'd in *Aqua Regia*, and precipitated with Salt of Tartar, it will, like Gun-powder, acquire an explosive Power. Gold is never corrupted by rust; or in the longest time, loses any thing by exhalation: Nature gives it perfectly pure in grains and glebes, of which there have been some found, that have weighed two pounds; and this Gold is called *Obryzium*; but it often requires the management of the Fire, as there is scarcely any Glebe that contains pure Gold, without a Mixture of some other Metals; unless, when it is most intimately united; and even then, it has in it something of Silver: But Silver and Copper excepted, 'tis rarely observ'd to be mixed with any other Metal: Almost all the world over it is distributed, more or less, and is found sometimes in a white Glebe, with black spots, which is accounted the best; at others in black, red, or yellows. In the Glebes, as they are dug from the Mines, there is observ'd a white, blue, red, and green Vitriol; and what goes by the name of Antimony of Gold.

It is separated from the Ore, 1. By torrifying it in a reverberating Furnace; by which means the volatile parts are carried off. 2. By boiling it in Water, that the saline and pinguious parts may swim at top, and so be easily taken away. 3. By rubbing it with Mercury, if the Mass is not pinguious. 4. By rubbing it with Mercury, and *Calx* of Vitriol, if the Glebe is fattish, and then boiling it in Water. 5. By *Aqua Regia*. 6. By certain Salts, which serve to fix the volatile Oil, or Salt; for these would otherwise carry off with them a considerable part of the Gold. 7. By washing it with Water; which is practised chiefly with Gold Dust.

See upon this head, *Lazarus Erker*, Lord *Verulam*, and the *Philosophical Transactions*.

- § 1. Of all bodies comes the nearest in weight to Gold; and the more so, the more it is purified.

Proper
marks of
Mercury.

2. It is the most simple of all bodies*, Gold itself not excepted, if it be perfectly pure.
3. In the Fire, it intirely evaporates in form of Smoke, with a degree of Heat, little greater than that of boiling Water.
4. It is not at all ductile under the Hammer, but will, by a gentle stroke, be divided into very small Particles; and the more so, the purer it is: No degree of cold has ever been observed to condense it into a solid Mass. Is it therefore fluid Gold?
5. Of all Metals, it unites the easiest with Gold, then with Lead, Silver, and Tin; with more difficulty still with Copper; and scarcely at all with Iron. In the union therefore of Mercury with Metals, as Mercury is the *Basis* of them all, is it not the Mercury, that by an affinity of nature, unites with itself? Hence, does it not unite so much the easier with any Metal, as that Metal contains more of Mercury, and less of any other Matter? This certainly seems very probable.

6. Both *Aqua Fortis*, and *Aqua Regia*, will dissolve it.

Hence then we may conclude, how difficult a piece of work it must be, to convert Mercury into Gold, as we must first give it weight, fixity, and ductility: In its nature, however, it approaches the nearest to Gold.

The greatest quantity of it now a-days, is found in *Friuli* in *Italy*, where it is produc'd, 1. In a *Matrix*, hard like Stone, and of the colour of *Crocus Metallorum*. 2. In a soft Earth, which yields fluid Mercury. 3. In Stones of a globular figure. 4. In *Cinnabar*.

It is separated from its *Matrix* by distillation; or by sifting it, and washing it with Water. That which in the Mines is found spontaneously fluid, without the assistance of Fire, is called *Virgin Mercury*.

h. 1. Comes next in weight to Mercury.

Marks of
Lead.

2. It is found by every sort of trial to be exceeding simple.
3. It fumes in the Fire, and if kept melted a good while runs through most Vessels; nor is it of a fixed nature.
4. It is the softest and least elastic of all Metal; not sonorous; easily ductile.
5. Next to Tin it melts with the least degree of Fire long before it is red hot, throws out a Calx, and quickly turns into Glass, which put again into fusion no vessel in the Fire is able to contain. Any light things thrown into it, it casts up to the Surface. It vitrifies with impure Metals, and carries them with it out of the concave Surface of the Test, leaving Gold and Silver only, pure from all the others. The rest it either dissipates in Fumes, or draws with it through the pores of the Test. After fusion, it presently hardens again into a solid Mass, but not so quick as Tin.

6. It dissolves in *Aq. Fortis*, but not in *Aq. Regia*, and yields a sweet salt.

There is abundance of it in a great many Mines in *Europe*; the consumption of it is very great; and though it is cheap, it is a Metal vastly useful, as well

* This seems to contradict what was asserted before of Gold; and indeed it does so, except you understand it in an Alchemistical sense, which was what our Author design'd. For these Gentlemen tell us, that Mercury is the *Basis* of all Metals; and that Gold itself is compounded of Mercury and a fixing Sulphur, which consequently therefore must be less simple than pure Mercury, which they unanimously agree to be perfectly homogeneous.

as of a wonderful nature. In the Fables of the Mythologists, it is called the Origin and Father of all other Metals, and at the same time their Destroyer.

7. Its Ore is heavy, shining, and of a lead colour, and is half Lead; 'tis sometimes too, white, red, or yellow; but these are not so rich. It has frequently somewhat of Silver in it, which is apt to impose upon the Assayers, if they are not aware of it.

Marks of
Silver.

- ♂ 1. Is the next heavy Metal to Lead.
2. This also is simple, nor shews the least dissimilarity in its parts by any common trials.
3. It is so fixed in the Fire, that it hardly diminishes, if it is perfectly pure. After keeping it fused in the Eye of a Glass-house Furnace for the space of two months it is said to have lost scarce $\frac{1}{12}$ of its weight; and it is a question whether that Silver was absolutely pure.
4. It is malleable, and may be drawn into exceeding fine Wire.
5. As soon as ever it is grown red hot, it melts.
6. It is dissolvable in *Aq. Fortis* alone.
7. It may be purified with Lead, being able to resist it.
8. With Antimony it runs into *Scoriæ*, and becomes volatile.

It is found in a great many places, in various, and very different beds, and has commonly a small quantity of Gold interspersed with it. There is often in the Ore a corrosive, bituminous Sulphur, which renders the Silver volatile, and carries it off; or changes it into glassy *Scoriæ*, much to the disadvantage of the Owners. It yields neither to Salt, nor Lead, and therefore they manage it with Mercury; and this they do by mixing it with the Ore after it has been torrifed and reduced to powder, and then in rubbing them together for a considerable time, by which means the Silver unites with the Mercury, and this they afterwards draw off by distillation. *Phil. Trans.* 589, 590, 591.

Marks of
Copper.

- ♀ 1. Is the next ponderous Metal to Silver.
2. It is simple likewise, though less so than the preceding.
3. In the Fire it is pretty fixed, but fumes, and discovers some volatile parts.
4. It is ductile under the hammer, and may be drawn out into very small Wire; it is very elastic too, and of a sharp sound.
5. It grows red hot before it melts, and requires the greatest degree of Fire to fuse it, next to Iron. When it is in fusion it wonderfully resists Water, and is agitated by it in a most violent manner, and hence if any Water happens to come to this Metal whilst it is melted, the event is exceedingly dangerous.
6. It is easily dissolved by any salt, and then becomes greenish, or blueish; but soon getting rid of its dissolvent, it grows of a dirty disagreeable colour, losing all its former beauty: Hence both in Air and Water it contracts a greenish mould, which is nothing but a collection of small Crystals.
7. With Lead and Antimony it readily runs into *Scoriæ*, or is changed into Glass; and then leaves the Test, either going off in fumes, or running through the pores of it.

Mines every where abound with it, when it adheres so firmly to its stony Ore, that it commonly passes fourteen Fires before it is pure. It has frequently Silver mixt with it, especially, in the black or light blue Ore; the yellow, green, and brown contain less: In its veins are very often found, green, blue, reddish

reddish and white Vitriols ; and very fine green and blue stones : So that there is no metallic fossil matter enriched with a greater variety of beautiful colours.

- 8 1. It too distinguishes itself by its weight.
2. It is less simple than the preceding, having manifest marks of a crude Sulphur, and a truly combustible matter, which may sometimes be raised into flame.
3. It is fixed indeed in the Fire, though not so much but that it fumes, throws out sparks like combustible Substances, and constantly loses of its weight.
4. It is ductile under the hammer, and may be drawn out into Wire, if you don't attempt it too fine ; for then it will split, or discover its brittleness : It is hard, and sonorous.
5. It grows red long before it melts, requiring the strongest Fire, and being melted with most difficulty of all Metals. When it is perfectly red hot, it will bear the contact of cold Water.
6. All Salts readily dissolve it, with which it changes of a red colour ; but it easily gets rid of its dissolvent, and then wastes into rusty *Scoriæ* : Hence it is scarce possible to preserve it from rusting.
7. Of all Metals, it is the most easily destroyed : with Lead, and Antimony it presently turns into *Scoriæ*.
8. It both attracts, and is attracted by the Loadstone.
9. It is endued with a medicinal vertue very beneficial to the Human Body, in which it may be nearly dissolved, and to which it seems to approach nearer in nature than any other Metal.

Properties of
Iron.

It is observed to be generated in all parts of the earth, dispersed through fat clayey earths, which being put into the Fire discover this Metal by their red colour. In the stony Ore it distinguishes itself by a rusty colour, or if the vein is extraordinary fine by a pale blue one ; nay, and often by its magnetic vertue. It is evidently contained in the native green Vitriol. It requires, however, the greatest degree of Fire to procure it pure from the Ore, as well as the assistance of certain proper materials, and a previous torrefaction in the Fire.

1. Of all Metals is the lightest.
2. It is much less simple than the former, emitting with a gentle Fire sulphureous fumes, which are easily separated from the metalline part, and are almost combustible.
3. Hence, it is much less durable in the Fire.
4. It is soft, easily bent, and ductile under the hammer, and may be drawn into Wire, but with much more difficulty than the former : It is not considerably sonorous, or elastic.
5. It melts much sooner than the other Metals, long before it is red hot, and in a degree of heat not much greater than that of boiling water ; but grows hard again immediately in the cold.
6. Whilst it is crude, and retains its natural Sulphur it is dissoluble only in *Aq. Regia* ; but if by Calcination it is purified from its Sulphur, even Vinegar will dissolve it ; and a little matter of the Solvent is sufficient.
7. It resists Lead and Antimony so strongly in the Cupel, that it cannot be forced out of it without great difficulty ; and not at all indeed, without the assistance of Copper.

Character of
Tin.

E

8. In

8. In many of its properties it comes near to Silver.

The Ore which produces it, is exceeding ponderous, though the Metal itself is but light. The Glebe it is found in is of a brown colour inclining to yellow, or, which is the richest, of a black one, smooth and shining, and sometimes not unlike the Iron Stone: It is contained likewise in a rocky substance very heavy and porous.

After the Ore has been burnt, pounded, and washed, it is melted, and separated from its Dross. The best sort of it is found in *Great Britain*, which yields vast quantities; and hence *Bochart* was led to conjecture that the word *Bretania* was derived from the *Syriac Barat Anac*, which signifies a field of Tin.

This History of Metals, which is undeniably true, furnishes us with the following observations.

The true principles of the transmutation of Metals.

1. That Metals are absolutely different from all other bodies hitherto known, whether natural, or artificial; as we find that the lightest Metal weighs more than twice as much, as the heaviest body of any other kind.
2. That they must therefore be vastly in the wrong, who pretend to convert any other body into Metal; for as the weights of bodies shew us exactly the quantity of matter they contain, the condensing them must be infinitely difficult, and scarcely to be effected without a creating power.
3. That the most certain rule of judging, how nearly pure Metals are alike in their intimate substance, is to be drawn from the nearness of their weights.
4. That there is no Metal therefore that comes so near to Gold, as Mercury, if you consider only their matter; for as to the other principle which gives to each its particular form, it must be quite of a different nature, and therefore does not enter into our present inquiry.
5. That the other properties of Metals, such as, fixity, colour, malleability, and simplicity, may possibly be more easily changed and produced.
6. That Gold consists of a most pure, simple matter, very like Mercury, fastly held together by another exceeding subtil, pure, and simple principle, which being intimately dispersed through the whole, firmly unites the Particles of the former both with itself, and with one another: These two principles are supposed to be Mercury and Sulphur.
7. That the other Metals are compounded of the same principles, but that they have likewise a mixture of another lighter substance in them, which in every particular Metal is different, and is called Earth; and hence they appear to be composed of three sorts of matter, to which in some of them, as a fourth, you may add a crude Sulphur.
8. That they may be resolved therefore into these their compounding Elements, which in different Metals, both in nature, and number, will be different.
9. That this may be effected, by Mercury, a resuscitating Salt, or Fire; by various methods, in various Metals.
10. That there is very little reason therefore for asserting that Metals are easily transmutable into one another, except you confine it to their mercurial part alone, their original Texture being first perfectly destroyed; and that hence no more Gold can possibly be procured from any other Metal, than in proportion to the quantity of Mercury which that metal contains.

11. That

11. That it does not in reality appear, that there ever has been any Metal produced by Art, different from the six which have been mentioned; notwithstanding what *Van Helmont* boldly asserts of Mercury fixed by his *Alcabeft*.
12. A person therefore acquainted with what has been said of Metals will not easily be imposed upon by empty promises, and specious appearances; since none of these deceitful Pretenders could ever truly counterfeit the weight of Gold, or produce a body that would be so fixed in the Fire as Gold or Silver: by these two properties then we shall be always secure against their cheats, or plausible reasonings, and be able to discover their spurious, artificial Metals; which brought to the anvil too generally want malleability.
13. That the six Metals, if they are melted in pure vessels, have all the very same appearance, and perfectly resemble Mercury, in colour, solidity, contraction of themselves into a spherical figure, attraction of their Particles, degree of fluidity, and mobility. Hence perhaps Mercury may be a Metal that requires the very least degree of heat to put it in fusion. Tin a Metal that won't run without a greater degree of fire; so that supposing the Air to have as much heat in it as is necessary to put Tin in fusion, then Tin would be Mercury, but would fume, and cast up a scum. Again, Lead would become Mercury, in a degree of heat still a little greater, but would throw out a scum too, and run through the vessels it was put into. A much stronger Fire still is necessary to reduce Gold and Silver to a state of fluidity, which would then be Mercury, and immutable. Copper requires yet a greater degree of heat to fuse it, and reduce it to Mercury, and then too it would be subject to change. And lastly, Iron which of all Metals runs in the Fire with the greatest difficulty, would then be fluid Mercury also, but as the former, would be likewise mutable.

Of S A L T S.

Salts, sometimes called concreted Juices, claim the next place in order to Metals; inasmuch as they are exceeding simple and enter into the composition of Semi-metals, and other Fossils. Fossil Salts.

By Salt, we mean a Fossil, which dissolves both in Fire and Water, and is of so simple a nature, that every single particle of it is similar to the whole, and impresses a taste upon the tongue. Its different sorts.

The natural Salts are, Sea Salt, *Sal Gem*, or fossil Salt, Fountain Salt, Nitre, Borax, native *Sal-Ammoniac*, Alum, and a Vague-acid of the pits. Fossil Salt, *Sal-Gem-mæ*.

Fossil Salt, the purer part of which is called *Sal Gem*, is found in different parts of the world, and is dug out of its pits perfectly pure, in vast quantities, and to prodigious depths.

Fountain Salt, is procured from running water, in which it is found dissolved, and when it is depurated, and inspissated, is exceedingly like Sea Salt. Fountain Salt.

Sea Salt, is dispersed throughout the Sea, and by simple evaporation, and purification is reduced into Chrystals. Sea Salt.

These three sorts of Salt, though they are different as to their manner of production, yet are found to be of the same nature; the same quantity of Water dis-

solves them all, viz. $3 \frac{1}{2}$ times their own weight; in our air they all spontaneously melt away; the Chrystals they form are nearly alike, being cubical, parallelopedal, or pyramidal, tho' one chrystallizes quicker, another slower; if they are put into *Aq. Fortis* they produce a *Menstruum* that will dissolve Gold; if they are urged by Fire they all yield an acid spirit, of the same nature; when they are dissolved in moist air, they leave a great deal of earth, and a fat, sharp, astringent liquor; they crackle in the Fire, which, if it is strong, will melt them; and then, if they are very pure, they will remain fixed in it a great while without undergoing any alteration; they yield no spirit, and but very little water; no Alkali can be procured from them; nor are they susceptible of putrefaction.

Nitre.

Modern Nitre, or Salt-petre, whose chrystals are octogonal prisms, is a semi-fossil extracted from an acrid, nitrous earth: it is put into fusion by a moderate Fire; scarce any water exhales from it, and 'tis pretty fixed: when it is melted it deflagrates with any inflammable substance: it dissolves in $6 \frac{1}{3}$ times its weight of water.

Nitrous earth, or stone, owes its vertues to the excrements of animals, or their putrified carcasses (those especially, whose food has nothing of Sea Salt in it, as birds in particular,) when the ashes of burnt vegetables, and quick lime happen to be mixt with them: and the nitrous matter being thus produced, is diluted with a great deal of water, filtered through sand, and then formed into chrystals with octogonal bases.

Nitre is generated from a fat alkaline earth, and air. *Hofm. de Est. Aq. Min. T. II. p. 42.*

Borax.

The third Salt, is Borax, or *Chrysocola*, which is a fossil of various figures, requiring more than 20 times its weight of water, with a great degree of heat, to dissolve it; its taste is bitterish, but with a sort of sweetness at its going off; it melts very easily in the Fire, and then runs off in a rising froth, by which means a great deal of water is separated from it, whilst the remainder subsides into a beautiful kind of glass: It very much forwards the fusion of bodies that are mixt with it; and hence is of great service in soldering of Metals, Gold in particular.

Fossil Sal
Ammoniac.

Next in order comes *Sal Ammoniac*, or *Sal Arenarius*, which is produced in the most scorching parts of *Lybia*. The *Sal Cyrenaicus* of the ancients, which was in such great abundance about the temple of *Jupiter Ammon*, appears by *Pliny's* description of the best sort of it, to have been exceedingly like the *Sal Ammoniac* of the moderns. The burning mountains too in different parts of the world cast out this sort of Salt; of which that from *Vesuvius* even to this time is esteemed the best.

And the
modern fac-
titious.

It ought, therefore, to be referred to the class of fossils; though that indeed which is brought to us now a-days from *Egypt*, is supposed to be an animal production. In reality, does it not every where owe its origin to foot?

An acid fos-
sil Salt.

The fifth of the simple fossil Salts, is an acid, vague, volatile, liquid one, dispersed perhaps every where throughout the Mines: This being united with a fossil Oil, as the *Petroleum*, *Oleum terræ*, and the like, may possibly produce the different sorts of native fossil pellucid Sulphurs, called quick Sulphurs; as well as those which are found united with the Semi-metals, Cinnabar, Antimony, and other Fossils; and that both the fluid and solid: with Metals it produces

produces the various sorts of Vitriol; with earths abounding with Lime the different Alums; and lastly from the *pyrites*, which is the *matrix* of Vitriol, calcined in a quick Fire, it gives us the common Sulphur.

Is not this exceeding like that acid, which fumes from the blue flame of burning Sulphur, and is so suffocating and destructive to all animals? certainly its analysis, and resolution would lead one to think so.

And for these reasons perhaps it may not improperly be looked upon as a male Salt, which seems to impregnate the female Salts, and earths.

The sixth, and last is Alum, which is a true Fossil, procured either from a Alum stone that lies deep in the earth, which is hard, capable of being cleft, abounds with Bitumen and Sulphur, and is easily inflammable; or from a bituminous combustible earth, which in burning sends forth a sulphureous stench, that is very pernicious: This matter exposed to the air for the space of a month, moulders into a powder, from which Alum may be then produced, though the earth was unfit for it before.

If the stony substance is first exposed to the air, and then burnt, it will flame, and by its smell make it evidently appear it contains Sulphur.

The matter therefore being thus prepared, by the air only, if from the earth; but both by air and fire, if from the stone; it is dissolved in water, and then by the addition of a fixt, or volatile Alkali is precipitated with an effervescence; by which action the predominant acid being united with the Alkali produces a new Salt; which therefore owes its being to the air, the Alkali, and the Fossil.

The precipitated matter being then separated from its *Lixivium*, and dissolved in boiling water, is inspissated in a leaden vessel and put into a tub, where after some time it shoots into white, or reddish octogonal chrystals; of a sweet roughish taste; not easily dissoluble in the air; and that require fourteen times their weight of water to dissolve them.

The acid of this Salt when it is forced out by the Fire, is like the acid vapour collected from burning Sulphur, in almost every property.

After the acid is drawn off, the *faeces* that are left behind, yield a large quantity of a light, subtil earth, which very much resembles bole.

If it is burnt with triple its weight of charcoal, it gives the Phosphorus of *Homborg*; and hence it seems to possess a particular power of exciting fire with the assistance of air.

In the formation therefore of fossil Salts, nature seems to have made use of a threefold acid; spirit of Salt; spirit of Nitre; and spirit of Sulphur; and that, in a very large quantity: with which she has likewise joined, a small portion of Sulphur; as well as water, and earth.

Of S U L P H U R.

The third class of Fossils, is composed principally of Sulphurs, though some Sulphur other bodies are referred thither likewise.

Sulphur, is a fossil body; hard in the cold, and easily reducible to powder; but in a moderate degree of heat running like melted wax; it may be raised by fire in a close vessel, intirely, and without any alteration; but if any air comes to it whilst it is melted, it will burn all away, with a blue flame, and a volatil fume, that is fatal to animals.

True Sulphur, as such, is found but seldom in the earth, and but in small Quick quantities;

quantities ; and there, it is either pellucid and yellow, like Amber ; or pellucid and red, like a ruby, which is called Sulphur of Gold ; or opaque, yellow, grey, or of various colours, and these go by the name of *Sulphur vivum*, or Virgin Sulphur.

Common.

As to all the common Sulphur, which is sold in *Europe*, it is an artificial production, from the stone called *Pyrites* ; which nevertheless seems scarce to contain any naturally in it ; for no Sulphur rises from its *matrix* when urged by fire but an acid liquor like the acid of Vitriol.

This fossil matter however, if it is first prepared by Art, will afterwards by the assistance of fire afford a true Sulphur.

And this is effected by keeping the *Pyrites* for a considerable time in a strong fire ; where it softens, calcines, cleaves asunder, and discharges a perfect Sulphur.

But if there is true Sulphur actually existing in the *matrix*, then it is only melted down in crucibles, which are placed in such a sloping manner, that the Sulphur as it melts may distill into proper receivers.

Now the vein of the *matrix* both of Sulphur and Vitriol, is the same.

And hence, Sulphur is artificially made too, from Oil of Vitriol, Alum, or Sulphur *per campanam*, united with some pinguious vegetable substance.

Sulphur therefore has not improperly been called by the Artists, resin of earth.

When it has been purified by repeated fusions, from what rises to the top, or subsides to the bottom, it is poured into cylindrical wooden moulds, and is then the common Sulphur of the shops ; of which that of a lemon colour is esteemed the best.

Auripigmentum, or Orpiment.

Orpiment, in a great many of its properties very much resembles Sulphur ; it is friable ; fusible ; easily inflammable ; and then becomes hurtful from its disagreeable sulphureous smell, not from a volatile acid ; it is unactive, and innocent, and does not do that harm to the bodies of animals, as is commonly reported ; it grows red by fusion, and then yields a volatile matter of an emetic quality. This improperly goes by the name of yellow Arsenic

This native Orpiment melted in a close vessel is converted into a brittle mass, easily reducible to powder ; of a beautiful bright colour, like that of red Lead ; not very acrid ; nor of a very poisonous quality ; and yet both the ancients and moderns have called it Realgar, red Arsenic, and Sandarach ; and by this confusion of names have given occasion to some errors, that have happened in the Art.

White Arsenic of the moderns.

As for the white, chrystalline, pulverizable Arsenic, which is such a strong poison, it is an artificial production of the moderns, not having been known above two hundred years ; and it is made in the preparation of Smalt from Cobalt, Flints, and a fixed Alkali : for whilst these materials are melting together, the flowers that rise in the operation are a crude white Arsenic ; which being afterwards put in fusion, with a strong fire, and in a close vessel, is the common white Arsenic of the shops. See *Kunkel, De Arte Vitriaria*, where he has given a cut of the furnace made use of for this purpose.

Modern yellow Arsenic.

If the Arsenical Flowers of Cobalt are melted down with a tenth part of common Sulphur, you have then a poisonous yellow Arsenic, which ought carefully to be distinguish'd from Orpiment, as it is a most insuperable poison.

But if you melt the same Flowers with a fifth part of Sulphur, you produce the

the poisonous red Arsenic of the Moderns, which we must take care too not to confound with the Arsenic of the Ancients, for the reasons already mentioned.

Hence therefore the modern Arsenic does not so much resemble Sulphur, but seems to possess a very particular quality peculiar to itself, and destructive to all animals: This the Ancients were not acquainted with; nor is it easily reducible to any *Genus* of known bodies: As it comes nearer, however, to Sulphur, than any thing else, it is referr'd thither. See by all means on this head, *Hofm. Obs. Phys. Chem.*

Those pinguious substances likewise, which are the natural production of the Earth, should be look'd upon as bodies that are near akin to Sulphur, inasmuch, as they contribute the greatest part towards its composition. Of this kind is *Petroleum*, whose name speaks both its nature and origin: This is expressed from melted *Bitumen*; drips down the rocks; is exceeding thin; very light; of a fetid smell, and perfectly inflammable; often swims at the top of fountains, and is so like a distill'd Oil in most of its properties, that many persons will have it to be prepared by a subterraneous Fire. This Liquid is often called *Bitumen*, tho' they differ in colour, smell, and transparency. Fossil liquid Sulphurs.

Naphttha very much resembles *Petroleum*, but is more diluted, thinner, and brighter; it is vastly inflammable; continues burning a long time, when it is once set on fire; nor can it be easily extinguish'd: It is the *Floss*, or most pure and subtil part of *Bitumen*. Naphttha.

The *Bitumen* of the *Latins*, and *Asphaltum* of the *Greeks*, is thicker than *Naphttha*, and *Petroleum*; very tenacious; but in its first form nevertheless, somewhat fluid; so long as it remains in its natural state, it generally swims upon Water; it burns exceedingly furious. Bitumens.

This however being concocted, and dried by the heat of the Sun or Fire, or even by time itself, grows harder than Pitch; shining; ponderous; melts again in the Fire; will mix with any thing oily; is inflammable; and is then called, *Pix Judæa* or *Bitumen Judaicum*. Jews Pitch.

Pissapphaltum, as its name indicates, is of a middle nature, between Pitch and *Bitumen*; black; earthy; fetid, and seems only in degree to differ from the former: And possibly it may be, either an artificial, or natural production, from a mixture of various fat substances with melted *Bitumen*. Pissapphaltum.

This, when it is brought by nature to such perfection, as to become black; hard; earthy; capable of being cleft; smooth; fetid, and shining; it then seems to form the Jet-stone, or the *Lapis Thracius* of *Nicander*. Jet.

And again, if the pinguious parts of *Bitumen* happen to be mix'd and concreted with a rocky Glebe, or perhaps the *Scoriæ* of Metals, and forms a hard Mass; disposed in flakes or *lamina*; black; fat; cleavable, and inflammable; it then seems to produce the *Lithanthrax*, or fossil Coal, which must also be referr'd hither. Lithanthrax.

Ambarum, *Carabe*, *Succinum*, *Electorum*, Amber, belongs likewise to this class, which seems to owe its origin to a bituminous Sulphur; it both burns and melts in the Fire; it consists of an acid Salt, both solid and fluid, and a fossil Oil, which very much resembles *Petroleum*: Of this there are different sorts, as the white, lemon-coloured, yellow; black, and red. Amber.

The *Oleum Terræ* of the *Indies*, described by *Neubovius*, is seldom brought to us, being secured by the Princes in *Asia*; whether therefore this is a species of *Petroleum*, or *Naphttha*, I can't pretend to determine. Oil of Earth. As

As for the common Oil which comes from the *Indies* under that name, I am inform'd, by a Gentleman perfectly acquainted with the affair, that it is nothing else but an expressed Oil from the Caco-nut, mix'd up with some medicated Earths, and therefore belongs entirely to the class of Vegetables. Is not what goes by the name of *Barbadoes* Oil, prepared too in the same manner?

Of STONES.

Stone.

A Stone is a hard Fossil; not ductile; brittle; fixed in the Fire; scarcely fusible by any Fire; nor dissoluble in Water.

By which marks it is perfectly distinguished from Metal, Salt, and Sulphur.

Stones may conveniently enough be divided into pellucid; semi-pellucid; and opaque.

Gems.

Pellucid Stones may not improperly be called Gems, and so reduced to a *Genus* under that name.

These, in all their properties, approach very near to Glass; tho' they exceed it in hardness, solidity, simplicity, and very difficult fusion in the Fire, and seem to consist of a most perfect fine Salt and Earth, intimately united together; as we see Ashes, which have a Salt in them, when melted in the Fire, run into Glass.

A transparent Gem, without the least mixture of colour, as nearly as possible resembles Glass.

The white, bright, pure Chrystal, that cuts Glass, is scarcely fusible in the Fire, is much like Glass, and is form'd by a certain particular concurrence and application of *Radii* and *Strata*, seems to claim the first place in this class.

The true Diamond, is an exceeding pure Gem; vastly hard; remarkably solid; perfectly transparent; very refulgent; of great value; coming nearest to the Chrystal which (perhaps of all Gems is the most perfect) and excelling every other body in its particular reflection of the rays of light. This will continue a very considerable time in a strong Fire, without being destroy'd.

The most pure of the Bastard-Diamonds, have somewhat of the nature of the true ones; but are softer; less solid, and less pellucid.

The white Saphir, is akin to the Diamond.

As likewise, the Oriental Amethyst, when it is either naturally or artificially colourless.

The Topaz too, and Chrysolite, when perfectly free from colour, are nearly of the nature of Diamonds.

The true *Astroites*, which by a certain law reflects the solar rays from one common point, belongs likewise to the class of Pellucids.

The exceeding hardness, solidity, and perfect transparency of these Gems, make them vastly esteem'd.

Gems that are pellucid, but enrich'd too with some beautiful colour, seem to consist of the same matter with the former, but to have receiv'd likewise in their first formation, a tinge from some metalline in particular, or other fix'd fossil mixture, which by this means becomes intimately united with them: This the resemblance of their colours to the tinctures of Metals, and the artificial manner of making them, sufficiently evinces. To this class are referr'd chiefly,

The Amethyst, Beryl, Carbuncle, Chrysolite, Granate, Jacinth, Opal, Ruby,

by, Sapphire, Emerald, and Topaz : Nor should, I think, the colour'd Chryfals be left out.

The exceeding great value of these too arises from their vast hardness, remarkable solidity, pure simplicity, and beautiful brightness of colour.

There is another sort likewise of a middle nature, betwixt Gems and opaque Stones, which may therefore be called the Semi-opaque, and seem of a more compound nature than the former: The chief of these are the following, which differ in degree of opacity.

Agat. Sand. One sort of the *Astroites*. The true *Lapis Armenius*. The Toad-stone. The Cornelian. The Chalcedony. The *Heliotropium*, or true oriental Jasper. Jasper. The true *Lapis Lazuli*. The *Lapis Nephriticus*. The *Leucophthalmus*. The *Malachites*. The Onyx. The *Sardius*. The *Sardonyx*. The *Selinites*, and the Turquoise.

These too, are esteemed in proportion to their solidity, hardness, transparency, and the beauty of their colours.

The opaque Stones are the Eagle-stone. Alabaster. The *Amianthus*. The *Belenites*. *Gypsum*. The *Hæmatites*. Jasper. The *Lapis Judaicus*. The Touch-stone. The Load-stone. White, Grey, Yellow, Brown, Black, Porphyrian, Red, and Green Marble. The *Ophites*. The *Osteocolla*, Pumice-stone, Lime-stone, Whet-stone, Mill-stone. Flint. The *Specularis*. Emeril, Talc, and *Tripoli*.

These last are of very different natures; some of them vitrifying in the Fire, and others turning into an exceeding fix'd calx.

Last of all come the fossil, native Earths, which for the most part are of a *Earths* pinguious nature, and may with Water be work'd into a paste, whence they are commonly called Boles; but are not dissoluble, either in Water, or Fire. These are, Clay. The *Axungia Terræ*, or *Lunæ*. The *Cimolia*. Fuller's-earth. The White Bole. The *Armenian*, *Cbian*, *Etrurian*, *Lemnian*, Yellow, *Mal-tan*, Red. Ruddle. The *Samian*. The *Selinusian*. All the seald Earths, and the *Tocaviensis*.

There are some likewise of a poorer sort; as White Chalk. Marl, and Ochre.

Of SEMI-METALS.

The seventh class of Fossils, comprehends those bodies, which evidently contain some true Metal in them; or at least something so like it, that it may almost be look'd upon as Metal, and indeed, has been rank'd under that denomination by very good Authors. These, if they are of the more simple sort, may properly enough be reduced to three species.

1. Semi-Metals, that consist of a true Metal, and a Salt, united together.

And these are generally called *Atramenta Sutoria*, *Calcantha*, Vitriols.

These now are observ'd to be of two sorts; one which owes its origin to Iron, and is of a green colour; the other produced from Copper, of a beautiful blue. As for the other Metals, they are scarce ever found in the Mines, in a state of solution; their dissolving *Menstrua*, the Acids of Nitre, and Spirit of Sea Salt, being never discovered there: And hence, you will hardly ever meet with the solutions of Gold, Silver, Mercury, Lead, or Tin, either fluid or concreted; at least in but a very small quantity.

Lead, it is true, may be dissolv'd by a weak Acid; but then the chemical Art informs us, how very difficult it is, to reduce it into Chrystals, as it presently gets rid of its acid, and turns into a powder, which goes by the name of Cerufs: And this is likewise true of Tin.

Every fossil Vitriol therefore that has hitherto been dug out of the Earth, owes its origin solely to Iron and Copper.

We don't deny, however, but that it is possible, that some particles of other Metals may be mix'd with Vitriol in a state of fluidity, and by this means become concreted with it; but that any other than Iron and Copper, has ever been actually dissolv'd by it, and so, equably and intimately united with it, wants hitherto confirmation.

This dissolvent, both of Iron and Copper, is that Acid, which when drawn off by a very strong Fire, goes by the name of the Spirit, or Oil of Vitriol; and is the very same that is separated by art from Alum, or collected from the fumes of burning Sulphur.

And indeed, both Vitriol and Sulphur, are generated, grow, and are procured from the same *Matrix*, viz. the Pyrites; which after it is dug, is exposed to the Air, freed from its great quantity of Sulphur, reduc'd to Powder, dissolv'd in Water, and then suffer'd to form its Chrystals about Sticks that are plac'd in it for that purpose.

It may readily likewise be produc'd from the *Misy* of the Ancients, by simple Solution, and Chrystallization.

Hence therefore Vitriol is of five sorts. 1. The green; which owes its origin intirely to Iron, and Spirit of Sulphur: This is extoll'd for its medicinal virtues, and is the best for making Ink. 2. The bluish, which consists of a great deal of Iron, and a little Copper, dissolv'd by Spirit of Sulphur; for if you make a solution of it with Water, and then immerge plates of Iron into it, you will find them ting'd of a Copper colour; which makes it evident, that it contains a small mixture of that Metal. 3. The white, which seems to be very little different from the green, and possibly owes its particular nature, only to a greater degree of Heat, as we see in the factitious; for in every respect but its colour, it perfectly resembles it. 4. The *Chalcites*, true *Calcanthum*, or red Vitriol; and this too is exceedingly like the green, and may be resolv'd into the same principles; it seems compounded chiefly of Iron, and an acid of Sulphur, with, perhaps, a little mixture of Copper. 5. The *Cyprian*, or *Hungarian*, which is perfectly blue, and consists purely of Copper, and the same Acid of Sulphur. The *Sory* too, which is an exceeding acrid, hard, coarse, fat glebe, seems to be nothing but a grey or black concreted juice of Vitriol; and hence will produce a Vitriol, by the help of Water alone.

The *Melenteria* also, which is a grey, or black glebe, of a caustic quality, is of the same vein, nature, and family.

These all therefore, for their *Basis*, have Iron or Copper; for their dissolving *Menstruum*, an acid of Sulphur; whilst Water, which dilutes the acid, and disposes in a proper manner the particles of the Metal, gives them their figure and transparency: And hence, according to the different proportion of these three principles, may all the variety of them, deliver'd by the Ancients, be understood.

The native Vitriols therefore consist of Water; an acid Spirit of Sulphur; and

and the Metals, Iron and Copper, mix'd in a certain proportion, and concreted into one mass.

2. Other Semi-metals are compounded of Sulphur and Metal, intimately united together: Of these the following are the chief.

Native Cinnabar, or the *Minium* of the Ancients, which is a composition of Sulphur and Mercury, fused and brought into union in the Mines, by some subterraneous Fire: This the artificial Cinnabar is a proof of. It is easily resolvable into true Sulphur and Mercury; from whence it appears, that there is in reality abundance of Sulphur in the Mines, which owes its production intirely to nature.

Sulphureous
Semi-me-
tals.
Cinnabar.

The *Stibium* of the Ancients, the *stibum* of the Greeks, and Antimony of the Moderns, consists of a true fossil Sulphur, and another matter exceedingly resembling Metal; which, could it be render'd malleable, would be truly of a metalline nature, and be a seventh ductile Metal: But it is universally acknowledged, that this manner of purifying Antimony, has not yet been discover'd. Mr. Boyle however, asserts, that by some secret methods, true fluid Mercury has been produc'd from it: And indeed, every modern dabler in the Art pretends to it. It is fusible in the Fire, and makes other Fossils melt with a great deal more ease than they would without it.

Antimony.

Being brittle too itself, if it is mix'd with bodies that were ductile before, it will render them brittle.

And again, if it is put among bodies that are fix'd in the Fire, by its volatile Disposition, it will make them volatile also; scarce any one being perfectly excepted.

It very much too increases the brightness and beauty of Gold.

And lastly, in its nature it seems nearly to approach to white Arsenic.

Bismuthum, *Bisemutum*, Bismuth, is akin to Antimony, and consists of *lamina*, or flakes disposed one upon another; in its white, bright colour, it resembles Silver; it is harder, and less friable than the former; nor ductile under the hammer; has evident marks of Sulphur in it; and by the action of an acid upon it, lets fall a bituminous matter; it is less fixed in the Fire than Metals; and being mix'd with them, renders them more volatile and friable.

Bismuth.

Zinetum, Zinc is very much like the former, but less friable.

Zinc.

3. To this class of Semi-metals, may be referr'd all fossil, chrystalline, stony, or earthy bodies, which have a mixture of true Metal in their composition; of which sort some are found interspersed thro' the veins of most Metals.

This class therefore will include a very large number of bodies, out of which we shall only take notice of the following, which are the most remarkable.

The *Lapis Armenus*, *Cyaneus*, *Lazulus*, which is a smooth blue Stone, spangled with golden stars, and is said to contain a great deal of Gold.

Lapis Lazuli.

The *Lapis Hæmatites*, which abounds with a metalline substance; is exceedingly like Iron; and sublimed with *Sal-Ammoniac*, smells very strong of an aromatic Sulphur, for which reason some persons have called it *Aroph*, or *Arôma Philosophorum*.

Lapis Hæmatites.

The Loadstone, which has a particular tendency towards Iron, is almost of the same colour, and very much of the same nature.

The Magnet.

Ochre too, perhaps, may come into this tribe, as it appears to be a precipitation of Iron from chalybeate Waters.

Ochre.

From what has been said then upon this head, we may be able to form a just notion of the principles of Fossils; for upon examination it appears, that they may be reduc'd chiefly to Mercury, Metallic Sulphurs, Salt, Combustible Sulphurs, Earth, and Stones; tho' it must be confess'd, that these are vastly different, if they come to be nicely examined in particular Fossils. We learn farther too, that they contain an acid Salt in them, which is exceedingly active; besides which, they are acted upon by no other moving power, but Fire.

Of VEGETABLES.

The next kind of bodies that come under the consideration of Chemistry, are Vegetables, or as they are commonly called, Plants.

A Plant in general.

By a Plant now we mean a Hydraulic body, which contains different sorts of juices, in various vessels, and by some external part of it, so adheres to another body, that through this part it is capable of drawing in the matter, both of its growth and nourishment.

By this definition then, we evidently see the difference between a Plant, and the fossil substances afore described; and that whether you consider the variety of its solid parts; the different nature of its juices; or its whole composition together, as made up, both of solids, and fluids.

The Root.

And again, the external part called the Root, which attracts its nourishment from the body to which it is join'd, sufficiently distinguishes it from every Animal we are hitherto acquainted with.

The solid parts of Vegetables are a mere Earth, so fastly united together by a tenacious, oily, glutinous matter, that they cannot be separated from one another, without the assistance of an open, flaming Fire.

The vessels of Plants, as they are exceedingly different in their make and position, so they are also in their contents and virtues.

The business of the Root, is to fasten the Plant to its soil, or (in which sense only we have here to consider it) to take in its nourishment; and hence sometimes, its whole surface is observed to perform this office; as we see evidently in the Mushroom and Puff.

For this purpose therefore, it consists of an infinite number of apertures of vessels dispersed through its whole surface, by which the nutritious juice is suck'd in, and so receiv'd into its vessels, and by these convey'd through every part of the Plant. These vessels may not improperly be compared to the Mesenteric Lacteals, and other absorbent veins in Animals.

This juice, however, at its first reception into Plants, is not of the same nature with the Plants themselves, but crude, and of the nature of the bodies, by which they are sustain'd and nourished. These now in general, seem to be either Earth or Water; which upon examination we shall find, receive again, sooner or later, the very same matter which the Plants had before drawn from them: For whether they are produc'd in the Waters, or on the Earth, when they come to die, they drop again into the same Waters, or Earth; or else are dispersed into the Air, whence, in form of Dew, Mist, Snow, Hail, Hoarfrost, and Rain, they descend again into the bosom of the Earth. Hence then it appears, that the Earth is a Chaos, of past, present, and future bodies, from which all receive their birth, and to which all do certainly return again.

The Water, Spirits, Oils, Salts, and whatever lies hid in the bowels of the Earth,

Earth, are put into motion, by subterraneous, artificial, and celestial Fire ; by which means they are rendered capable of being mixed with Water, and consequently of being applied to the roots of Vegetables, that are inserted into the Earth.

The Water again, of the Sea, Rivers, and Lakes, receives, as the Earth does, the bodies that float about in the Air ; and contains besides a variety of other matter, which it washes off from the Earth.

These crude Juices circulate through Vegetables in the greatest quantity, and with the swiftest motion in the Spring-season; and are then particularly observed to be watery, thin, and inclining to the acid ; as the liquor, that upon incision distils from the Birch, Walnut-tree, or Vine in the month of *March* demonstrates.

Afterwards however, as they are propelled through the various organs of the Plant, from the make of the Plant itself, from the effects they have impressed upon them by the Fire in the Earth and Heavens, from the changes of Moisture, Drought, Cold, and Heat, and lastly from the vicissitude of day and night, and the various seasons of the year, they are by degrees concocted, and made more perfect, and in particular parts of the Plant putting on different natures, become the proper Juices of the Plant.

The Leaves from the make, number, and fineness of their vessels, receive The Leaves. the most subtil of the Juices, and in a very large Surface expose them almost naked to the Air, which various causes renders very active ; here therefore they undergo very great alterations, and being perfected according to their particular natures are returned back again to the Plant ; the Leaves performing the same office in Vegetables, as the lungs do in Animals, as we learn from the elegant Observations of *Malpighi*.

The Juices that properly belong to the Leaves themselves, are the honey Dew that is spread over them in summer nights, a wax that oozes out of them, Manna, and the *Thereniabin* of the *Arabians*, which being put into motion and concocted by the heat of the Sun, are condensed by the Cold of the succeeding night, and so may be gathered from their Surface.

Afterwards the Cups, *Petala*, or Leaves, *Stamina*, and *Apices* of the Flowers, The flowers. bring the Juices thus prepared by the Leaves to greater perfection, and impress upon them, more certainly, that distinguishing character, which is peculiar to the Plant; as well as fit them for producing, preserving, and nourishing a new Embryo: this certainly, the affinity between the Leaves and Flowers, their near situation, the origin of the Buds, and the make of the Flowers, induce us to believe.

Here is generated that fragrant, reviving, almost vital *Aura*, that Flowers in their perfection so delightfully breath forth ; which, probably, by its prolific odour may be grateful to the Embryo: this is certain, that it is a very pure, and most excellent liquor, and if it is mixed with any thing else, loses it former beauty and excellence.

In the Flowers too is produced true honey, which oozes out into receptacles that provident nature has joined to the bottoms of the Leaves: this the Bees suck up, convey into their little bags, distil into their combs, and then secure with wax.

On the *Apices* of the *Stamina*, and on the *petala* there is observed likewise a wax,

wax, which the Bees scrape off with their rough feet, roll up into balls, dispose under the hinder part of their bodies, and so carry to their hives, in order to form and close up their combs.

The Seed.

The fruit, is the repository of the Seed, and its contents. The Seed, is the Embryo of the Plant, with a uterine *placenta*, or one, two, or more Cotyledons, to which the Embryo is fastened by an umbilical cord. The Cotyledons for the most part abound with a Balsam disposed in proper cells; and this seems to be Oil brought to its greatest perfection whilst it remains humid, and then lodged in these repositories. One part of the composition of this Balsam is oily, and tenacious, and serves to defend the Embryo from any extraneous moisture, and by its viscosity, to entangle and retain that fine, pure, volatile spirit, which is the ultimate production of the Plant: This the Alchemists have stiled, the *Spiritus Reſtor*, the inhabitant of Sulphur, the *Archæus*, and the servant of nature.

This Oil is never observed to enter into the vessels of the Embryo, which are too fine to admit so thick a fluid. The spirit however being quickened by an active power may possibly breath a vital principle into the Juices that nourish the Embryo, and stamp upon it the character that distinguishes the family; after which, every thing is changed into the proper nature of that particular plant. That this spirit now, is truly the efficacious part, is evident, for when that is gone off, the Oil that remains is quite vapid and unactive. 'Tis this that gives Plants their fragrant smell, and peculiar tastes; nor do their particular colours a little depend upon it. This Spirit *Ijaac Hollandus* called the *Quinta Essentia*, or quintessence of Plants.

Again, as the dry, brittle, fibres of Vegetables, require something to soften them, that they may bend easily without danger of breaking, they are provided with another sort of Oil running in its proper vessels by the sides of the woody Filaments; this may be discerned to drop from the middle of the wood, when it is heated, and by warmth, or length of time, is easily changed into a Balsam, and Refin.

The Bark.

This Oil, which is much less volatile than the other Juices, being concocted by the heat of Summer, is carried into the Bark, which like the *Membrana adiposa* of Animals is furnished with proper cells for its reception; in these receptacles it is first detained, and collected by the Cold of Autumn, that by thus forming a pinguious covering, it may secure the whole body of the Vegetable, from the injuries of Frost and Rain during the Winter Season. This always contains in it an acid spirit; which is a preservative against putrefaction. In this Oil of the Bark consists intirely the value of some of the *Asiatic* and *Indian* Plants; as we see in the Cinnamon of *Asia*, in the Bark of whole trunk and branches resides that choice Oil, which is so vastly valuable; whilst the Bark of the root affords us that wonderfully medicinal Oil, called falsely from its smell, Oil of Camphire. The Sassafras too of *America*, from its Bark yields us a very beautiful Oil; as in this part lies the vertue of that noble Febrifuge the Quinquina of the same country. Nay and the vertues of the *European* medicinal Vegetables likewise are very often to be sought for in the Bark; witness, the Caper tree, the Tamarisk, and the Ash. In the winter time therefore, the Bark contains a large quantity of these Oils; whereas in the Spring, and Summer, the other Juices, which abound with a Water, Salt, and *Sapo*, proper to the

the whole Plant, pass through it in great abundance likewise; and hence at those times what it yields by a chemical Analysis, is very different from what is procured from it at others. The true Oil that belongs properly to the Bark, in its natural state is liquid, though by time and the heat of the Sun it will alter its consistence, and thicken into a Balsam. This again by longer time and a greater degree of Heat, being yet more inspissated, becomes a pinguious sort of a Resin; and by a continuation or increase of the same causes, acquires both the name, and nature of a Resin: This therefore owes its origin to the Oil, but is freed in a greater degree from its acid spirit; and it then melts, and burns all away in the Fire, may easily be dissolved and mixed with Oil, never suffers any solution from Water, hardens in the cold, and then loses its oily tenacity, and grows brittle. This Resin being yet further concocted, grows still harder, and then it is called Colophony. In this part of Vegetables, there is observed too, a thick tenacious Juice, which goes by the name of a Gum; this likewise will melt and consume in the fire, but in the cold, except it be extreme, retains its tenacity, and is intirely dissoluble in water. This oily Mucilage serves like a Pigment to cover over and defend the Buds of Trees, but will melt with a moist warmth, and easily runs from them, nor is ever so far hardened into a crust as to do any injury to the tender twigs.

About the bark of Plants, especially the umbelliferous kind, there is found still another Juice, which is a mixture of a Gum, and Resin, and therefore called a Gum-resin. Hence one part of it like a Gum easily melts in water; whilst the other is not at all affected by it, but in the manner of a Resin is readily dissolved and mixed with Oil: Of this sort are Aloes, Myrrh, Galbanum and a great many others.

And lastly every Plant contains in it a particular and peculiar Juice, which is produced by the whole efficacy of every part of the Plant successively applied to the crude Juices it is continually receiving. This therefore, when it is thus prepared, possesses the true nature and virtues of the Plant. This Juice can scarcely be reduced to any class of things yet known, and therefore must be looked upon as something perfectly singular.

If you examine the Leaf of the *Cbelidonium Majus* in a live, flourishing Plant, you may observe a parcel of Fibres arising from the Stalk, which unfold, and disperse themselves all over the Leaf. You may perceive too that these are every where sending off branches, which joining with one another compose a curious kind of net work, which almost fills up the whole *Area* of the Leaf. If you gently now prick any one of these little ramifications, there presently issues out a Juice of a golden colour, which has the true virtues of the *Cbelidonium*. In the same manner in the Spring you may procure from the common Aloe, a yellow, bitter Juice, which circulates through the Plant, in its proper vessels. The Poppy too upon making an incision distils a pure milky Opium. But here it is proper to observe, that these Juices, whilst thus simple, and separate, are vastly different from the mixture that arises from the confusion of all the Juices of the Plant together.

This then, Gentlemen, is what I thought proper to lay before you of the History of Plants, before I proceed to explain to you the methods in which they are managed by the chemical Art; nor do I see that more is necessary. For hence you may see how vain the endeavours of those Chemists must appear, who pretend

The proper Juice.

pretend by their Art to be able to exhibit to you those parts of Vegetables in which their particular virtues consist, without a mixture of any of the other parts with them. If they would do this, they must certainly make use of very different methods from what they do at present, or else they will take a great deal of pains to no valuable purpose; but on the contrary will lead us into mistakes. And indeed, with submission to some famous Authors, I must take the liberty to declare, That Distillation, Fermentation, Putrefaction, and Combustion, produce such considerable alterations, in the particular *crasis* or constitution of Plants, and consequently in the medicinal virtues which depend upon it, that we ought to use a great deal of caution, and circumspection, before we can pretend, from these Operations, to determine the true causes of those virtues: Not that on this account this noble Science ought by any means to be neglected; Nay, for this very reason it should be more vigorously cultivated: For by this Art alone we are instructed, what such, and such particular Operations are capable of producing from any given bodies; and this alone corrects the error of those who practise it: These two advantages therefore, sufficiently recommend it; and by these alone it is capable of leading us to an infinite number of beautiful Discoveries.

The *Spiritus Rector*; an exceeding fine Oil which is the true seat of this spirit; an acid Salt; a neutral Salt; a fixt, or volatile, alkaline Salt; an Oil mixt with a Salt in form of a *Sapo*; and a saponaceous Juice arising hence; an Oil which is most firmly united to an Earth, nor is easily separable from it; and lastly a pure simple Earth, which is the firm *Basis* of them all; are those principles, which Chemistry applied in a proper manner, has really discovered and produced from Vegetables.

Of ANIMALS.

Of Animals.

The third class of bodies, that have engaged the labours of the Chemists, are Animals, called the Animal Kingdom: But as of these the corporeal part only, has come under their consideration; hence when we speak of Animals, we mean only their bodies, and the parts of them, neglecting intirely their other principle, which is a subject of a very different inquiry. In this sense then, an Animal is defined a hydraulic body, which subsists by a constant and determin'd motion of humours through its vessels, and which contains within itself certain vessels, like the roots of Vegetables, by which it draws in that nutriment, which supports its being, and increases its magnitude.

Now the vessels, which thus perform the office of roots, are observ'd in almost every kind of Animal, and that chiefly in the small guts, going by the name of the lacteal and mesenteric veins. The food, and drink which Animals take in, being applied to the mouths of these absorbent vessels, is the matter by which they subsist, and is the same to them, that the Earth is to Vegetables; and the concave *superficies* of the mouth, *oesophagus*, stomach, and small guts, which is in the inside of all Animals, are the parts to which the nourishment is apply'd, and through which they receive it. Hence then it appears, that Vegetables suck in their nutritious juices by external roots, Animals by internal; and that the Earth, which is the support of Vegetables, is always without them, whilst Animals receive their nourishment constantly from within. And this observation holds true, even in that kind of Animals, which naturally

turally grow, and are strongly join'd to some other body, as is evident in the Limpins, Oyfters, and other *Zoophyta*, whose shells adhering to rocks, or pieces of wood, contain an Animal firmly fasten'd to them by a very tenacious ligament: For these very shells, so long as the Animal lives, receive from this inclosed body, by certain vessels destin'd intirely to this office, their nourishment, support, and increase, whilst the Animal itself takes its food in at its mouth, and conveys it into its intestines, in the same manner as all others do, that are at liberty to move about from one place to another.

But farther, even the *Fœtus* of oviparous Animals, which reside, and are confin'd in their shell, till cherish'd by a pregnant warmth, and nourish'd by their own white, being still planted as it were in their yolk, they grow to maturity enough to break their shell, get out of their prison, and shift for themselves: Nay and lastly, those, whose eggs are lodg'd within the *Uterus* of the mother, to which they grow as it were by means of cotyledons, or a *placenta*, and umbilical cord, and are thus cherished and supported: I say, both these, tho' in regard of their Cotyledons, *Placenta*, yolk, umbilical cord, and *omphalo-hepatic* vessels, they then very much resemble a Plant; yet during the very same time, they take in at their mouths the liquor contain'd in the *Amnion*, convey it into their intestines, and by this means are nourished in the manner of other Animals.

Hence then, as we see evidently, that there is a great analogy betwixt Plants and Animals; so we perceive likewise, that there are some circumstances, wherein they evidently differ.

But farther, as we observe among Vegetables, that some are fix'd in the Earth, others fluctuate about in the Water, and a third sort grow in both; in like manner we learn from the Zoographers, that there are some Animals that live on the Land, some in the Water, and others, that to answer their different necessities, are equally suited either to Land or Water.

And lastly, as Plants, by the apertures of the vessels on their surface, draw in the humours that float about in the Air; so likewise the bodies of Animals are known to do the same.

But we shall yet again find a farther agreement between them, if we consider that they are both supported by the same kind of nourishment: For as Plants flourish and increase by the juices they draw out of the Earth, so Animals live either upon Vegetables, or the parts of other Animals, which upon examination, we shall find to have been fed with Vegetable juices: The matter therefore of both is the same.

And as the juice, which Vegetables receive from the Earth, is not of their nature, but crude, at its first reception; in the same manner, the food, which Animals take in, and the chyle which is produced from it, does not presently put on the Animal nature, but retains a considerable time the properties of those bodies from whence it was derived.

Indeed afterwards, by the surprising effect of the animal machine upon them, and the mixture of the juices with them that are already concocted, the crude ones by degrees are wonderfully chang'd, and in every part of the body put on new appearances, as will be taken notice of in its proper place. It is sufficient to our present purpose to observe, that the longer the food has been taken in to the Animal, the oftener it has circulated through every part of its body,

and the greater number of its juices it has been mix'd and incorporated with, the more it constantly recedes from its own nature, and approaches to that of the body into which it is received.

The Spirits
in Animals.

Among the humours of Animals there is one that is vastly more subtil than all the rest; and this is called the exhaling Spirit, and seems to contain that singular quality which is peculiar to every particular Animal, and distinguishes it from every other. This we learn evidently from your Hounds, who will single out, and pursue over a great deal of ground, and through a vast confusion of tracks, that particular Animal which they first got fresh scent of, without any regard to the rest of the herd. We see the same thing too in their following their masters through common ways, where there is a great number of persons passing every minute backwards and forwards, and yet most certainly finding them out. Hence therefore it appears, that these *Effluvia* must be exceedingly subtil, and perfectly distinct from every thing else. These seem to be of an oily nature, or to reside in a most subtil vehicle, which owes its origin to an oil; as the analogy of things, and the rest of their properties induce one to believe.

Their Water.

Water constitutes the greatest part of the animal fluids, as in reality it does of most others; and indeed, it is so intimately united even with their most solid parts, that there are scarce any of them that are intirely without it; as the chemical Art has long ago informed us.

Their Salt.

There is a Salt too discovered in them peculiar to the Animal Kingdom, besides those Salts which they take in with their food, which from the power of the body suffer no alteration.

Now this Salt was never observed to be a fix'd one.

Nor yet so volatile, as ever to exhale from the body of the hottest Animal, so long as it continued in a state of health.

However, if for a good while you apply to it a degree of Heat, little greater than that of boiling Water, it will become intirely volatile.

Again, no person living, has ever discovered this Salt to be acid, unless it happens so, from things of that nature, which the Animal had received from without into its body.

Nor lastly has it ever appeared by any experiment that it is alcalious, so long as the Animal is in health, nay, nor even when it is sick; for upon a very careful examination that I made upon some urine, which had been retained five days in the body by a disorder in the urinary passages, I found, that even in that time, it was not become of an alkaline nature.

The same, however, by putrefaction, or a greater degree of heat, will be changed into a perfect alcali; but whenever in its natural state, by inspissation, and letting it stand undisturbed, you can artfully reduce it into little glebes, it appears to be a Salt different from every one that we are yet acquainted with: It comes nearest, indeed, to *Sal-Ammoniac* of any, but still, in some of its properties, it differs from that too; for *Sal-Ammoniac*, if put in a strong Fire, will be all raised without undergoing any alteration, whilst that which is drawn by Fire from urine, which is the *Lixivium* of the animal Salts, becomes immediately and intirely alcalious.

In short, after a great many experiments made on purpose to determine the true nature of this animal Salt, as it really exists in sound bodies, and acts there by.

by its own peculiar vertue, it appears to be of a mild disposition ; possessing a saponaceous quality from an Oil that is united with it ; being a kind of middle Salt, between a fixt and volatile one ; having not the least mark either of an Alkali, or an Acid ; being easily, however, resoluble into a volatile fetid Oil, and a volatile alkaline Salt, and hence very much disposed to putrefaction.

Nor let any one be here led into a mistake by the fixt Salt, which is produc'd from the ashes of urine when burnt in the Fire ; for this is nothing else but the Sea Salt, that was first taken into the body, which is able to bear all the actions, and powers, of the animal machine, without suffering any alteration in its nature.

And to the same cause do we owe that small quantity of acid, which after so much trouble, and with so strong a Fire we are able to extract from human blood ; for it certainly appears to be only an acid Spirit of Sea Salt that was united with an Earth, and is now forced out by this excessive degree of Heat.

And hence Animals, in whose food there is no mixture of Sea Salt, have neither this fixt Salt in their urine, nor latent acid in their blood.

The Oils which upon careful examination Chemistry has discovered in Animals are of a very different nature : Some, for instance, are so subtil, that they'll bear to be mixed with Water, and become volatile with a small degree of heat, in which respect they very much resemble the spirits of Vegetables, in their natural state ; but they differ vastly from those which are produced from them by the help of Fermentation.

There is another sort of Oil, which contains but a very small quantity of Salt in it, and is of an exceeding soft and smooth nature, serving to lubricate and supple the more rigid parts of the body : This in the cavities of the bones, is called marrow, in the *Membrana adiposa*, fat ; in both which it is collected, and reserved for proper uses : It is this, that helps to sheath, and soften, the sharp humours of the animal body ; and 'tis this that has sometimes been observed swimming upon the top of blood.

Again, there has been discovered another Oil which differs from the former, being concreted with the animal Salts, and so rendering them of a saponaceous quality, peculiar to the animal body : This, if you separate it, appears of a different nature from those already mentioned, being more acrid, fetid, and volatile.

There is yet a fourth kind of Oil, whose office is firmly to unite together the Elements of the solids, but so, as still to leave them a requisite degree of flexibility. This was originally form'd, and always continues in intimate union, with these Elements of Earth, not suffering itself easily to be separated from them : This dissolution, indeed, a strong Fire will effect, as well as putrefaction produced by a long continued action of the Air, Water, or Heat upon it ; for then it becomes volatile and flies off, leaving nothing behind it but Ashes, which easily moulder away. Whenever this Oil is alone, it always discovers itself by an intolerable noisome smell.

But of all the Oils that are discovered in the animal body, there is none so wonderful as that which is drawn from their inspissated juices, when they are exposed for a great length of time to an exceeding strong Fire, and goes by the name of *Phosphorus*. This naturally takes fire in the Air, and burns away, leaving a fixed, acid, fluid behind it.

Earth of
Animals.

Earth of
Animals.

In the last place, there is found in Animals an Earth likewise, which serves as a *Basis* to the whole body, connects all the other particles together, and retains the fluids within their proper bounds.

This now differs very little, if at all, from the pure Earth of Vegetables; for whenever you separate them carefully, and examine them nicely, they appear to be perfectly alike. A plain proof of this we see in the docimastic Tests, and the little Furnaces made use of in assaying of Metals; for nothing is fit for this purpose, but a most simple earthy matter, that will neither melt in the Fire, nor run into Glass: But whether now you procure this from the Ashes of burnt Plants or Animals, if you do but take care to separate it perfectly from every thing else, it equally answers the end: Nor indeed in the Earth thus procur'd, does there seem to be the least difference in any of its properties.

Their che-
mical Ele-
ments.

Thus then I have explained to you the principles, which enter into the composition of the animal body; those at least which Art has been able to discover, and lay before us; nor has there hitherto been observed any greater variety.

'Tis idle, however, hence to imagine, that the most accurate mixture of these Elements together, after they have been nicely separated, will ever produce the natural humours from whence they were extracted: On the contrary, the composition will most certainly be vastly different: For in every part of the animal Body, we find the humours of so singular a nature, that every one appears perfectly distinct from all the rest. The particular seat, for instance, of the bitter Bile is in one place; that of the Hepatic in another; the Seed is formed and perfected in its own proper organs; whilst another part gives being to the animal Spirits; the Chyle again of the Stomach, Intestines, Mesentery, Thoracic Duct, *Vena cava*, Heart, Lungs, and Arteries, is different in every one of these parts of the Body; not to mention the Milk, Fat, Lymph, *Serum*, Saliva, Blood, and Urine which are produced from it.

From what has been said then, it plainly appears, that there is an extraordinary agreement between the Elements of Animals, and Plants, so that the former seem almost to be made up with the matter of the latter; and likewise, that the chief difference between them, consists in the variety of their structure, and the swifter circulation of the aliments through the Animal.

And thus much for the Objects of Chemistry.

Actions of
Chemistry.

Chemistry then is engaged in the examination of the Bodies comprehended in the three Classes we have hitherto treated of. Now the alteration that is induc'd upon these by this Art, is owing intirely to motion: And here either a new one must be produc'd; or else one that was in being before, must be destroy'd, chang'd in degree, or alter'd in directions. These changes now happen sometimes to the whole Mass, its form remaining perfectly the same; and at others, to the particular Particles also, of which the Body is compounded. And on these very simple actions depend all the effects produc'd in the chemical Art; which, tho' they are so simple, yet from the vast number, and great variety of the constituent Particles of Bodies, they present us with an infinite number of new and surprizing appearances: Nor can we, upon the most strict inquiry, discover any other causes of these alterations; nor indeed, is it possible to conceive, how the Art of Chemistry can effect any thing more. Let us consider, for instance, one single Body, and suppose both the whole Mass to

continue

continue at rest, and all the Particles of it one among another; will it not for ever continue the same without any alteration? Certainly, tho' all the powers of Chemistry should be exerted upon it, yet if no motion is excited, either in the whole, or any of the parts, they would leave it perfectly the same as they found it: But again, let us imagine a motion to be impressed upon the Body, so as to move the whole Mass, without inducing any alteration in its compounding Particles; why then too we shall have perfectly the same idea of the Body as we had before, except, that in every point of time it changes its situation: But now, should the Particles of the Body themselves be put into motion, then it's easy to conceive how an infinite variety of effects may be produc'd, which it is impossible for us to determine. The whole business of Chemistry therefore is to unite, or separate; nor is there a third thing that it is capable of performing; and hence all its operations may be reduc'd hither, without exception. Nor let any one be offended at this simplicity, as if it was impossible, that from this alone, should arise so great a number of very different and wonderful effects, which we observe no where else; for it is a known, and settled truth, that the simple mechanical union of different Bodies with one another, is capable of producing very surprizing varieties in the compound. The Arithmeticians too evidently demonstrate, that from a few Elements, dispos'd, and chang'd, according to the laws of combination, may be form'd an infinite series of new Bodies. And lastly, from the application of one Body to another, there often appears a new power, which before lay intirely concealed. If, for instance, no two Loadstones had ever been brought so near together, as to be within the sphere of each other's activity, we should never have had a notion of any such thing in nature as a magnetic Power: If again, no Iron had ever been seen in contact with the Magnet, certainly, the peculiar, and stupendous tendency that is observed betwixt these two Bodies towards one another, had never been discover'd: And lastly, if Iron touch'd by the Loadstone had never been applied to another piece of the same Metal, either touch'd, or not touch'd, what person living had ever been able to find out those hidden virtues, which in this case are the cause of such singular motions? But it will farther appear in the History of *Menstruums*, that a greater number of Bodies have this mutual tendency towards each other, which whilst they are at a distance is not perceptible, but upon their near approach, discovers itself immediately. From what has been observ'd then, it evidently appears, that by the resolution of compound Bodies into their Simples, and the composition of Simples with one another, may arise an infinite number of appearances, that we were not acquainted with before.

If a Body undergoes any alteration, but still retains the same quantity of matter, then, the figure only will be changed, or the surface altered; but even this so simple a change presently endues it with new powers. This we see plainly in the mechanical Art, which by changing the figure only can work the same piece of Steel into instruments of vastly different properties. Let an ounce of Steel, for instance, be nicely formed into a Wedge, Knife, Dagger, Lancet, Sphere, Cube, Cylinder, Prism, Pyramid, and Cone; will it not then, under every one of these shapes, acquire new and peculiar powers?

On all these accounts, then, it is evident that the simplicity of the actions of the chemical Art, is no hindrance to their producing an infinite number of different effects.

And,

The power
of Bodies
from their
change of
figure alone.

And, indeed, it is of some consequence to conceive of this affair in a proper manner, as the Chemists are always prejudiced in an opinion, that their Art does really contain in it something yet more mysterious: If you examine their performances, however, you will perceive the truth of what has been asserted. Certainly, Calcination, Fixation, Vitrification, Sublimation, Fermentation, Putrefaction, Digestion, Depuration, and Adunation, with whatever other Operations they reckon proper to their Art, may be reduced hither.

A chemical Analysis does not exhibit the parts of Bodies as they existed in the Bodies themselves.

We must not, however, pretend to affirm, that those very parts, into which a Body may be separated, did really exist in the Body, in the same manner as they appear to us after their separation: For since the same powers that disunite these Corpuscles, may produce in them likewise a very great alteration, we shall often fall into an error if we suppose that the compound bodies in reality do contain these very Elements.

And, indeed, upon the resolution of Bodies, there often arises in the parts of them new virtues, which never discovered themselves by any effect in the bodies whilst they were intire; of which there is an infinite number of examples.

From both these reasons therefore it appears, that the Chemists are not altogether in the right, when they pretend to exhibit to us the first Elements of bodies, and think they can determine the nature of Compounds, from the knowledge they have of the Elements which by chemical Operations may be extracted from them.

Physical Atoms.

The examination of Bodies, it is true, informs us, that there are in nature certain Corpuscles, which when perfectly separated from all others, are not mutable by any cause we are hitherto acquainted with; whether it proceeds from their excessive, and more than adamantine hardness, which prevents any farther division or change; or arises from their very great subtlety, by which they are capable of eluding the force of all natural Powers.

When the resolution therefore of Bodies is carried so far as to reduce them to these fine Elements exceeding, there is a stop put intirely to any farther division, till these again are either united with one another, or with some other compound Body.

Scarcely ascertained by Chemistry.

These principles the Philosophers call, Elements of Bodies; and into these the Chemists have often asserted that they have reduced them; but they themselves confute their own opinions. We can't, indeed, but allow them, that the Elements of Fire, Air, Water, Earth, Alcohol of Wine, Mercury, and the *Spiritus Rectior* of every body, and some other things, do appear exceedingly subtil, and durable, when they are absolutely simple; but that these particles can ever be collected, and exhibited to us pure and without any mixture, no Art hitherto has been able to demonstrate: And indeed, that there is nothing of this simplicity in the common chemical Operations, has long ago been past dispute.

The productions of which are seldom simple.

Fire perhaps, and that only, whilst it passes through Gold, or the like substances, may give us its Elements perfectly pure: But what person living can by any Art ever show us one drop of pure simple Water? and this in the rest is still more difficult. There is no need to mention Air, Earth, and the others.

Nay farther, the parts into which the greatest masters pretend to have resolved compound bodies, are not themselves of a simple nature, but mutable,

and

and capable of farther division. This the Water, Spirits, Salt, Oil, and Earth extracted from animal, or vegetable bodies plainly evinces, Nay Alcohol itself is separated in burning into different principles.

And lastly, from a composition of the Elements, which the Art of Chemistry is capable of reducing bodies to, we can scarce ever again produce the original compound. This we have a proof of in the *Analysis* of Blood, Wine, and many other things.

It is necessary therefore to fix some sure limits to our Art, which we must not exceed if we would avoid mistakes, and come at the truth. It must be allowed indeed, that certain chemical Operations, do always produce in Animals, Vegetables, and Fossils, some determined effects, which by their proper marks may be easily distinguished; but whether the things they lay before us did really exist in the same manner in the bodies themselves before these Operations, we cannot always rightly determine, without borrowing arguments somewhere else. Alcohol of Wine, for instance, by the help of a proper fermentation and distillation, may be always procured from certain sorts of Vegetables, in the same manner, and perfectly of the same nature. Nor was it ever possible to draw this spirit from any other substance whatever; nor from this, but by means of this double Operation. This liquor therefore, that the Chemist exhibits to us, was never discovered in Vegetables, till they had undergone both a due fermentation, and distillation. Hence too, nobody, can give any tolerable account of its matter, cause, nature, and virtues, besides the Chemist. The same thing holds true likewise in a great many other instances. This Art therefore we circumscribe within a narrow compass; on this account we assert it to be more valuable, excellent, useful, and necessary; and 'tis under these limitations that we are ambitious of professing it.

It appears then at length by the help of the chemical Art only, that there really is in every single Animal, and Vegetable, a kind of *Aura*, or Vapour, that is proper only to that particular body; and that this is of so subtil a nature, that it discovers itself only by its scent, taste, or some peculiar effects. This Spirit expresses the true genius of the Body in which it resides; and it is this chiefly that accurately distinguishes it from all others. The infinite fineness of this Vapour makes it invisible to the eye, though assisted by the most perfect glasses; nor can the most exquisite Art detain, and collect it by reason of its vast volatility: When it is pure therefore, and separated from every thing else, it grows impatient of rest, flies off, and mixes with the Air, and so returns to the grand Chaos of all volatile bodies. There, however, it still retains its own proper nature, and floats about till it descends again with Snow, Hail, Rain, or Dew: It then sinks down into the bosom of the Earth, impregnates it with its prolific seed, mixes with its fluids, and so at last unites itself again with the animal and vegetable Juices; and thus by this revolution returns into new bodies, in order to govern them and render them active. This Spirit, from its vast penetrability, exquisite subtlety, and prodigious volatility, the ancient Alchemists, who were certainly the top masters of the Art, and the most consummate Examiners of natural bodies, called the *Spiritus Rector*, or Governing Spirit.

Now that this Spirit should be confined, and remain in its proper body, the all wise Creator has united it with a tenacious, durable Oil, which neither, Air,

Nor will these again united produce the same compound.

The just Conclusion from a chemical Analysis,

The *Spiritus Rector* of the Alchemists in compound Bodies.

An Oil the true seat of this Spirit.

Water,

Water, or natural heat can easily dissipate; that by this means, being intangled in its viscosity, it might not too readily fly off, and so leave the body it was designed to govern, and moderate. Hence the same famous Authors loudly assert, that this Spirit resides in a Sulphur.

On which
account it is
more volatile.

Again, the Oil that thus serves to hold down and secure this Spirit is found to be more volatile than any other of the oily substances in the same body: and it seems formed of such a nature, to the end, that it might almost spontaneously exhale with its Spirit, as the body tends towards its dissolution; lest the Spirit which is so vastly useful, should remain unactive in the body after death.

Of this Oil
the Spirit is
but an exceeding small
particle.

And lastly, nature is so sparing in the distribution of this Spirit, that it allows to every Body but an exceeding small particle of it; which, however, is of so noble a nature, that it is abundantly sufficient. The antient Adepts have been bold enough to pretend to measure the quantity of this Spirit, and tell us that it is $\frac{1}{8200}$ part of its seminal Body; and that it is always found in this proportion in every seed in which it resides.

But prodigiously active.

They assure us farther too, that they have observed it to be vastly active, and have learned by repeated observations that if you cherish it with a pregnant warmth, and support it with proper nourishment, it will still increase in activity, and in a wonderful manner continually acquire new strength for the production of an Offspring like itself. Hence they stiled it the Vital Spark, the Son of the Sun, the Spirit that nourishes within, with many other appellations of the like nature.

This wonderful affair
illustrated
by an Example.

Now before I proceed any farther, give me leave to illustrate this whole affair by one single Example: To this purpose let us pitch upon a Vegetable, that evidently distinguishes itself from every thing else. Let it, for instance, be Cinnamon, that noble Aromatic, which is of so fragrant a smell, and so delightful a taste, far excelling almost all others, even the most precious. If you cautiously then, and according to Art, distill a pound of the choicest of this Spice with boiling Water, and take care that nothing of it be lost, it will yield you a milky Liquor of a fine smell and taste, and at the bottom of it, a small quantity of a red Oil, which is exceedingly fragrant, and possesses in a very great degree the true virtues of the Cinnamon; as indeed does this milky Liquor. If you then remove both these, and boil up the Cinnamon that remains with fresh Water, you will draw off a clear, watery Liquor, of an acid taste and faint smell, which is so far from containing any signs of Cinnamon, that it is so like many others, you won't be able to distinguish one from the other. Examine now the *Residuum* of the Decoction, and you will find it of a brownish red colour, an acid austere taste, without smell, or any thing that gives the least Indication of Cinnamon. The body of the Spice, indeed, that remains in the Decoction, you would swear to be Cinnamon, it represents it so exactly in its figure, and outward appearance; but upon farther examination, you will find that this is the whole it retains of this noble Bark, having lost all its former excellencies: And indeed, there is a little difference betwixt this, and any other Bark or Wood, that has been treated in the same manner.

The true peculiar virtue, therefore, of the Cinnamon is contained in the distilled Water, and the Oil that subsides to the bottom of it. If you let, now, this Water remain at rest for a good while in a close vessel, it will let fall an Oil, grow clearer, and become less aromatic: In the Oil therefore chiefly resides

resides this choice noble vertue. But again, if you separate this water from the subfiding Oil whilst it yet remains strong of the Cinnamon, and put it into an open bottle with a small mouth, the whole place will smell strong of Cinnamon, and in a little time you will have the Water quite vapid, without any of the properties of the Spice; and yet you will find that it has lost no more of its weight, than common Water would have exhale in the same time, in the same vessel, and in the same place: The fine vertue therefore of this Water is really lodged in an exceeding small quantity of it, which consequently, must be extremely efficacious. Lastly, if you expose the Oil abovementioned to the Air in a wide-mouth'd glass vessel, there will be diffused through the whole place a most fragrant, delightful smell of Cinnamon; but in the mean while the Oil will lose its peculiar vertue, and after a short time there will remain an Oil, almost of the same weight with the former, but perfectly exhausted and deprived of all its original qualities.

Hence then it is evident, that all the proper aromatic vertue of Cinnamon resides in a very small quantity of Oil; and that even of this, it constitutes but an infinitely small part. And this particular demonstration will almost universally hold good.

The masters of this Science who have been most happy in their discoveries, tell us, that they have seen these Spirits even in Metals, and every kind of Fossil; that they are locked up in their proper Bodies, and confined there in their fixed Sulphur; and that whenever they can extricate themselves from their fetters, and become free, they then grow vastly active, insinuate themselves into other kind of Bodies, and are exceeding efficacious in the cure of diseases. But enough of this; if your curiosity about these things leads you any farther, consult the Adepts in these mysteries. For my own part, I don't choose to say any thing more upon this head, lest I should be suspected of recommending, and imposing on others, those things to which I myself am not equal.

The effects of this Art the Chemists have reduced principally to four *classes*; which are all produced either by adunation, or separation. When, for instance, they resolve a Body into any distinct parts which they collect and separate from it, they call this Operation extraction, and to those parts chiefly which are the most considerable they give the name of an *Extract*: Thus, when they draw from Wormwood the penetrating, bitter part only, they call it the Extract of Wormwood; as the most subtil part of Iron artificially separated from it goes always by the name of the Extract of Iron. Hither therefore are referred a great number of Operations, which may be performed on the same Body, as Distillation with Water, or without it; Decoction, and the inspissation of this Decoction through different degrees; Tinctures, let the *Menstruum* made use of be what it will; &c.

But when an Extract is drawn from several Bodies mixed together, in the same manner as the former was from a single one, it then changes its name for that of a *Clyffus*. And this appellation serves likewise for different Extracts prepared from the same Body, and afterwards mixt together; as when the Water, Spirit, Oil, Salt, and Tincture of Wormwood are artfully compounded into one mass, which possesses the united vertues of them all. Under this head therefore may be reduced a great number of beautiful productions of this Art; as the artificial Soaps, &c.

H

A Magistery

A Spiritus
Refor in
Metals and
other Bodies.

The classes
of chemical
Productions.

Extract.

Clyffus.

Magistery.

A *Magistery* seems at first to have signified among the greatest Masters of Chemistry the most excellent production, or masterpiece of their Art: For they tell us, they can change any simple Body into a matter very different from the former, and that commonly a liquid one, without any alteration in its weight, or the least separation of its parts. Thus, for instance, they assert they can reduce an ounce of Gold into a fluid of the same weight without the least admixture of any thing else; just in the manner as we see it when put in fusion by Fire. This, certainly, were we Masters of it, would be a most noble Art; but it lies hitherto out of our reach, unless you will suppose, that the effects produced by Fire are something like it. This however we must allow, that wax brought once over the helm, undergoes a surprizing alteration without any separation of its parts.

Elixir.

Lastly by the word *Elixir*, seems to have been meant the composition of different Bodies into one, so as perfectly to change their form, without making any alteration in their weight: And hence 'tis a kind of Magistery from several Bodies, as the former was from one. This *Paracelsus* asserts he has performed in Aloes, Saffron, and Myrrh, but conceals the only solvent which is able to effect this wonderful Operation; for which *Van Helmont* blames him, though he has not at all mended the matter himself. What reason is there however that we may not expect this from the chemical Art? Certainly, the preparation with tartarized Tartar, setting aside the skins of the Saffron, pretty nearly effects it: Nor do we make any doubt but that other Chemists are acquainted with better Solvents. It is certainly an argument of a weak mind to measure and limit other persons understanding by our own; though it must be confessed too, that the Artists by their too great pretensions very much lessen the opinion we should otherwise have of them.

I am well apprised that the terms abovementioned have been used in a different sense by very good Authors; but then, there are famous ones too, that have understood them in the manner, in which I have explained them. Let every one make choice of that, which pleases him best.

The service of the Art to Natural Philosophy.

The use of
Chemistry
in Physics;
As it makes
use of Fire,

And discover
that
which we
were not be-
fore ac-
quainted
with.

As Chemistry is engaged in the examination of all sensible Bodies, it is evident it must necessarily enter into, and be of use in all the branches of Natural Philosophy. And as Fire chiefly is the *Medium* by which it brings about the changes it produces in the Bodies that come under its management, in this very respect it must be of service to Physics, since Fire too, is the very instrument that Nature herself generally makes use of in the Operations it performs upon material Beings. As Natural Philosophy therefore is the knowledge of created Bodies with all their different modes of existence, it must certainly be promoted by the chemical Art. Give me leave to explain this a little more clearly. 'Tis the business of the Philosopher to deliver a true and accurate account of natural Bodies together with all their affections and properties. Now this knowledge cannot otherwise be obtained, than by carefully making observations upon all those Beings which the great Creator has formed within the compass of our senses. The first therefore, and indeed the principal part of this Science, consists in collecting together all those *Phænomena* of Bodies, which our senses are able to discover; and then reducing them into
a natural

a natural History. Now there are two different ways of coming at these Observations: The first, when we regard the appearances of things only as they happen indifferently to all in the common course of nature without any design in the human mind towards their production; and this is not of so great service to the Art, as in this case it is chance only that discovers to us certain properties, which happened to be produced at those particular times: The other, when we designedly apply different Bodies to one another that we are well acquainted with, purely with a view to observe the new *Phænomena* that will arise from them. And this now, is of vastly more service to the Philosopher than the former: For, to mention no other reason, there are an infinite number of properties of Bodies, and those too very efficacious ones, that could never been found out in the common order of nature, but then only discover themselves, when the Artist with his Fire in particular, comes to examine them, either jointly or separately, on purpose to know what will be the result. And, indeed, Chemistry is almost the only Art, that seems suited to cultivate this second, and most valuable method of making physical Observations. 'Tis this that resolves compound Bodies into their simple parts, and after it has carefully examined them combines them together again, in order to know, what new appearances, and powers, will thence arise: 'Tis this, that separates, or compounds various Bodies, and then examines them nicely with a determinate, and well observed degree of Heat, in order to find out if possible, what it is in them that nature is chiefly engaged about: And lastly, 'Tis Chemistry that by these means discovering how it may exactly imitate the natural and common *Phænomena* abovementioned, hence truly explains, and exhibits to us the instruments by which nature so efficaciously operates; and thus pries into her most secret methods of working, and very often prudently directs and improves them to its own advantage.

Not only taking notice of common *Phænomena*,

But making Experiments with views to new Discoveries;

And that more than any other Art.

A proof of this we have in Gunpowder, Phosphorus, liquors that upon mixture raise violent Ebullitions, and break out into flames, and an infinite number of other instances. We must, indeed, acknowledge that persons skilled in Mechanics, Hydrostatics, and Hydraulics, from certain general and universal properties of Bodies, may most certainly explain a great many physical Actions: But still, let them be ever so much masters of these Sciences, they will never hence be able to discover those effects of Bodies, which depend intirely upon the proper, and particular nature of some certain Bodies only, and which had never existed had it not been for those peculiar virtues. Whenever, for instance, the Loadstone, and Iron touched by the Loadstone, come near one another, what swift, and surprizing motions are immediately produced, which are no where to be seen in nature besides? Now that Chemistry is much more likely to help us to the knowledge of these particular qualities than any other Science is evident past all dispute; as this Art is vastly the best suited to the disposing of Bodies towards these kind of Discoveries. We may very justly therefore conclude, that of all Arts ours is the principal, and most efficacious in the promoting of natural Knowledge. A person that is master of this, will in reality make use of his Knowledge for the producing of its proper physical Effects, and not sit down satisfied with subtle words, or idle speculations. When the Chemist explains to you the nature of Glass, he at the same time teaches you the sure way of making it. If he talks to you

of Fermentation, he gives you an instance of it likewise to make it more evident. In short he never pretends to any thing more, than what he is willing to let you see he is able to perform. He don't trouble his head with fruitless Inquiries into ultimate causes; the present causes of things are what he studies, and what he teaches. He never invokes Demons, Hobgoblins, or Spirits, to his assistance; but performs all his Operations by the simple application of natural Bodies to one another. Nor does he concern himself at all about substantial forms; but, more to the purpose, takes pains to discover to us by their effects, those peculiar qualities and powers which nature has implanted in every particular Body; and then informs us how we may make use of them for the performing many surprizing Operations. Nor will he ever when at a loss, fly to, and take refuge in occult qualities; no, instead of that, by the help of his Art, he will search out, and discover those effects, which are falsely ascribed to those names, and then produce them into practice. The creation of the seeds of things, and the proper formation of every Body in its first original, he readily confesses he is not acquainted with; but takes a great deal of care to observe all the appearances that arise thence, and having faithfully collected them, makes a prudent use of them in the managing and changing of natural Bodies. These happy fruits is Chemistry capable of producing for the service of the Philosopher; and this Art, was it properly cultivated, would lead us to that knowledge of natural things, which the famous Lord *Bacon* so much wished for, and gave us a sketch of, and which afterwards, upon the beautiful design of that great Master, was improved and carried on by the immortal *Robert Boyle*.

The use of Chemistry in Physic.

The great
service of
Chemistry
in the medi-
cinal Art,

As it teaches
us the na-
ture of the
Solids,

And Fluids.

Now all that has been asserted of the usefulness of Chemistry in natural Philosophy, will hold equally true in the Art of Medicine: For this treats of the Human Body, and the powers, and effects of other Bodies upon it, neither of which can be thoroughly understood without the assistance of Chemistry. It will not however suit with our present design to enter into this affair too minutely, and therefore we shall only cursorily hint at some of its services in this Science. Chemistry, then, alone informs us, that the first Elements of which the solid parts of the Body are compounded, are a mere Earth firmly united together by an oily glutinous matter, which cannot be separated from them but by the extreme force of an open Fire. 'Tis this teaches us too, that Water also insinuating itself among these Elements, serves to bind them together, and being consolidated and concreted with them will not be expelled without a great deal of difficulty. 'Tis this farther that first explained to us the origin of this Earth, Oil, Water, and all the humours of the animal Body, from the Aliments it receives, these being first carefully examined according to Art; of which without this assistance we should have been intirely ignorant. And as for the parts, kinds, powers, and changes, observed in these humours, who can give any tolerable account of them without a thorough acquaintance with this Science? And lastly, as there is a certain degree of Heat that constantly accompanies a perfect state of health, which now a-days we are able to determine by the Thermometer; and as this when rightly discovered is the true measure of its active power: Chemistry far excels all other Sciences in explaining the proper effects of this Heat.

'Tis

'Tis true, indeed, that Mechanics, Hydrostatics, Hydraulics, and the other parts of Natural Philosophy, help us to the knowledge of a great many things that happen in the animal Body, whilst it continues in a state of health; but then, Chemistry leads us to a great many likewise, that we could not possibly have learn'd any where else: So that we are oblig'd to confess, that there are abundance of truths, and those of the greatest importance too, in the whole physiological branch of Medicine, that we could never come at, without the assistance of the chemical Art. But the greatest glory of this valuable Art consists in its being able to discover and correct those errors, which some whimsical dabblers in Chemistry had introduc'd into Medicine, as *Boyle, Bohn, Hoffman, Homberg*, and others, have by beautiful examples made appear. Those vain, trifling Chemists, were certainly in the wrong, when they pretended by their Art alone to explain physiology in all its parts; nor however are they less mistaken, who imagine they can do the same thing without it. No; let Anatomy faithfully describe the parts, and structure of the Body; let the Mechanic, by his particular science, examine the Solids, whilst Hydrostatics helps us to the laws of Fluids in general; and the actions of them, as they move through given canals, are explained to us by that beautiful Science Hydraulics; and lastly, let the Chemist add to all these, whatever his Art, when fairly and carefully apply'd, has been able to discover: And then, if I am not mistaken, we shall have a complete account of the physiological part of Physic.

In which it alone makes the most useful discoveries,

And corrects its own errors.

Nor is Pathology, as I apprehend, less beholden to the chemical Art than the former. Would you understand the causes, modes, and effects of the degeneration of the humours in the animal Body? Would you know how the juices are vitiated, when they move too slowly, are perfectly at rest in their vessels, or run out of them, and stagnate in the cavities? Or would you form a just notion of the alterations, that the Oils, Salts, Spirits, and Earth, that are mixed with our Fluids undergo, when they circulate through the Arteries with too great rapidity? You must go to Chemistry, and that only, for your information. Here too you will plainly discover, what Acrimony there is in the Body, how many sorts of it there are, whence it had its origin, and what are the effects of it after it is produced; which in vain you will seek for any where else. This will inform you farther, how the constituent parts of the Blood are compacted together, and by what means they are again resolved. And lastly, here you may learn the nature of *Pus, Ichor, Sanies*, virulent Fluids, and a putrid Gangrene, and what is the certain event of a *Sphacelus*. Now search after these things in any other way, and I am certain, with your utmost endeavours, you will never be able to give any tolerable account of them: Nay, the very Diseases of the Bones themselves cannot be rightly understood, without calling to our assistance the labours of the Chemists.

Assists Pathology.

But some persons will be ready to say, we allow you, indeed, that Chemistry may be of service in the physiological, and pathological parts of Medicine; but as to that part which treats of the signs of Health, Sickness, and Life, this was cultivated so accurately by the ancient *Greeks*, that there can be no room left for its assistance here. To this we answer, It cannot be denied, but that they did take an infinite deal of pains in collecting together the Signs of Diseases, and afterwards communicated them with as much integrity; but still, all their labours were confined to the examination of those things only, which

Of use in Semiotics.

which nature spontaneously offered to their observation. In this, we confess, they were surprizingly careful and accurate, even to that degree, that they scarce left any thing to be added by those that came after them. All these things therefore must the Chemist borrow from them, and them only, before he pretends to make use of his Art for gaining a knowledge of Diseases; and these he must gratefully acknowledge, as the effects intirely of their wisdom. But then, if we would rightly understand what every individual sign truly signifies, we shall be at a loss without the assistance of our Art, which alone is able clearly to explain it. This I could particularly demonstrate in every single instance, would the nature of our present business admit of it. But to mention only a few. The Ancients knew, that the more frequent Pulse of the Arteries, was a certain indication of a present Fever; and taught us, that the degree of it was to be measured by the number of strokes within a given time: By this means they tell us, the native Heat is increased, the radical Moisture destroy'd; and hence, according to the different degrees of it, Life itself is brought more or less in danger. The famous *Harvey* has farther inform'd us, that the quickness of the Pulse is owing to the more frequent reception of the vital Blood from the Veins into the Heart, and expulsion of it thence into the Arteries: And here their observations rested, nor serv'd us any farther. The Chemist, however, by the assistance of unexceptionable experiments, is still able to proceed, and teaches us, that by this increase of Heat from the celerity of the Pulse, the more fluid parts of the Humours must necessarily be dissipated, and the remainder inspissated; that the Oils will be dissolv'd and mix'd with the Blood, and by the attrition they suffer in the course of circulation, will become acrid, volatile, and putrid, and in this condition, being strongly press'd against the fine vessels of the Brain, will of consequence, wonderfully disturb it, nor will be easily again disengag'd from their union with Blood; that the Salts of the Humours will lose their natural ineptitude to motion, and become almost volatile; from an innocent, mild, disposition, will grow vastly acrimonious; and change their soft saponaceous quality into a fiery, corrosive one, and become, as some have asserted, a perfect Alkali. By this means, therefore, the Chemist comes to a right understanding of this Sign; and at the same time explains to us the use of it. With regard to the Urine, the Ancient Physicians were very careful in inspecting it, in order to discover, if possible, the internal disposition of the Body, and the more occult Symptoms of Diseases; and the Moderns are obliged to do the same: But of what service has this been to Physic? certainly of very little, as the judgment form'd from thence is very precarious: But let now a Physician, that is versed in Chemistry, examine it according to the rules of that Art, and how many, and how useful will be his discoveries? The quantity, colour, taste, contents, whether swimming at top, the middle, or subsiding to the bottom, and the spume, will make appear the true disposition of the Water, Salt, Oil, and Earth in the Urine, and consequently in the Blood at that time; and hence they discover to us the intimate disorders of the Humours, which are otherwise out of our reach, and serve as Prognostics, to point out to us the good or bad event, that in a short time is likely to follow. Here therefore, and here only can the Physician truly learn, both how to manage the present Symptoms, and foresee and provide against future events, in such a manner, that nature may be supported, and not left to sink under them.

them. 'Tis the Chemist, farther, that is alone capable of accurately distinguishing by their Signs, the true nature of sweat, *pus*, *ichor*, the *sputa*, and the excrements discharg'd by stool: Not that he is able to perform all this by the assistance of his own Art alone; but when to this he likewise joins a competent knowledge of Medicine, then it is he becomes truly qualified to discover, by the help of them both together, a great many things, which, otherwise, must certainly have escaped our observation. And it were much to be wished, that those Gentlemen of the faculty, who are such enemies to the Chemists, would consider this affair in a proper light; and then they would not so rashly condemn an Art, whose assistance may be of service to Medicine, but cannot possibly do it any prejudice. We confess, indeed, that some of the chemical Profession have done a great deal of mischief, by boldly venturing upon the practice of Physic, without sufficiently understanding it; but then, this was the fault of the Men, and not of the Science.

Again, its impossible for any person rightly to determine the diet that's proper for people in health, unless he knows what kind of corruption our meat and drink will naturally undergo, from the peculiar temperament of the Body that receives them, or the particular degree of exercise to which it is accustomed. In running-footmen, husbandmen, and all persons used to hard labour, fish, and fresh meats, putrify immediately from the violent motion of their Bodies, if they are not eat with a good deal of Salt: For such therefore, brown Bread inclining to be sowerish, Corn food, Milk, and Fish or Flesh dried in the Air or Smoke, and well seasoned with Salt, or Vinegar, is the best food; as Water, or stale small Beer, is the most proper drink: For since, by this excessive motion, the Bile, and the whole mass of Blood, necessarily tend towards putrefaction, this must be guarded against by those foods, which by their acidity, saltiness, or firmness, are least disposed to this kind of corruption. On the contrary, your pale studious persons, who sit long at their books, and deny themselves proper exercise, should eat only those meats that are easiest of digestion, and are soonest converted into the proper nature of the animal Humours: For these therefore, as Chemistry teaches us, the softer kinds of fresh meat, fish, and eggs, with a little salt, are the most convenient. And in short, if there's any Science that truly explains the nature of our Meat, and Drink, their Matter, and the method of pickling and preparing them; Motion, Sleep, the Excretions; and those passions of the Mind, that are of service towards the preservation of Health; it is, beyond all contradiction, that of Chemistry.

If we consider, lastly, the Therapeutick part of Medicine, we shall find, that the chemical Art is here of vast service also: For where shall we procure a suitable diet for our patients? Where shall we find Medicines proper for supporting of life, or recovering of health? Or where shall we be furnish'd with those Remedies that are capable of correcting things foreign, and hurtful in the Body, or expelling them out of it; or that will soften and sooth whatever is so sharp or stimulating? I say, how shall we come at all these, except by suitable helps, which Chemistry chiefly explains; which that alone digests in order, and best adapts to their proper uses? And indeed, it would be nothing absurd, should I assert, that it is this Art that most accurately points out to us those methods, by which we may learn from the Symptoms of the sick, whether, in what manner, and by what methods, we ought to act, in order to secure and

Nor less in
Dietetics.

But principally in
Therapeutics.

and establish the life of the patient, and to correct or remove both the cause of the Disease, and the Disease itself. And here give me leave to recommend to your reading those things I formerly wrote, *de Methodo Medendi*, for the use of young Physicians.

Now the truth of what has been asserted, is confirmed by the authority of the great Lord *Verulam*, who by experiments, being thoroughly convinced of it, every where strenuously recommends the chemical Art, as proper for the fully completing every branch of Medicine. I might mention too the illustrious *Boyle*, who in his elaborate pieces, *The Sceptical Chemist*, which he himself enlarg'd and illustrated, *Of the uncertain success of Experiments*, *Of specific Remedies*, *Of the history of human Blood*, *Of the usefulness of experimental Philosophy*, *Of the mechanical production of Qualities*, and a great many other Tracts, has evidently demonstrated the use of Chemistry, in every part of Physic. It is needless sure, after these two, to mention any body else: However, for your farther satisfaction, you may consult the *Philosophical Transactions* of the *English*, and the *Memoirs de l'Acad. roy des Sc.* of the *French*; and there you will see how industriously this Art has been cultivated for the improvement of the knowledge of Medicine. But the *Ephemerides* of the *Germans* are particularly stor'd with elegant arguments to the same purpose. It is, however, our great misfortune, that the most expert and learned Physicians, have very seldom been thoroughly acquainted with Chemistry; as on the other hand, the greatest masters of Chemistry have hardly ever had a true notion of Physic, to the great detriment of both these noble Arts. *John Bohn*, and *Fredric Hoffman*, indeed, excell in both; and by this means distinguish themselves above all the rest, and deserve the highest praises. I don't mention with these *Otto Tachenius*, and *Francis de le Boe Sylvius*; because out of an excessive, and rash fondness for the chemical Art, they would not allow it to be the servant of Medicine; but judging more from their own inclination, than the nature of the thing, would have it her mistress. Whatever I have been able to collect from this Art, that may be safely, and usefully applied to Physic, you have, in a little Treatise I wrote *De cognoscendis & curandis Morbis*, and in my *Materia Medica*, which I published afterwards.

Usefulness of Chemistry in the Mechanic Arts.

Chemistry
of service to
Mechanics.

By which are commonly understood those Arts, that are cultivated and performed by manual operation, and which are perfectly different from that mechanical Science that is the business of the Geometrician, which explains the powers of Bodies, from the properties that belong to Bodies in general. To this latter, Chemistry is of no manner of service; but the former, which consist in the managing, and changing of Bodies, are very much promoted by it.

To Paint-
ing.

The Art of Painting, which by Colours can, to the life, truly express all visible objects, and hence is able to represent the most beautiful parts of the creation, and transmit them down to posterity, is of so fine and noble a nature, that it has always been honoured with the regard, and esteem of Princes. Consult on this head *Junius*, in that vastly laborious work, *De Pictura Veterum*. Now this, tho' it receives the assistance of a great many other Arts, yet in that part, which consists in the preparation of beautiful, and durable Colours, Chemistry very far excells them all: A few examples of this will be sufficient. The Pigment, called the *Ultramarine*, which is of so charming a blue, and infinitely lasting,

lasting, is prepared from the *Lapis Lazuli*, intirely by the help of Chemistry. The common Blue Smalt likewise, is a beautiful production of the same Art. See *Antonius Neri*. L. VII. 115. and Dr. *Merret's* Notes upon the same. What is it that the greatest masters of Painting are fonder of, than a fine durable Green? Why the lovely Ultra-marine Blue, mixt with a holding Yellow, will give you one that will retain its beauty for many ages. Was it not therefore for Chemistry, Painting would intirely want these two delightful Colours.

What shall we say of those Colours, called *Laccæ*, which are chemically prepared by coction, and precipitation? Do not these, by their brightness and clearness, give Pictures a vast deal of lustre and beauty? But for these, we are intirely indebted to Chemistry, as you may see in the same *Neri* L. VII. 116. 120.

Not to mention Cinnabar, Orpiment, Ochre, or that Preparation of Bones that the Painters make use of, which is made by calcining them in a close vessel to an intense Blackness. It appears therefore evident, that tho' the Arts of Chemistry, and Painting, are in their nature perfectly different, yet this, without the assistance of the former, would want its greatest ornaments: Nor indeed, could the Painter well do without it; tho' the Chemist stands in no manner of need of the Art of Painting.

The industry of the Chemists has discover'd an invention, by which they are able to incrustate Metals, Gold in particular, with most pleasant, beautiful Pigments, which shine like Glass, and are composed chiefly of a metalline or glassy Matter, and a most penetrating fix'd alkaline Salt. These, they call *Emausta*, *Amausa*, *Esmailades*, *Smalta*, Enamels; which by the brightness, and elegant variety of their Colours, are vastly agreeable; nor will any length of time destroy them. Consult again the famous *Neri* in all his *sixth Book*, and you'll think your time very well employ'd; but more particularly *Isaac Hollandus*, who has treated so largely and finely of this noble Art, which vies with the most magnificent tessellated works of antiquity. It is certain, the fair Sex are indebted to it for most of their valuable ornaments. In Enamelling.

There is yet a third sort of Painting, viz. that upon Glass, which is exceeding beautiful, representing its figures in Colours that are wonderfully strong, and at the same time transparent. A noble instance of this surprizing Art, we have in the Windows of a Church at *Tergou*, in our Province of *Holland*, which now-a-days can hardly be imitated. For formerly they were masters of a particular method, by which, after they had laid their Pigments on the Glass, they could, by the assistance of Fire, vastly heighten their Colours, and dispose them to a perfect transparency, and at the same time make them penetrate into the very substance of the Glass, without running beyond their proper lines, or confounding themselves in the least with one another. And indeed, I don't see that any thing can possibly be invented more curious, and ornamental, for the decorations of Courts, and Churches. We have not, however, a great deal of reason to hope, that this Art will ever be again retriev'd, unless the Chemists will diligently employ all the productions of their Art, in order to discover it. In staining of Glass.

Akin to Painting, is the Art of Dying, which consists chiefly in tinging In Dying. Silk, Cotton, Flax, and Wool, with beautiful Colours, and so furnishes us with curious Garments, Tapestry, Banners, &c. Now this Art depends principally

cipally upon three things. First, the materials to be dy'd must be perfectly clean'd, that they may easily suck in, and retain the Dye; which is done by soaking, beating, and scouring them with various *Lixiviums*. And here, putrified human Urine, the acrimonious Salt of Ashes, divers sorts of Soaps, and the Gaul of Animals, are of principal service. By these the viscous kind of Glue of the Silk-worms, that firmly adheres to the threads of the silk, which are always double, is diluted and wash'd off, by which means they become pure, and fit to receive their Colours; and by these the fetid oily impurities of the Wool, and the tenacious greasy matter, which has long been concreted with the Flax, is intirely discharged. Now in the choosing, preparing, and applying all these materials, the knowledge of the skilful Chemist is of a vast deal of service, so that he is continually improving them by the discovery of something new, and useful. The second thing requisite in Dying, is a proper preparation of the Dye, that it may perfectly penetrate into the substance of the thing to be dy'd, and then may retain its beauty without any alteration. *Cornelius Drebbelius* of *Alcmar*, in our Province, a man of remarkable integrity, and so perfectly skill'd in the most profound parts of Chemistry, that he was rank'd amongst the Adepts, and was in great esteem with one of the Kings of *England*, besides other things, left behind in writing, a particular method of dying Wool of a bright flame Colour; by which secret, *Kustelaer*, his Son-in-law, afterwards got a great deal of money. The rich Colour of Cochineal may be heighten'd by Spirit of Nitre, till it is perfectly bright as Fire; but then, by its Acrimony, it too much corrodes the Wool; you may soften it, however, by the assistance of Tin, and then you have a Dye that is no ways injurious either to Silk or Wool, whose beauty is exceedingly durable. The third thing necessary in Dying is fine Colours; and those our Art is capable of procuring. I remember, as I was formerly shewing a famous Dyer some liquors prepared from a solution of Copper, he seem'd surpriz'd at the elegance of the appearance, and declared he would give any thing for those Colours, were it possible to make Cloth take them in their proper strength and brightness. And no wonder; for in the Azure, Violet, and Green, Colours from Copper, which at the Will of the Artist are in a moment made fuller, or paler, there is such a vast deal of beauty and variety, that any person, who had the Art of Dying Wool, Silk, Linnen, and Cotton, with these Colours, in such a manner as to make them hold and not fly off, might certainly get an immense sum of money. It is therefore past all dispute, that the knowledge of Chemistry would be of great service to the Dyer, since by the help of it, he might be continually improving his Art by new and beautiful discoveries.

In making
Glas.

But if there's any Art that is greatly beneficial to mankind, it is certainly that of making Glas. 'Tis this, that by the Polisher's assistance, so comfortably helps the defects of our Eyes, and lengthens out our pleasure of reading, even to great old age. 'Tis by this alone that we are secured from scorching Heat, and piercing Cold, kept free from Dust, and preserved from the inconveniency of the Wind, in our Houses, Coaches, and Ships; and at the same time have light enough perfectly to distinguish the Objects about us. Pure Glas does not easily stain, and when it is, may be clean'd again with all the ease imaginable. This exposes to our view the things it incloses, and keeps them for ages; nor makes any alteration in them, or rarely suffers any from them.

And

And indeed, whatever is preserved in a Glass vessel, that is perfectly closed, and intire on every part, becomes immutable, and incorruptible. Glass eludes the power of all corrosives, even the *Alcabeft* itself, if there ever was any such thing, which it is said it is able to confine, whether it boils in it, or agitated by the Fire flies about in it; whereas the *Alcabeft* dissolves every thing else into a pure Water. Glass is the principal instrument in the Art of Chemistry; is of a very ancient invention; was cultivated chiefly among the *Egyptians*; in the time of *Tiberius* was rendered malleable; and is at present, and has for some ages past, been made in the greatest perfection among the *Venetians* and *English*. And certainly, was it not for its great abundance, it would be more valuable than any kind of Metal. Now the choice of the Materials for this noble work, the artful preparation of them, and the proper mixing, melting, and bringing them to their greatest purity, depend so much upon Chemistry, that they really receive no assistance any where else, but hence are capable of daily improvement. From Flint, Sand, and Stones, are made the various kinds of Glass; and the different methods made use of in the burning, and calcining them, in order to reduce them to a *Calx*, make a vast deal of difference in their beauty. The diversity of the Ashes too, as they are procured from Plants of various kinds, will make a considerable alteration in its goodness. That made from a pure, acrid, fixt alkaline Salt, melted with the best sort of *Calx* of Flint-stones, is of all the finest and most perfect. And here, the more there is of the Salt, and the less of the Flint, the more fine and perfectly transparent will the Glass be: But then its charms are not of long continuance, as it is very ready to crack and flaw, either by Fire, or Water, by which means it loses both its beauty and transparency: It is apt too to damage things that are put in it, and very often quite spoils them; as Tea, which in a green Glass suffers no manner of alteration, in the most beautiful sort loses all its vertue. For our business therefore we always choose the green Glass, which is most durable, and is composed of a larger proportion of Sand, and a lesser of Salt, kept melted for a considerable time in a strong Fire. But these hints are sufficient; as you may consult upon this head, the valuable *Antonius Neri* of *Florence*, in his Book *De Arte Vitriaria*; the famous *George Agricola*, in his seventh Book of *Fossils*; that celebrated *Englishman*, *Dr. Christopher Merret*, in his observations and Notes upon *Neri*; and *John Kunkel*, who, at the vast expence of that truly generous Prince, the Duke of *Brandenburg*, brought this Art almost to its greatest degree of perfection; as appears by his commentary upon *Neri*, which he publish'd at *Leipsic* in 4to, in the year 1679; but more especially in the Tract *De Gemmis Artificialibus*, which is annexed to it.

There is another kind of Glass, that is transparent likewise, but at the same time so enriched with some beautiful Colour, that it almost vies with the brightest natural Gems. This noble invention now owes its origin to the chemical Art, and truly imitates nature, by intimately mixing the infinitely divided particles of Metals with the purest, and most perfect Glass; and by this means, giving it a lasting beauty. So that, in reality, there are scarce any stones, valuable on account of their Colour, whose agreeable appearance this Glass cannot be made to resemble. And indeed, should ever any person happily improve the Art of Glass to that degree, as to be able to increase its weight by Fire in a sesquialter proportion, we may then, by the assistance of Metals, make

In making
artificial
Gems.

artificial Gems of the same brightness, with those that are the true production of nature ; for the more dense and solid the pellucid matter is, the stronger will the colour of the Metal appear, that is dispersed through it : But as this condensation of Glass has hitherto been beyond the reach of Art, the substance of the artificial Gems is less dense than that of the natural ones ; and consequently the vibrations of the rays of light are more weak and languid, and want that vividness that is peculiar to the other. Some have, indeed, attempted to increase its weight by a mixture of Lead ; but then, it grows too soft. It is well worth while therefore, for the lovers of Chemistry, to employ their utmost endeavours for finding out a method of condensing of Glass ; for it certainly will abundantly recompense all their labours. There is yet a second thing requisite to the perfection of artificial Gems, and that is, the giving Glass such a degree of hardness, that it may not by wearing, lose the lustre of its polish, but retain its beauty, and put on the incorruptible nature of a natural Unit. And lastly, when we have communicated to it a proper solidity, and hardness, we must afterwards colour it with some rich metalline Tinctures ; and then, we might by Fire form the Mass thus prepared into multangular Bodies, that would excell the natural Gems, both in magnitude, and variety. For we have an incredible number of the choicest colours, that might be either intimately mix'd with the Glass when 'tis in fusion ; or be disposed upon its surface, and by the assistance of Fire, be made to penetrate into its substance, if that ancient Art should again be restored. Now it is Chemistry alone that furnishes us with these three principles, on which the artificial way of making Gems intirely depends, and gives us frequent opportunities of improving this beautiful Art.

As the greatest masters, however, in the chemical Art, have never been able to give artificial Glass a requisite weight, and hardness, some of the subtlest of them took it into their heads, that the most clear and perfectly pellucid fossil Chrystal, might possibly answer the same purpose ; for this being naturally very heavy, and hard enough to cut Glass, wants only colouring with some metalline Tincture, without destroying its transparency, or the beauty of its polish, to make it nearly resemble natural Gems. This therefore they attempted by heating the Chrystal red hot, and then extinguishing it in colour'd Liquors ; but the flaws that were occasion'd in this operation disappointed their expectation, which would otherwise in some measure have been answered. See *Boyle of Gems*, p. 19. 44. Others have endeavour'd the same thing, by cementing Chrystals with different kinds of Metals, and not without success ; for the Metal being afterwards melted, and forc'd up by Fire, penetrated intimately into their substance. And it is possible, that some time or other, there may be discover'd some artificial Pigment rich with a metalline Colour, which being incrustated over Chrystal, may by Fire, be perfectly diffused through its whole Mass, and give it a most beautiful brightness. Now these methods, which seem the most likely to produce something considerable in this elegant Art, depend so intirely upon Chemistry, that there is not the least reason to expect any assistance in this affair from any other Science.

In Metal-
lurgy.

As for the Art of Metals, the knowledge of Chemistry is so necessary to this, that it seems to claim it wholly to itself. I don't mean here that Art, which consists in the boasted production, and transmutation of Metals ; of this
I shall

I shall honestly relate those few things, I have, upon mature deliberation, been able to discover, when I come to discourse of the usefulness of the chemical Art in Alchemy. In this place I would be understood to treat purely of that Art, which teaches us how to prepare Metals for the ornaments and uses of life. Gold, for instance, is frequently of a pale colour, and that from a great many causes; now this the Chemist, by a cement, or *Regulus* of Antimony, can heighten in the Fire to a most beautiful yellow. This we see at present in the gold coin of *Holland*, which far excels all other in its particular lustre; for which, we are beholden to the curious and peculiar skill of the master of the Mint. The same Metal, when it is perfectly pure, is from its natural softness unfit for coining; but tempered with a proper alloy of Copper chiefly, or Silver, it excellently answers that valuable purpose. Silver, in like manner, is too soft, and ductile, either for coin, or the common uses of life; but is easily rendered fit for both by a due admixture of Copper. 'Tis needless to mention Brass, which is a composition of Copper and *Lapis Calaminaris*, and much resembles Gold in the brightness of its colour; or that Metal made of Copper and Zincq, called *Prince Robert's Metal*, which being nicely gilt vies in lustre with the most beautiful *Obrizum* Gold. As for the Art of Gilding the baser Metals with Silver, or Gold, how curious is that Art, and how valuable? These now are all instances of the service of Chemistry in the metallic Art; and though they are few indeed, yet they sufficiently demonstrate what an infinite number of effects might be produced, would the skilful Chemist make a proper use of his Art in the various compositions of Metals. Nor even in this affair don't Medicine receive some advantage; witness the cups made of *Regulus* of Antimony tempered with other Metals, which communicate a medicinal quality to the Wine that is put in them. And it is ten thousand pities the famous *Van Helmont* should have been so unkind to his poor fellow creatures in distress, as to conceal from us the Art of making a particular Metal, which he tells us made into rings, and worn only whilst one might say the Lord's Prayer, would remove the most exquisite hæmorrhoidal pains, both internal and external, quiet the most violent hysteric disorders, and give ease in the severest Spasms of the Muscles. p. 745. § 39. 'Tis right, therefore, I think, to prosecute Inquiries of this nature; for there is very frequently some hidden virtues in these Compositions; and we may make a vast many Experiments of this kind without any danger or inconvenience. Metallurgy again, that consists in the knowing and distinguishing the fossil glebes as they are found in their subterraneous veins, and thence producing pure and perfectly distinct Metals, depends intirely upon our Art. This is plain, even from this consideration, that Chemistry owed its origin principally to Metallurgy; and this, by modern inventions, it now again vastly assists and improves. But we need not stay much upon this Head, if you will carefully consult *George Agricola*, *Lazarus Erkerus*, *John Rudolphus*, *Glauber*, and others, who have for the most part borrowed what they have, from these. For your greater satisfaction, however, I will give you three or four Examples. It is a known thing among the Chemists, that it is very easy to prepare a matter, which being mixt with Gold, Silver, and other Metals will render them so volatile, that they may in a glass vessel be brought over the helm with a moderate heat. And experience as certainly evinces, that there is very often in the native Glebes that

contain the richest Metals a certain substance, which, when the fossil is exposed to the management of the Fire, carries off a great deal of the Metal with it, to the prodigious loss of the Owners. There is, for instance, a volatile, noxious Sulphur very often united with Gold and Silver, which disperses vast quantities of these Metals into the Air whilst they are only torrifed by the Fire. But the industry of the Chemists has discovered certain methods, by which they can at once render these volatile Glebes so fixt, that they will bear fusing in the strongest Fire; and by this means the Metals will be separated from every thing else. You know that *Regulus* of Antimony, mixt with a double quantity of the corrosive Sublimate of Mercury, will by a gentle Fire be changed into a fat substance that is extremely volatile; and that this by a moderate degree of heat will rise in deadly Vapours, and by the repeated action of the Fire become at last a limpid Oil that fumes spontaneously. This, I remember, I have frequently both explained to you, and demonstrated before you. Pour, now, upon this Oil an equal quantity of pure Water, and it will presently in a surprizing manner turn of a white colour, and precipitate a white metallic *Calx* of Antimony, which is so capable of bearing the Fire, that it may be intirely melted into a mass like Silver, and is the finest *Regulus* of Antimony that Art can produce. Let us therefore, from this simple Experiment, learn to mix Water with the volatile Glebes, and observe whether by this manner of treating them, they won't yield a greater quantity of the richer Metals than they did before. Iron likewise being added to these Pores in their calcination, oftentimes so absorbs the Sulphur, that it cannot carry off the metalline Particles along with it. And the fixt alkaline Salts too have saved a great deal of treasure by subduing and resolving the Sulphurs, or Acids, which being dispersed through the metallic substance made it volatile in the Fire. The richest Silver Mines of *Peru* are unfortunately infested with a pinguious matter, which makes the Glebe of a volatile nature when it comes to the Fire, by which means there was formerly an incredible quantity of Silver intirely lost. But the Chemists have now instructed us, first, to torrify the Ore with a gentle Fire, then, to reduce it into powder and rub it with Mercury, afterwards to wash it in a proper manner with water, and lastly to collect the Silver together into one mass, by putting the matter thus prepared into a Retort, and forcing out the mercurial Particles with which it was united; and since this has been practised there has been scarcely a grain lost; by which means there is an infinite deal of wealth preserved, which would otherwise have been dissipated into the Air. The difficulty of perfectly separating Silver from the Tin that is found mixt with it, used to be a matter of great concern, both to the Miners, and the persons employed in the docimastic Art: But since we have learned from the Chemists that by the admixture of melted Copper the Tin may be easily disingaged, and carried off, we can collect the Silver pure from the ashes with a great deal of ease, and little expence. There are a thousand other advantages for which Metallurgy is indebted to the Art of Chemistry; but you don't expect that I should be more particular upon this subject; nor indeed will our present business permit it.

In the Art
of War.

Again, the chemical Art alone furnishes us with a great number of instruments of War, that were intirely unknown to the ancients, and which, indeed, are so destructive to the moderns, that we should have been happier without their discovery. But

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as the evil and restless spirits of some part of mankind are perpetually the occasion of War, and violence; hence 'tis absolutely necessary that we should be able to repel force by force, in order to defend and secure ourselves; and in this, money excepted, the whole stress lies at present upon the Inventions of Chemistry. In the twelfth century Gunpowder was found out by *Roger Bacon* in *England*; and with this he imitated Thunder and Lightning, but to the happiness of that age did not employ this wonderful discovery for the destruction of his fellow creatures. About two hundred years after, *Bartholdus Schwartz* of *Germany*, a Monk and Chemist, accidentally observing the sudden expansive power of this powder, whilst he was preparing it for medicinal uses, immediately made a trial of its surprizing force in an iron Tube, and soon applied it to the Art of War, and taught it the *Venetians*. And indeed the whole force of War now a-days consists so much in this chemical Invention, that by the help of this the weakest boy may overcome the most valiant hero; nor is there any thing, be it ever so strong, that is able to stand against its stupendous power. The great *Coeborn*, therefore, General of the *Dutch* forces, wisely considering the efficacy of this chemical Discovery, immediately changed the whole Art of War, and all the methods of defence; so that those fortifications which were formerly looked upon as impregnable, are now not able to secure the persons that defend them, or preserve them from danger even within their own walls. And indeed the power of this wonderful Powder, is yet more and more to be dreaded. As for that Powder which is compounded of Sulphur, Nitre, and the burnt *Faces* of Wine, the force of it is so prodigious, I can scarce mention it without shuddering. Who can think of the violent explosive faculty of *Aurum Fulminans*, and not be astonished? When we mix the chemical Oils of the most fragrant Aromatics, with a liquor extracted from Salt of Nitre, we produce something vastly more powerful than Gunpowder itself, which spontaneously, without the application of Fire, rages in a most furious manner. And lastly, which it gives me pain to mention, let me here put you in mind of that melancholy accident, which happened in *Germany* from some *Balsamum Sulphuris terebinthinatum*, which being unfortunately quite stopped up in a Bolt-head, the glass burst by the heat of the Fire with a prodigious explosion, far superiour to any of the former. Heaven grant that the noble Inventions of this valuable Science may be no farther improved by the craftiness of mankind to the destruction of one another; the fear of which obliges me to conceal many things, I could otherwise mention, that are still much more pernicious, and detestable.

That the ancient *Magi* of *Asia* were men of superiour wisdom, I think is sufficiently agreed by the learned world. And that this name has not always signified evil Agents, Contrivers of mischief, and Slaves of the Devil, is evident from the *μάγοι ἀπὸ ἀνατολῶν*, mentioned by *St. Matthew*, who were famous for their knowledge of the Stars, and sincerely worshipped the true God, by whom they were accepted. That they were in great esteem too with the Princes of that country, in ancient times, and consulted in their most weighty affairs, we have related in abundance of places of History. And we find that *Zoroastres* himself, the King of the *Bactrii*, who was the founder of this sect, is chiefly extolled for his knowledge of the heavenly bodies, whose motions, and the principles of the world, he is said to have studied with a great deal of application. *Justin. l. 1.* For this reason therefore, as *Cicero* tells us, the *Persian* Kings were instructed

In natural
Magic.

instructed in the Art of Magic, before they were admitted to the government. *De Divinat.* I. 91. And he likewise assures us, that the *Magi* in *Persia* were looked upon as persons of great wisdom, and learning. *De Divinat.* I. 47. It happened afterwards that an illiterate set of men, greedy of fame and riches, endeavoured by their deceitful cunning, and juggling tricks, to imitate the profound knowledge of these Wise Men; but their frauds being often openly detected, the Magic Art came to be basely exploded; which has frequently too, though undeservedly, been the fate of Mathematics. The employment of the true *Magi* was to search carefully, and curiously into nature; by which means they often discovered things that were concealed from the observation of others, and which the all-wise Being designed as the proper rewards of laborious study and application. Hence the ignorant regarded them as men endued with more than human knowledge, which they imagined therefore they received by the intercourse and instructions of Dæmons, and for that reason paid them great reverence, tho' more out of fear than any real respect. And this they were the more naturally led into, as it has been a prevailing opinion of all ages, that there are two kinds of Spirits, the one good, the other evil; and that these being perfectly skilled in natural knowledge, and moved the one with love, the other with enmity to mankind, endeavour by their skill to allure them into their service, the good, in order to make them happy; the evil, with a design to make them miserable. Whether this way of thinking be just, or no, I do not here examine. The perfections, powers, instruments, and hidden faculties of nature, the production of supreme Wisdom, vastly, I confess, exceed my comprehension. By that little however which we do know, we are disposed to believe, that there lies hid in the bosom of futurity, an infinite number of things, that will some time or other be clearly revealed to mankind, of which at present there is not the least shadow of appearance. Who can deny, that there may be beings, who have a faculty of looking more intimately into nature than the most sagacious human mind was ever capable of? Who can demonstrate but that these Spirits, without corporeal assistance, may be able to get acquainted with Bodies, understand their powers, perceive the chain or order of causes, see things present, foresee things future, and know things that are past? Nor is there any absurdity in supposing, that these Dæmons may insinuate their thoughts into human minds; since we at present are no more acquainted with the connexion, and mutual intercourse of thinking beings, than we are with the number of different kinds of beings, that are endued with understanding, will and affections. Nay even the manner of motion's passing from the moving body into the body it strikes against, is more than we are able hitherto to explain. Will any person dare to assert that it is impossible for thin incorporeal images to fly about in a hollow empty form, that has in the open Air seen the Spectres reflected from a concave *Speculum*, which so strongly, and perfectly represent the dimensions, colours, and every thing that appears in the solid bodies, that one can't help being surprized even though one is aware of it; and yet if you offer to touch them, you find them a perfect shadow? And as our soul is united to a body, by whose assistance it perceives things without us, why may not every one of these volatile *Species* have a spirit implanted in it, capable of penetrating, moving, and changing every thing? Whether these things are so, or not, I don't pretend to determine; 'tis possible
time

time may discover it. Nor will I assert, that there have been persons who by the assistance of Dæmons have been able to know, and do more, than they could have done by their own natural powers; nor yet will I absolutely deny it. 'Tis an argument of too much presumption and vanity in us, who scarcely know any thing, to take the liberty to speak confidently of things that are far above our reach. I would not have you imagine, however, that I design by this to persuade you to believe, a parcel of old wives fables, the reveries of idle persons, the stories of credulous ones, or the fictions of those that design to delude us. Nothing less! I am too sensible that it is with the ignorant chiefly that these things find credit; with men of sense very rarely; and that always the less, the more cautious we are, and the more circumspection we use, that we are not imposed upon. As for the foretelling things future; the discovering of secrets; the raising the passions of the mind, and fixing them upon any object one has a mind to; the creating, removing, or asswaging distempers by numbers, words, signs, figures, inarticulate murmurs, charms, little images, a look, or laying on of hands; the changing one's self, or others, into different forms; the making persons invisible that are in your company; riding through the Air at one's pleasure; the giving life, sense, motion, voice, and affections to inanimate beings; the calling up of Ghosts, Dæmons, Spirits, and the Bodies of the departed; the mastering, driving away, and binding of Spectres; the obtaining of honours; the finding of treasures; the making money always return back again into its master's pocket; the rendering Bodies invulnerable; the getting the better of one's enemies; the fixing them like statues at one's pleasure; the ruling the Elements; the overcoming even nature herself, so that neither Fire or Water shall have any power over us; the raising meteors in the Air by a command; the taming and governing the most furious wild beasts, purely by incantation; and the producing ludicrous appearances only with a word; these, and such like things, are what the true *Magi* never pretended to, but are only the boasts of crazy-headed people, which the superstitious are apt to believe, and the wicked sometimes invent in order to delude the credulous, and get them into their power. Against such foolish notions as these, that famous Author, whom I have before mentioned with respect, *Roger Bacon*, wrote with a great deal of strength, and shews us that there is in reality no such magic Art in the world; nor does he believe there ever was. On the contrary, he carefully inculcates, that there do actually reside in natural Bodies, certain latent and hidden powers implanted in them by their Creator, by which as wonderful effects may be produced, as were ever ascribed to the borrowed assistance of the Devil: That these qualities however cannot be discovered without a very laborious, and diligent inquiry; but that when by assiduous Study, and proper repeated Experiments, they have been once found out, they may then, by a due application of them to one another, be made use of for the production of such things as, to persons unacquainted with these properties, will seem contrary to the laws of nature, and will therefore be concluded to be the effects of a preternatural power. And this kind of true substantial knowledge may properly be called natural Magic. This is that magical Art which I would endeavour to recommend; and this in reality is very serviceable to mankind, very entertaining to persons that are acquainted with it, and by its wonderful Operations very well suited to shew forth the praise and glory of the great

Creator. Indulge me a little, and I'll give you a few Examples of this, which intirely depend upon the chemical Art. Suppose an Author of undoubted veracity that lived a thousand years ago, should have told his posterity, that there was in his time a man who publickly gave out before a vast number of witnesses, that a prodigious tower, which they there saw at twenty furlongs distance, should at a certain point of time spontaneously rise into Air, and presently fall down again in ruins; and that it happened exactly as he had foretold; would not every one that read this look upon it as a fabulous story, or else, regard it as the effect of a power superiour to that of men, or even nature itself, and consequently ascribe it either to the Divine Being, or some infernal Spirit? And yet if you imagine that at that time there was but one man in the world, such a one for instance as *Mahomet*, or *Haly*, that was acquainted with the force of Gunpowder, and that he had conveyed a sufficient quantity of it under the tower, and according to the modern invention had artfully disposed a piece of clockwork in such a manner among it, that at the very moment of time that he had fixed, it should by striking a flint against a piece of Steel set fire to the Gunpowder; you see with how much ease he might have performed this surprizing miracle, by which he would certainly have gained so much credit, not only with the common people, but even with men of understanding, that he might have influenced their minds in what manner he had pleased. When the secret indeed comes to be discovered, our admiration ceases; and we then look upon these things as the production only of natural powers, which before we thought superiour to any magical Miracles that have ever been related. Not that even at this time the most sagacious person living can truly comprehend the cause of this surprizing effect; but we are falsely apt to imagine that we perfectly understand those things, which we see very frequently happen. It is possible in the same manner for a person to foretel, that in an hour's time there shall happen an Earthquake in a certain part of the earth, which shall at first send forth a prodigious black smoke, and afterwards burst out into crackling flames. People indeed that heard it would be apt to laugh at us; but then certainly they would be as much surprized when they found it to be true. And in order to this, take only equal parts of fresh filings of Iron and pure Sulphur, rub them together, and with a little Water make them into a paste of about fifty pounds weight, then put this a foot and a half under ground, and ram the earth hard down upon it, and your prediction will be fully compleated. Surprizing effect! that cold Iron, inactive Sulphur, and cold Water, only by being mixt together, should, under a weight of earth, be capable of producing Heat, Smoke, Fire, and Flame, without the least assistance of Fire. But again, there is a story of a Tutor, who after all other endeavours to no purpose, by a contrivance borrowed from Chemistry, happily reclaimed a noble youth, who by his dissolute life brought disgrace both upon himself and family, and seemed past all hopes of amendment; and this was in the following manner: One night as he lay in the same room with this young Gentleman who was fast asleep, he got out of bed softly, and with some English Phosphorus wrote his name in large letters on a board that was at the feet of the bed, and added three words, intimating that if he did not immediately repent, he must expect to die in a very short time: When he had done, without disturbing his pupil he stole gently to his bed again, but then

then made a great noise on purpose to wake him, and laid himself down as if he was asleep. The youth presently started up in his bed, and listened attentively in order to discover the occasion of his surprize, but heard nothing except the snoring of the other, who feigned himself asleep; but looking accidentally towards the feet of the bed, he saw some letters shining with a blue light which vastly astonished him. Upon this, he calls to his companion, and shews him the writing; who making as if he knew nothing at all of the matter, professed that he did not see any thing; which so much the more increased his terrour. The servants who were not in the secret, were then called to bring in some candles, upon which the letters disappearing, they declared too that they saw nothing; and indeed the youth himself was astonished to find that the writing was vanished. The servants went away again, but left a candle which happened to shine upon the board; the tutor sets down by his pupil and persuades him to go to sleep, tells him 'twas only a dream, and then goes to bed himself, and puts out the candle. As soon as ever the room was dark, the youth no sooner looked towards the fatal place, but he again saw the same letters, at which being vastly frightened, he cries out, and begs his tutor to come to him; who then pretending himself to be afraid, confessed that he did indeed see the writing, and that not without a great deal of astonishment; and then took this occasion to admonish him sincerely to repent, in obedience to this Miracle, and calling for a candle spent the remainder of the night with his pupil, who was under great concern, and was brought by this means to a better way of life. Now this story, if it is true, as I have frequently heard it affirmed, is an Example of natural Magic from the chemical Art: If it is only a fiction, it is certainly a possible one, since such things may at any time be effected by the help of Phosphorus, as nobody that knows any thing of the matter will deny. If the power of Phosphorus be so far weakened by a soft Oil, that it may be applied to the skin without burning it; then the face being rubbed with this Oil will shine terribly in the dark; and yet upon the approach of a light the shining will intirely disappear; which being again removed, the countenance will regain its former brightness, than which nothing certainly can be more surprizing. Suppose now a person was to anoint his face, hands, hair, and beard with this sort of Oil, and then dispose himself in some dark place; would not the credulous vulgar presently imagine there was something in it celestial, angelical, or divine, and be ready to believe any thing upon such a one's authority? Give me leave yet to mention another thing, which you yourselves have been here often eye-witnesses to, and that is, the surprizing effect of mixing together two liquors perfectly cold, which in a moment boil up in the most furious manner, and burst out into a beautiful flame. Now if the thickness and blackness of the smoke, and the brightness of the flame is so astonishing in the middle of the day, would it not to appearance be vastly more terrible, if the Experiment was performed in the dark, when the flashes of the light must be abundantly more visible? And, indeed, if we compare this wonderful *Phænomenon*, with the stories that are told of magical Spectres, I verily believe we shall scarcely find any of them that will equal it. Now this is the effect only of one drachm of one of the liquors and two of the other; what therefore must be the event should pounds of them be mixed together? Certainly the force of the smoke, and flame,

would be infinitely great, nor any ways to be restrained, but would overthrow every obstacle that stood in its way, and destroy, and consume every thing about it with a Fire not to be extinguished. And which is still more surprizing, if the same Experiment is performed *in vacuo*, it acts with so much the more violence, and in the very instant of mixing, tears every thing to pieces, and flies about with a force superiour to the strongest Whirlwind. The *impetus* of this Fire is certainly of a vastly different nature from that which was raised about *Creusa's* head by *Medea*; for by the strength of this even the whole court might have been blown down and turned into ashes. But again, who has ever heard, or read of any thing so wonderful and terrible ascribed to the magic Art, as we have known effected by *Balsamum Sulphuris terebinthinatum*? which being closely confined in a Bolthead, and forced by a strong Fire, burst the vessel with a stupendous noise, and produced such strange and peculiar effects, that in all the extraordinary *Phænomena* I have read of Thunder and Lightning, I don't remember ever to have met with any thing that equalled them. See the *Observationes Physico-Chemicæ* of the famous *Fredric Hoffman*, lib. III. Obs. 15. where you will find an account of many things which you would have thought absolutely impossible to be effected by the powers of nature. Among others, you have there some very surprizing effects of Spirit of Wine, which a Cooper putting into a strong cask with some lighted Sulphur, and then perfectly closing it up, there followed a most violent explosion, that tore the vessel to pieces, and was the occasion of some accidents that are almost incredible. But lastly, when we see the skilful Chemist take a parcel of clean glasses, and in a moment's time produce all sorts of colours, and as suddenly destroy them, then renew them again, and vary them at his pleasure, does not this, to a person that never saw it before, or knew any thing at all of the matter, appear supernatural, and even greater than the power of Magic? There are an infinite number of other instances to the same purpose; but let these suffice to demonstrate the usefulness of the chemical Art in natural Magic. Give me leave, however, to trespass upon your patience a little longer, whilst I add a few more observations upon this subject. The Divine Being has created the human Species in such a manner, that those in particular, who are in some measure adult, and enjoy a perfect state of health, are capable of perceiving and understanding the changes and properties of the things about us, that have a power of producing some alteration in the Organs of our Bodies, and by this means exciting ideas in our minds. This is evident beyond all contradiction, let the immediate cause of it be what it will. Now the first time that this happens to us in our life in any extraordinary instance, it generally affects our minds in such a wonderful manner, that it engrosses all our faculties, and often gives us an infinite deal of pleasure; though sometimes indeed it proves too strong for our mortal powers, and quite overwhelms us. The *Illustrious Boyle* tells us a story of a man that was totally blind from his childhood, occasioned by a Cataract in each eye, which afterwards being happily couched by a skilful hand, he was instantly restored to his sight. But what was the consequence? Why, the man was at first so vastly transported with the pleasure of seeing, that his sensations were raised to such a degree, and his Nerves so strongly affected, that he narrowly escaped falling into a *Delirium*. They were forced therefore immediately to cover up his eyes, and afterwards

terwards to let in the light a little at a time, and thus accustom him to it by degrees ; by which means, never any thing like it happen'd to him afterwards.

For the same reason, the Author of Nature has wisely provided, that the aqueous humour of the eyes of children should be always turbid, and somewhat opake, when they are first born, and afterwards by degrees become pellucid. And in like manner the external orifice of the *Meatus Auditorius* is constantly closed up with a sort of callous membrane, and the passage itself has not its proper length and curvature, by which the force of every sound would be vastly increased; by which means the child, when it comes first into the world, is secured from any inconvenience that might otherwise arise from the noises about it. Afterwards, indeed, as it grows able by degrees to bear stronger sounds, the acoustic tube is lengthen'd, and the membrane drops off of its own accord. And here give me leave to observe, how imprudently those people act, who suffer the children of Princes and great men, to be exposed to the light of abundance of candles, and shock'd with the noise of cannon fired at a small distance from them, as soon as ever they are born. If persons therefore of this rank, should ever be committed to any of your care, as seems promising from your Genius's, and indefatigable application, be sure take care, that the tender infants are not injured in this manner; either by wholly forbidding it, or at least advising, that it may be put off till a more proper opportunity. But to return: You know that we are affected in a different manner by things we are used to, and by things that happen but seldom: Hence it comes to pass, that being deceived by custom, we are apt to think we perfectly understand the nature, and causes of the former, whilst we look upon the latter as something miraculous, and are ready to believe, that they cannot be accounted for by the common laws of Nature. Those appearances therefore, that fall frequently under our observation, tho' in reality we are perfectly ignorant of their causes, we readily call natural; and on the other hand, those, that offer themselves to us, in a manner quite uncommon, we conclude to be above the power of Nature. And hence, when we see any physical *Phænomena*, which are not produced by the natural Powers which we observe in those Bodies which we have chiefly to do with, but depend on the singular properties of some particular Bodies which we are perfectly unacquainted with, there presently arises in us a suspicion of Magic. Of this, give me leave to mention the following instance. Count *Furstenburg*, a military officer, coming one day into a shop, where they were filing some iron and brass, and seeing the filings promiscuously scattered one among another, he smil'd upon *Zwinger*, who was then at his work, and ask'd him in a joking manner, what he should give him to separate the particles of Iron and Brass perfectly from one another? *Zwinger* merrily answer'd, he would do it for a very small matter; nay, even for a bottle of wine. This being agreed to, he took a Loadstone, and applying it to the heap, with a sort of incantation, to amuse the Count, call'd the filings of Iron, which came leaping and running to the Stone, and left the Brass intirely by itself. The Count, who had never seen or heard of any thing of this nature, tho' a wise officer, and brave soldier, immediately cry'd out, that it was done by the power of the magic Art. See *Zwinger's Treatise*, 239. But lastly, and I have done, when we observe any uncommon changes in the appearances of the Bodies about us, which depend upon

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some qualities of those Bodies, which nature never discovers of herself, but which then only appear, when the Bodies have been properly prepared, either by art or accident, we are then, too, ready to look upon such *Phænomena*, as the effects of Magic; which the following example may serve to illustrate. If you take the very cold Salt of Nitre well dried, and mix it with half its quantity of the purest Oil of Vitriol, and then put this mixture into a Retort, and by the help of Fire force it into a dry Receiver, in form of a very red, volatile, acid, fiery Spirit, you will then have such a Liquor, as has never been produced either by Nature or Art, in any other manner than this, which was discover'd by *Glauber*. Again, take any of the choicest strongest aromatic Vegetables that grow in the hottest Climates, boil them strongly in pure Water, and confine the Vapour with a proper head in such a manner, that it may pass through a Tin worm every way surrounded with cold Water, and it will be condensed in form of Water, at the bottom of which you will find a fragrant heavy Oil, that perfectly expresses the qualities of the Spice from which it was distilled. And this Liquor too, is the sole production of this operation. Take now one part of this Oil, and pour upon it in a quiet vessel, two parts of the abovementioned Spirit, and there will immediately arise a most violent conflict between them, they'll puff up, cause a furious ebullition, and throw out a kind of lightening, that consumes every thing that is near it. Here then you see a *Phænomenon*, the causes of which are implanted in these Bodies, but in such a manner, that they never discover themselves, except they are first managed and prepared in the manner describ'd; and consequently, the knowledge of producing these extraordinary Motions, and Flame, depends intirely upon the three circumstances taken notice of; nor can they be effected in any other natural way. Hence then we conclude, with how little reason we can pretend to limit, and determine, the powers of created beings, whatever age we live in: For there may always lie conceal'd in the bosom of Nature, infinite numbers of properties of Bodies, vastly more wonderful than any that have been yet discover'd; nay, and even those things that in one age are vulgarly known, in the succeeding are frequently lost, and when in after-time they come again to be found out, are look'd upon and extoll'd as new and wonderful discoveries. But we must quit this subject, which would carry us to a very great length, were it accurately treated in the manner it deserves.

In Cookery.

How comfortably are the necessities of mankind provided for, by the Art call'd Cookery, which preserves and prepares our Food, for the easy support of life, and is as serviceable to people in health, as Medicine is to those that are sick. Now this, tho' exceeding ancient, nay, possibly coeval with mankind, may receive a great deal of assistance from Chemistry. The acid Liquor, for instance, drawn by Fire from Sea Salt, if it is diluted with a proper quantity of Water, wonderfully preserves Fish, Flesh, and other things that easily putrify, prevents their being corrupted, gives them an agreeable taste, fits them for the easiest digestion, guards them against the bad effects of excessive hot weather, and even cures the distempers that this heat is apt to produce. And hence it is of infinite service to Sailors that are obliged to go into those parts of the world, where the Water and Fish putrify, Flesh stinks, and Bacon grows rancid, with the extreme heat of the Climate. Upon this head *John Rudolphus Glauber*, who wrote some Treatises, *De Consolatione Navigantium*, *De Prosperitate*

tate Germaniæ, and others upon the same kind of subjects, deserves the highest commendation. He, in those informs us, how a man, without any trouble, may in a little vessel carry about with him a Liquor, which only being made use of to the quantity of a few drops, will answer very valuable purposes. There too he teaches us, that by proper solution, depuration, inspissation, and preservation from the Air, we may prepare a Liquor from corrupted Corn, now-a-days called Malt, a little of which contains a good deal of nourishment; and farther, how this, with a mixture of Wheat-flour, may be made into Biscuits that will keep a considerable time, and are very hearty Food. The illustrious *Boyle*, in that excellent Piece, *Of the Use of Experimental Philosophy*, gives us an account of some simple methods, borrowed chiefly from the chemical Art, by which Flesh, Fish, and Eggs, either fresh, roasted, or boiled, may for a vast while be preserv'd from corruption. And it is this Art that furnishes us with those Pickles, that will even correct and prevent the progress of putrefaction, after it is but just begun.

The juice of Grapes, Apples, and almost all summer Fruits, if you boil and inspissate it when it is fresh press'd, may be thicken'd into a durable Mass, a bit of which being again diluted with Water, will even in winter nearly regain its native sweetness; and that, whether it is prepar'd with Sugar, or without it. If this same Juice is press'd in the time of vintage, and suffer'd to ferment, work, and deposite its Lees, it then becomes good Wine; and here, upon examination we shall find, that in almost every step, from the beginning to the end, we are obliged to proceed according to the rules laid down by our Art: Nay, and even the faults which are apt to happen in the making, and which the Wine is liable to after it comes to perfection, are chiefly prevented, and corrected, by the helps we borrow from Chemistry. If it begins to fret again, inclines to be tart, or is growing foul, it is this Science that presently furnishes us with suitable Remedies; or if you would make it into Vinegar, this will teach you by what means you may effect it. The same Art too instructs us how to prepare Wine from all sorts of pulposus Fruits: Grapes, all kinds of Cherries, Gooseberries, Berberries, Currants, Elderberries, Pears, Apples, and the various sorts of Plums, are all, by the management of the skillful Chemist, made to produce an agreeable Liquor, which truly deserves the name of Wine, and is with a little assistance equally grateful. And all these now are constantly observed to be of the same nature and efficacy; for they all agree in this general property, that the first Liquid that is separated from them by a gentle heat, is pregnant with Spirits, which will burn in the Fire, and may be diluted with Water; and this Liquor, when it is perfectly rectify'd according to Art, you will always find exactly the same, from whichever of the abovemention'd Fruits it is produced. Nor has happy *Britain* any reason to repine, that in her soil Grapes won't ripen to that perfection, as to be fit to supply her with Wine, since Nature has so liberally indulg'd her with Apples, which with proper management yield a Wine, that in the fragrance of its smell, and gratefulness of its taste, vies with the richest of *Italy*, *Spain*, and *France*. Nor is the juice of the Grapes in *Holland* rich enough for this purpose; but then, they have a way of preparing the same from Currants, Gooseberries, and Elderberries, which is little inferiour to the produce of the hotter Climates. And lastly, from Herbs themselves, after being prepared by boiling them with

In making
Wine.

a gentle Fire, may be drawn a Spirit, tho' in but a small quantity, which is considerably strong. Now after all these are skilfully made, is it not the Chemist that teaches us to preserve them, and prevent a new fermentation by the assistance of the fumes of burning Sulphur, and at the same time to keep them fresh, and secure their flavour? 'Tis from the chemical Art that we learn how to soften Wine, when it is too rough by a small mixture of Salt prepared from the burnt *Fæces* of the Wine, and how to recover it, when 'tis grown tart by a proper addition of Crabs-eyes, or Chalk. And it was to the sagacity of the Chemist, that we were beholden for the discovery of that abominable practise which some persons made use of with their sharp crude Rhenish Wines, which was a certain management of them with Lead, by which they could give them an agreeable mellowness, but which enervated and destroy'd the drinkers of it with insuperable Palsies; for which reason it was justly branded with a most rigorous punishment.

In Brewing.

Isis, and *Osiris*, instructed the countries that were destitute of Wine, by what methods they might prepare Beer from Corn, which was very properly therefore called the Wine of *Ceres*; and hence *Tacitus* tells us, that the ancient *Germans* used to make Wine from corrupted Corn. Now this the Art of Chemistry lays claim to in a particular manner, they both having their rise in the same part of the world, viz. *Egypt*. And indeed, *Basil Valentine* has elegantly given us the whole doctrine of the secrets of Alchemy, in his description of the Methods of making Beer, which he has examined with all possible nicety and accuracy. But there's no need to enlarge upon this head; for as there is very little difference between Wine and Beer, what has been said of the usefulness of the chemical Art in the former, your ingenuity will easily apply to the latter.

And thus, Gentlemen, I think I have sufficiently made appear the abundant services that all the mechanical Arts, or the chief of them at least, receive from Chemistry. And hence, I believe, I may safely conclude, that if the particular Artists in the different branches of Mechanics, had a good knowledge of the chemical Art likewise, they would be able to improve their several professions to very great advantage. There are therefore very many and weighty reasons, that urge us to apply the Art of Chemistry to all other Sciences that are engaged in the examining and changing of natural Bodies. And this we should do with a resolution, carefully and faithfully to take notice of every thing that we may be so happy to discover, which we should afterwards digest in order, and publish to the world; that thus, by the united labours of us all, human Arts may be improv'd, and carry'd to still greater and greater perfection. What I have been able to contribute to this valuable purpose, I have given you; I confess, indeed, it is but a little: In this view, however, the pains I have taken, will be of some advantage, if it serves to incite other persons of a happier genius, and greater application, to make more useful Discoveries.

In Alchemy.

And now at last we are come to lay before you a few simple observations concerning the excellent usefulness of the chemical Art in Alchemy; where I shall candidly represent the affair exactly as I have found it. Among all the Writers of Natural Philosophy, it has not yet been my fortune to meet with any, that have more intimately examined, and evidently explain'd the nature of Bodies, and the effects they are capable of producing, than those that have gone

gone by the name of Alchemists. For the confirmation of this, lest I should be unjustly suspected of prejudice, I beg you will read, but with a vast deal of attention, the works of the principal, true, professors of the alchemistical Art. Give me leave upon this head, to quote *Raymond Lully*, in that Treatise of his, which he calls *Experiments*. There you will see with what perspicuity he explains the nature and actions of Animals, Fossils, and Vegetables, and that purely from simple experiments, without any circumlocution, disguise, or fiction; and I am satisfied, you will candidly acknowledge, that you can scarcely find these things treated of in such a manner any where else. The observations, says that Author, that Bodies resolv'd by our Art, expose to the Eyes, and discover to the Mind, are of infinitely more force to gain the assent, than the utmost strength of pure Argument; by these we perform what we assert, and give Examples of what we inculcate. And it certainly must be allowed, that he did as he said: So that in reality, these men attempted to found such a Philosophy, as the great Lord *Verulam* so earnestly wish'd for; which should consist in the right comprehending and explaining to others those powers of Bodies, which being in action, would constantly produce certain determin'd effects; and hence should lay down no other causes of things, than what being at any time supposed, would certainly and readily effect those very things, thus always performing at pleasure whatever it asserted the truth of. They laugh'd at the subtle universal causes, which the Schoolmen, making an ill use of their leisure, imposed upon the learned world; for these were intirely the effect of pure speculation, and the knowledge of them did not at all qualify the possessor for any physical operations. And hence they most carefully inculcate throughout their Philosophy, that it is absolutely impossible for the utmost Art of man to produce any effects in natural Bodies, which shall exceed those powers that the divine Being has implanted in them: That some of these qualities lie open, and manifest to every one's observation, for the necessary uses of life; whilst others of them are more abstruse and conceal'd, and are only discover'd to those persons, who with diligence and constancy wisely apply themselves to search out the deeper and more hidden Works of the great Creator: But that both nevertheless are to be regarded as equally natural. They assert, therefore, that no person living, even supposing him to be possessed of all the wisdom of past and future ages, can ever, with all his skill, either create any one single Being, a grain of Mustard-seed, for instance, out of nothing, or produce it from any other kind of matter, that is of a different nature: But that prudent men, however, by receiving and examining created things, as they are offered to their observation, may, by the help of proper Experiments, come afterwards to discover by what law Nature acts, and what methods she pursues, in forming, producing, and perfecting every particular Being, according to its proper and peculiar Nature. And here they observe, that this is found to be the grand principal law, that every thing is generated from something of the same kind that first existed. Thus Plants spring from Plants; Animals from Animals; and Fossils from Fossils. They further assert, that the whole power of Generation consists in one seminal principle, which digests and changes the crude matter it receives into its own likeness, and forms it into a resemblance of the original: That in order, however, to a fruitful procreation, there is absolute-

ly required both a Male and Female, without whose natural conjunction, no Offspring can ever be produced: That when the prolific Seed is safely secured in the Matrix or Womb that nature has design'd for it, and has there for a convenient time been cherish'd, and supported with a kindly warmth, and proper nourishment, there will then appear a new Being resembling its father; whereas if Nature is any ways broke in upon, and disturb'd in her proceedings, her designs will prove abortive, and the thing that was intended will not be accomplished. Hence they infer, that after creation is once perfectly compleated, there is nothing begotten *de novo*; but that all things spring and increase according to certain laws, purely from the Seeds of something of the same nature that was in being before; that any created thing therefore, by means of its Seed, may be multiplied *in infinitum*, but not without it; and consequently, that the whole face of the Earth might be covered with one sort of Plant, as Fennel, for instance, if its Seed was continually gathered, sown, and cultivated, as its particular nature requires. They remark yet again, that there are found in Nature some Bodies, and those generally exceeding simple ones, that are not observ'd to have any seminal power in them; and hence, neither increase themselves, or transmute any other Bodies into their Nature, but serve, either to put every thing in motion, as Fire; to dilute, and be a proper vehicle for nourishment, as Water; or to give strength and stability to compound Bodies, as Earth, when it is perfectly pure. Now these things being found by an infinite number of Experiments to hold good in all other parts of Nature, they at last discover'd, that even Fossils were subject to the same universal law. For tho' their natural simplicity, and the similarity of their parts are inconsistent with the organical, compound, fabric of a Seed; yet they are found to be indued with a certain innate faculty, by which they can attract a proper *Pabulum* for their increase, and apply it in such a manner, as to be hence continually propagated. They add farther, that the Spirits called *Reſtores* are sealed up, and do not appear in Metals so long as they are dead; but that when they are resolv'd, open'd, and vivified, they then manifest themselves, and produce very sudden and wonderful effects; and that even here there is a kind of prolific union; for they tell us, there is an impregnating Male, and a fruitful Female, by whose procreating power live Metals do propagate their Species. Nor have they conceal'd from us, by what methods Metals may be made alive, with what degree of Fire they must be managed, in what proportion they must be mix'd, and with what *Pabulum* they must be nourished, in order to make them capable of being multiply'd as long as you please. And lastly, they assure us, that Metals alone, on account of the extraordinary simplicity of their Nature, may be produc'd in the least time imaginable from a mercurial heavy fluid, fix'd by a sulphureous seminal principal, if they can but be intimately mixt by the assistance of Fire, and join'd together with an indissoluble union: That thus Mercury is the Mother of Metals, and the quickening Sun the Father: And hence, that that may be effected upon Metals in the twinkling of an Eye, if they are first artfully and properly vivified, which would not have been brought about by a subterraneous Fire in the Bowels of the Earth under a long *Series* of years. They confess'd, indeed, that in the Vegetable, and Animal Kingdoms, the action of procreation is limited, and determined by nature within its proper time: And that it was impossible it should be otherwise, considering

considering the exceeding tender nature of the Seed, its compound, intricate, and curious structure, the very various, and numerous parts of which it is composed, and how easily the living spark in the center of the prolific Sulphur, or the little Embryo, might be destroy'd. But at the same time they tell us, that in the pure Metals, Gold, Silver, and their Mother, Mercury, there is such a similarity of parts, that every individual particle is perfectly of the same nature with the whole Mass: That they are observed to be so greatly immutable, that neither the gentlest or strongest Fire is capable of destroying them: That the prolific seminal power resides in Fire, and hence acts with infinite celerity, and in a moment assimilates the mercurial matter that is suitable to it: That upon this principle depends the increase and procreation of pure Metals: And that thus may be prepared the *Philosopher's Stone*, which will convert all other Metals into Gold; on which head, if you desire to know my opinion, I'll give it you freely.

The wise *Socrates* having a Book of *Heracitus's* given him to peruse, that was wrote in a very intricate and abstruse manner, he read it over with a great deal of care, and when his opinion was desir'd concerning it, the great man answer'd, that in those places where he understood it, he found it excellently well done, and believed it was the same, where he was not able to comprehend it; but that it required the most subtle penetration to come at the sense of it. In the same manner, where I can discover the meaning of the Alchemists, the truths they deliver appear very evident, and are express'd in the most simple terms, nor are they often mistaken themselves, or do they impose upon others. When I come therefore to passages where the sense is more obscure, why should I pretend to condemn them of being in the wrong, who have shewn themselves vastly my superiours in the Art, and from whom I have got a great deal of information, where they thought it proper to express themselves clearly? For they themselves declare, that when they come to treat of the utmost limits and perfection of the Art, they designedly tell us no more than that the Art is true, in order to excite proper persons to pursue and discover it: That they are obliged in honour, not to publish a secret that might be abused to a great many ill purposes: And that it is enough, if they point out to us the tract that Nature teaches us to follow, and prevent our falling into errors. For this reason therefore, I am rather apt, in these circumstances, to lay the fault on my own ignorance, than to accuse them of vanity. With proper deference, however, I must take the liberty to make the following remark: When I read over the Secrets of those excellent Artists and great Masters of Nature, I am apt to doubt, whether, after they had by pure observation made so many, and such singular discoveries, they did not arrive to such a quickness in perceiving the consequences of things, as led them to relate those things for facts, which they judg'd might possibly be, nay, and certainly would happen, if they had prosecuted the inquiries they had in their view. And indeed, *Alexander Suchtenius*, a considerable Author in Alchemy, who was a scholar of *Paracelsus*, and a zealous defender of his Doctrine, seems to intimate something of this nature; for after having try'd a great many things to no purpose, he tells us, in the end of one of his Treatises of Antimony, that all the Philosophers, of which he there mentions the chief, died before they had brought their speculations to a proper issue. Now supposing this to be true,

true, which I don't pretend to determine, yet every grateful mind will think itself vastly obliged to them for discovering to us those physical truths, which it cost them an infinite deal of pains to come at the knowledge of. And the great Lord *Verulam* very properly compares them to a Father, who when he was dying, made his lazy Sons believe, that in a certain field he had hid a treasure; upon which, as soon as ever he was dead, they went to digging, in hopes of finding the riches, but were baulk'd in their expectations, tho' the service they did the Land abundantly recompenc'd their trouble. These few things concerning the knowledge of the true Alchemists in Natural Philosophy, I have long desired to make known, that they may not be misrepresented, and condemn'd by persons, who are no ways capable of forming a proper judgment of their abilities. The chief performances the Alchemists pretend to are, as follow:

The preparing the *Philosopher's Stone*; a small portion of which being thrown into Metals, whilst they are in fusion, will in a moment transmute the true mercurial part into *obryzum* Gold, purer and finer than was ever dug out of the Mines, or procur'd by any docimastic Art; and at the same time will instantly consume and dissipate every thing contain'd in the Metals, that is not of a metallic mercurial Nature. This, they say, is of the same weight with Gold, brittle like Glass, of a very deep red Colour, and runs in the Fire like Wax.

The making another Stone of the like Nature, call'd the *Lapis Argentifiscus*, which will in the same manner turn all Metals, except Gold and Silver, into the most perfect Silver.

The carrying the *Philosopher's Stone* to such a degree of perfection, that being cast into melted Gold, it will totally convert the Gold into the *Philosopher's Stone*.

And the exalting this still higher, so as to change pure Mercury intirely into the same Stone.

They say farther, that they have discover'd a Body prepared by Art, which is of such vast efficacy, that if it is mix'd and united with any thing, either in the Animal, Vegetable, or Fossil Kingdom, it will so far improve their natural inherent vertue, as to render them the most perfect in their kind. In the human Body, therefore, it would prove a universal Medicine, so disposing both its Solids and Fluids, that it would become absolutely sound, and would continue so, till it was gently consumed and worn away by the necessary actions of life itself, and then would leave the world easily, and without reluctance. The same thing too it would effect in any living Animal; and if it should insinuate itself into the roots of Vegetables, it would greatly increase both their beauty and fruitfulness. To this noble figment they gave the name of the *Universal Ferment*.

They pretend likewise, to make artificial Gems, that shall perfectly resemble, and be of the same value with natural ones.

And to exalt the baser imperfect Metals into Gold, by carrying on their coction and purification from that step, where Nature was defective and left off. For it is their opinion, that the ultimate design of all Nature's operations in the Mines, is the production of Gold from Mercury by the assistance of Fire, and by refining and filtering it through pure dense Bodies: That if she is hindered in her proceeding, either by the want of Fire, the looseness of the passages through

through which it runs, or the mixture of any heterogeneous matter with it, there then arises a crude Metal which is not perfectly homogeneous, and hence mutable by the Fire. And thus they say are produced all Metals except Gold, Silver, and Mercury; which, nevertheless, may be still so far perfected by Art, as to be converted into Silver and Gold. This last, however, was not the universal opinion of the Alchemists. And indeed, Lead, Tin, Copper, and Iron, seem as perfect in their kind, as Gold; and are always found to be precisely of the same determinate nature. And, perhaps, the particular nature of Copper may render it as fit, or fitter, both for philosophical purposes, and the common uses of life, than either Silver, or Gold, although it is less simple, and consequently more changeable. Nor in reality is it at all probable, that this Metal should, by any continued subterraneous digestion and separation of its heterogeneous parts, be ever exalted into Gold, or become any thing but the most perfect Copper; which is likewise true of all the rest. I confess indeed, that something of Gold may be obtained from what we call the baser Metals, if they are kept a long time in the Fire; but then it is not certain, whether this is actually produced there by carrying on those Metals to greater perfection; or whether it is only separated from them by the force of the Fire. Nor can I easily conceive how it comes to pass, that lead, which of all solid Bodies, comes nearest in weight to Gold, should be reckoned so much more distant from it in nature than Silver; since all the Adepts assert with one consent, that the Demonstration from weight is of more force than any mathematical one. But I have sufficiently tired both your patience, and my own, upon this subject, and therefore to conclude. Let us never imagine that we are able to determine how far the powers of nature may extend. Those things are looked upon as impossible, that ignorant people are not acquainted with. The ancientest Philosophers gave some hints of an eternal Fire, solid, and durable even under Water; and were ridicul'd for their pains as a parcel of idle men: But since it has been discovered by *Craftius*, improved by *Kunkel*, described by *Boyle*, more clearly explained by *Newentyt*, and most plainly of all treated of by *Hoffman*, the possibility of the thing is actually demonstrated. The artificial Thunder and Lightning of *Roger Bacon* were looked upon for a good while as fiction, and deceit; but they afterwards were made appear by *Schwartz* to have too much truth in them. And the other things that I have mentioned in natural Magic, to persons perfectly unacquainted with Experiments, will seem much more incredible than the transmutation of Lead into Gold with regard to its mercurial part, its original form being first perfectly destroyed. There are inconveniences in being too credulous; and so there are in being too sceptical. It is the business of a wise man to try every thing, and abide by that which he finds to be true; nor ever to prescribe limits to the power of the omnipotent Governour of the universe, or the natural beings which he has created.

Now we are upon this head give me leave, before we proceed, just to mention the *Apparatus*, that the greatest Masters in the Art declare to be absolutely necessary for bringing this grand *Arcanum* to perfection. And first they all agree, that Gold, Mercury, and Fire, are principally requisite. As also Lead, Iron, Antimony, and Nitre, and the nitrous spirits drawn from it. A Cupel. A glass Pestil and Mortar. A Retort, Receiver, and pure Water. A Fur-

nace,

nace, Bellows, filtering Papers, a glass Egg, or Matras, and an Athanor. The whole charge of which upon computation never amounts to 20 l. Sterling, setting aside the value of the labour.

Of the Instruments of Chemistry.

Having thus, Gentlemen, explained to you the Bodies about which Chemistry is engaged, and the ends that it chiefly proposes in the changes it produces in them, I suppose of course you will be desirous to be informed by what methods these may be brought about; which I readily comply with. As it is impossible now that any Art can produce effects without proper instruments; hence these, of consequence, come first under our consideration. A person, for instance, desires that I would acquaint him, what it is in Wormwood that gives it its bitter taste, and that I would separate that part from all the rest. Now here I must know that Water just ready to boil will fetch all that is bitter out of the plant, if it is poured on, digested, decanted again when it is impregnated, and this is repeated so long till the last after standing some time comes off as insipid as it was put on. The Plant then will intirely have lost its bitterness, which will all be contained in the Water: And here you see evidently, that Fire, and Water, are the Instruments made use of in this Operation.

For in every Art that instructs us in the changing of Bodies, that particular thing is called an Instrument, which either has or may have given it a certain peculiar motion, which being applied to the Body to be changed will produce such an alteration in it, as the Art had before determined. And thus in Chemistry we have Instruments by which we are able to perform the actions we desire; and these we usually reduce to six, as the principal, with those Chemists who have cultivated the Art with the greatest accuracy; and they are as follow. Fire, Water, Air, Earth, the Solvents which the Artists call *Menstruums*, and the common furniture of the Elaboratory; all which the Chemist ought well to be acquainted with, if he would rightly understand the Operations, which are effected by the help of them. Of these therefore I shall treat in the order I have mentioned them, beginning first with Fire, as there never was, or can be any chemical Operation, in which Fire is not concerned; which is not so universally true of the rest.

Of FIRE.

The power of this is so great, its effects so extensive, and the manner of its acting so wonderful, that some of the wisest nations of old revered and worshipped it, as the supreme Deity. Some of the Chemists too, after they had discovered its surprizing vertue, have suspected it to be an uncreated Being. And indeed, the most famous of them have acknowledged it as the source of all their knowledge; and hence have professed themselves Philosophers by Fire, nor thought they could be honoured with a nobler title. Now among all the wonderful properties of Fire, there is none more extraordinary than this, that though it is the principal cause of almost all the sensible effects that continually fall under our observation, yet it is itself of so infinitely a subtil nature, that it eludes the most sagacious inquiries, nor ever comes within the reach of our senses: and hence others have been led to be of opinion that it ought to be looked upon as spirit, rather than Body. It

Fire of a
wonderful
nature.

It is necessary, therefore, if we would keep clear of mistakes, to act with the utmost caution in our searches after a thing whose nature is so hidden and mysterious. And for this reason we must absolutely disengage our selves from all mere speculations, nor give into any precarious *hypothesis*, how plausibly soever contrived, unless we would run headlong into confusion, and uncertainties: For if at setting out we lay a wrong foundation, the errors that arise hence will diffuse themselves through all the branches of natural Philosophy; since in all the productions of natural effects, Fire, as I observed before, has always far the greatest share.

To be in-
quired after
with cau-
tion.

When we set about therefore to inquire what Fire really is, we must begin perfectly as though we knew nothing of the matter, and must intirely lay aside every notion that we had formed of it before. And here we must follow the analytic method of the Geometricians, who in order to come at the knowledge of any thing, proceed as though they were ignorant of it, and that they may constantly keep this in their eye, represent it always by some sign that only expresses something unknown, and that is then sought after. Nor do these religious Observers of truth, in their inquiries after things they are not acquainted with, ever make use of any other properties, than what are evidently observed in the things themselves, or have been before clearly demonstrated.

Not from
Hypothesis.

And I will venture to assert, that this extraordinary circumspection is never more necessary, than in the subject we are at present engaged in: For the Elements of Fire pervade and reside in the most solid matter of Gold, as well as in the most perfect *Torricellian vacuum*, and are equally dispersed and distributed through all Bodies, and every part of space; as will be evidently made appear hereafter. And hence it comes to pass, that there is nothing in our philosophical Inquiries more difficult, than truly to distinguish the particular action of Fire from that of the other causes that in every physical Operation concur with it; and yet the nature of Fire is so vastly different from theirs, that they cannot be confounded with one another without the utmost impropriety, and danger of mistakes.

One difficul-
ty in this
Inquiry.

There is yet another difficulty that puzzles the Philosophers in their searches after Fire as much as the former, and that is, the vast subtlety of its particles, which in their fineness not only exceed every thing yet known, but penetrate into the most solid, and even the smallest Corpuscles that ever fall under our notice. And hence it comes to pass that we find such very different, and absurd opinions concerning its nature, even among those Authors, who have studied it with the greatest diligence, and happiest success. And the errors that have risen hence, have not only infected Chemistry and Philosophy, but have also spread themselves into the medicinal Art, as every Physician must acknowledge, who has carefully considered what has been advanced concerning innate Heat, radical Moisture, and many other things that depend upon them. Let us therefore in our Inquiries on this subject proceed as if we were perfectly unacquainted with it; and let this be the case, 'till we are able to come at some certainty about it.

A second.

It is impossible, however, with our utmost endeavours, so to disengage our thoughts in this affair, as not to retain at least that idea of Fire, by which every person says he knows whether it is present in any particular place, or is absent.

The signs
of its pre-
sence to be
first investi-
gated.

absent from it. For it is absolutely necessary that this mark should be perfectly obvious to our senses, and that we should all agree about it; otherwise the word Fire even among persons that talk the same language, would signify nothing at all. And the same Observation equally holds true of every thing else. If a person should say, for instance, that he knows nothing of the nature of Thunder; yet still under this word he conceives this notion of it at least in his mind, that it is something that produces a very extraordinary noise in the Air, and thus understands the same thing by this term as every body else does, nor will easily confound it with any thing else. In like manner, both the learned and the ignorant, if they use the same speech, as soon as ever they hear the word Fire, immediately think of the very same thing. And indeed were not this the case, that word would have no more effect upon the person that heard it, than if it had been spoken to an *Indian*, or an *African*.

The requisites in these signs.

Now this general mark or character must belong so peculiarly to Fire, that it must not be common to any thing else; for otherwise, we shall be constantly at a loss how to distinguish Fire from any other of those things, that this property might equally point out.

Nor is it less necessary that this mark should be an individual one, and absolutely inseparable from Fire, so that wherever Fire actually exists, this should also most certainly and constantly be present with it; for by this means alone we shall be able to come at the knowledge of it, a sign being of no manner of service, if the thing signify'd may nevertheless lie concealed, and not be discovered by it.

And lastly, it is absolutely requisite, that this character should lie open to our senses, and easily affect them; and should plainly point out to us the degrees in which Fire increases, decreases, or continues in any space, or Body. If these three properties, therefore, are found together in any character of Fire, we may venture to make use of this for our purpose.

The use of such a sign.

And then safely relying upon this, we may cautiously proceed to some physical Experiments in order to get a farther insight into the nature of Fire, which though indeed it lies out of the reach of our senses yet, by this sign will certainly discover its being present: Especially, if we set about our Inquiries with prudence and diligence, on purpose to examine into its hidden properties, when we are once undoubtedly sure of its presence. And, then besides, any accidental discoveries that unexpectedly offer themselves to our observation in the prosecution of these Inquiries, will likewise prove of service: For both these will serve to furnish us with arguments, which being properly reduced into order, and rightly improved, will help us by degrees to an insight into the nature of this abstruse, and mysterious Being. And how can we be afraid of falling into mistakes, whilst we pursue this method, which is universally approved by men of the soundest judgment, as the only certain one in searching after natural knowledge?

The difficulty of finding such a sign.

It must be acknowledged, however, that it is exceeding difficult to discover such a mark of Fire as will always demonstrate its presence, let the quantity of it be ever so small; and that for the following reason. Upon examination it evidently appears that there is an incredible quantity of true Fire even in those places, where every body not only judges there is none, but imagines there is really something of a quite different nature. In a hard frost, for instance, it will be demonstrated,

demonstrated, that Fire is actually contained in the very coldest masses of Ice, and may be instantly produced from them with a great deal of violence: And yet at that time it no ways manifests itself to our senses; not one of its actions appears; nor any of the effects that are commonly ascribed to it. I don't pretend, therefore, to lay down any mark, by which a person may be sure of the presence of the very least quantity of Fire; but I'll venture to offer one which will certainly discover it when it is somewhat greater; which will be sufficient for our purpose. And as in Bodies, we have no idea of great, or small, except by comparing the Bodies, either with one another, or with some certain measure: So here, though the absolute quantity of Fire in a given place, cannot by any sign be rightly determined; yet we are able to demonstrate how much there is more, or less of it there, than in any other place assigned. In like manner it is difficult to ascertain the absolute degree of Fire in any particular point of time; and yet the various degrees of it at different times may be easily compared with one another.

Whilst we are engaged now in pursuit of the marks abovementioned, those effects first offer themselves to our observation, which are produced by the power of Fire alone, and by which, when they are manifest to our senses, we universally infer the presence of Fire. These therefore we may fairly make use of for the present. For if those physical changes which are the sole production of Fire very easily affect our senses, they will serve as a certain indication of Fire; and if these constantly appear wherever Fire is generated, we shall come, in reality, at the very thing we desire. Nor need we here be over solicitous lest among these effects there should be sometimes intermixed others, that owe their being to some other causes; for when we come to consider them more nicely, we shall easily be able to distinguish those that are proper to Fire, from those that are common to it with other Bodies. Let us therefore at first assume those properties only that are commonly, and universally ascribed to Fire; and afterwards proceed to examine them with care, and accuracy, in order to make a proper discovery of those among them, that we are particularly in search after. Now of these the following are the principal. 1. Heat. 2. Light. 3. Colour. 4. Expansion or Rarefaction, both of Fluids, and Solids. 5. The power of burning, melting, &c.

Such signs are the sensible effects produced by Fire.

These therefore let us consider in order. Heat then in the first place is ascribed to Fire, and that with the greatest reason, as they are most intimately connected together. And yet if we closely contemplate this very idea of Heat, we shall easily perceive that people mean nothing more by it, than a certain sensation of the mind, excited by the application of Fire to the sensible parts of the Body. But by this perception certainly we understand nothing of the action of Fire, or the alteration that is produced in our organs of sensation by it. And hence Heat, considered only as it exists in the mind, whence alone it receives its name, does not really signify any thing corporeal, but indicates only some affection, or change of our thinking faculty. When any person is hot, he has a clear and distinct idea of what he feels at that time; but yet he will never thence be able to obtain the least knowledge of Fire, or the changes that it then produces in him. Let me ask you, Gentlemen, what it is you feel in yourselves, when you say you are warm; is it not a perception of somewhat agreeable? Now compare this with what the Physicians are of opinion

The examination of these, and first of Heat.

happens then in the Body; and what a prodigious difference! They tell us that during that time a most subtil Fluid is moved in the capillary Nerves after a particular manner: But is it possible that ever such a notion as this should enter into any person's mind purely from the sensation of warmth, should he be affected with it ever so often? But consider again, what is the standard by which every one measures his proper degree of Heat? Why, so long as a man enjoys perfect health both in body and mind, he will confess that the kindly warmth he then feels, excites an agreeable sensation in his mind. If this afterwards lessens by degrees, and at last becomes imperceptible, he then says he is cold: As on the contrary, if it is increased beyond that degree which affected him with pleasure, he complains of a troublesome Heat. But there is nothing in all this that will be of any service to us, as a Criterion of Fire. Besides, as in all other circumstances, so here, the degree of Heat that we are constantly accustomed to, we are not sensible of; and hence we are apt to look upon every degree of it, that is less than the natural, or usual one, as no Heat at all; which leads us continually too into mistakes: Whereas on the contrary, those persons that have for a long time been inured to cold, are thence affected in a very different manner from what others are. It is an old Observation that subterraneous places afford a most refreshing coolness to persons melting with Heat in the sultry Dog-days; and that on the other hand, when the Body is almost frozen with the winter Cold, it will perceive a kindly warmth in the very same places. And hence it has been falsely inferred, that these places under ground undergo a true *Antiperistasis*, and grow colder in Summer, and warmer in the Winter; whereas we certainly know that cellars considerably deep are colder in the former, and warmer in the latter: Indeed if they are sunk to a very extraordinary depth, the degree of Heat continues always pretty nearly the same. From all this we conclude then, that the informations we receive from Heat are very precarious and uncertain. For your farther satisfaction, however, I will mention one instance more, of great consequence too in Physic, which will still farther confirm my assertion, that we can by no means determine with any certainty the quantity of Fire, by that Heat with which our senses are affected. In the summer time, when the Heat grows excessive, suffocating, and intolerable to persons in health, occasioned either by the reflexion, or refraction of the Sun from the Clouds, there follows very frequently Thunder and Lightning, with large showers of Rain, and sometimes of Hail; and this no sooner happens, but the Air grows chill, and this very troublesome Heat is succeeded by Cold. With this sudden change we are ready to shudder, and feel as though we were pierced through with a Winter's Frost; and yet I have found by repeated Observation, that the Air at that very time, though it seems so cold, is in reality so very warm, that should the same come upon us suddenly after a very hard frost, the Heat of it would be greater than we could possibly support ourselves under: For should a room, in the sharpest frosty weather, be heated to the same degree, as the Atmosphere is in the month of *August* after such Thunder, there is no person living who had been abroad a good while in this piercing Cold, that could bear the Heat of this room, but would soon faint away. From the whole therefore we conclude, that Heat is a very uncertain measure of the quantity of Fire.

Secondly of
Light.

Again, Light is looked upon by judicious Men as a most certain Demonstration

stration of the presence of Fire. For, say they, does not this offspring of Fire evidently point out its parent, and hence imagine, that the stronger, and brighter its rays are, the greater quantity of Fire is really contained in it; and that on the contrary this decreases in the same proportion, as the splendour of that noble Being is diminished. This therefore they imagine may be laid down as a mark of Fire. But how little, Gentlemen, are they acquainted with experimental knowledge that are of this opinion? If you make any doubt of this, put a piece of Iron in the Fire, and let it remain there 'till it's almost red hot, then carry it into the dark, and it will afford no light at all; and yet if you apply it to the body of an animal, it will burn it to the bone, nay the very bones themselves, with a hissing noise, and a very disagreeable smell; or if you lay it upon a piece of dry wood, you will produce both sparks and flame. Here, therefore, there is a vast deal of Fire without the least appearance of Light. On the other hand, take a concave *Speculum* made of solid Metal, and exactly polished, and in a clear winter night oppose it to the Moon when it is at the full and upon the Meridian, then place a piece of white paper in the *Focus*, so that it may receive the contracted image of the Moon, and you will have so refulgent a Light, that the strongest eyes will not be able to bear it; and yet in the center of the *Focus* there will be a very piercing Cold. The same Experiment was performed by that famous *English* Philosopher Dr. *Robert Hook*, (who seemed formed by nature for Experimental Philosophy) with a double Convex-glass, and the image of the Moon received upon a paper in the *Focus* was excessive bright; and yet upon putting a very nice Thermometer into the *Focus* there did not appear the least sign of Heat, or Fire. The same thing was afterwards confirmed by *Tschirnhausen's* glasses at *Paris*, *Mem. de l'Ac. Roy. des Sc.* 1699. p. 110. And lastly, in the *Focus* of *Vilett's* Mirrour directed to the Sun at mid-day, there is not the least appearance of a lucid image, unless it falls upon an opaque Body, or a person should on a sudden fatally put himself directly against it; and yet there is in that very place a Fire so intensely hot, that it is able in the least instant of time to melt even stones themselves. Now will any one pretend that Light can be a proper measure of the quantity of Fire, when we evidently see, that there may be the strongest Fire without any visible Light; and on the other hand, the most refulgent Light without producing the least degree of Heat?

Upon the head of Colour now, there is little room to say any thing: For as this is either Light itself, or a various reflexion of Light from opaque Bodies, it is evident from what has been demonstrated of Light's being an insufficient mark of Fire, that Colours of consequence must be much less so. And Colours

As these, therefore, do not answer our purpose, we must carefully examine the remaining effects of Fire, to see if we cannot at last discover one of them, which will serve us as a certain token, and a proper measure of the presence, and quantity, of this most active Element. But alas, Gentlemen! the more accurately one contemplates them, the readier one is almost to despair of gaining one's point, they appear so full of contrarieties. If we consider, for instance, its power of attenuating Bodies, why we see, on the other hand, that a great many are more closely compacted together by it. Some are consolidated by this Element, whilst it has a power of dissolving others. Many it separates into different parts, though at the same time it unites, and combines others more And the other effects of Fire.

intimately, than can be effected by any thing else; as we see plainly in the making of Glafs, and the mixing of Iron and Gold. But this fruitful argument will carry me to too great a length: In short, therefore, I'll venture to assert, that you can scarce mention any one effect of Fire, which you may imagine to hold good in all Bodies, but I'll shew you a quite contrary one produced in some, by the very same Fire. You'll be apt therefore to say, does then this wonderful cause produce no one effect, which is always, and every where the same, perfectly inseparable from it, and constantly invariable in every kind of Object? Why, Gentlemen, I believe there is such a one; and by the most faithful, and diligent inquiries I have been able to make, I never could discover any more.

The rarefaction of Bodies a mark of Fire.

For upon a careful examination of natural Bodies, I don't find any one to which that Being may not be applied, which we generally call common Fire, whether solar, artificial, or subterraneous: But ever body, without exception, that has been hitherto try'd, upon its being united with this Fire, increases in its magnitude, swells, and rarefies, without any apparent alteration in its weight. Nor does it at all signify whether they are solid, or fluid; hard, or soft; light, or heavy; for the same law holds constantly and universally true in all.

If you take two Bodies, however, of the same bulk and weight, one of which is solid, the other fluid, you will always observe this difference, that the fluid one will suffer a greater expansion from the same Fire, the solid one a less: At least, I have never found it otherwise in those that I have hitherto made trial of. Fluids, therefore, are more proper for the examination of Fire by this effect, than Solids. But again, I have constantly found, that those Liquors which are less dense, and light, are always the most rarefied by the same degree of Heat; and consequently, the expansion of the lighter Fluids will most sensibly affect us, and are therefore the most suitable to indicate to us the very minutest augmentations of the smallest Fire. The truth of this I confirm by the following Experiment: You perceive, that this Glafs in my Hand, which consists of a spherical Body, and a narrow cylindrical Neck, is fill'd with fair Water as high as this mark which you observe on the Neck; as soon now as I dip the bulb of the Glafs into the warm Water that is contain'd in this open vessel, you see immediately that the Water in the Neck rises above the first mark, and ascends continually, so long as it acquires a still greater and greater degree of Heat. Again, if I take it out of this Water, and put it into that other which is somewhat hotter, you perceive that it rises still higher in the Neck of the Vial. And lastly, as I move it nearer and nearer to the Fire, you discern that it is more and more expanded; and that it descends again by degrees, as soon as ever I remove it farther from it. Now does it not hence very plainly appear, that the Water is expanded by the Fire, so as to take up a greater space when it is heated, than it did when it was cold, and that, without any sensible increase of its weight? And is it not as evident, that this solid glafs Vessel is not equally dilated with the Water; since, tho' this is heated to the same degree, and indeed sooner than the Water, yet the Bulb is not now able to contain it as it did before, and therefore some of it rises into the Neck? Again, please to turn your Eyes this way, and here you'll see how much quicker Alcohol of Wine rises in this Glafs, when it is immersed

immersed in the same hot Water, and how swiftly it mounts to the very top of the Neck, so that it is ready to run out at the Mouth. Hence then, with me you will readily infer, that Alcohol, which is lighter than Water, is sooner, and more rarefied by the same degree of Heat. These Experiments therefore, tho' they may seem plain and trifling, evidently confirm the truth of what I asserted. And I wish that those Gentlemen who have had a thorough knowledge of Hydrostatics, had given us the comparative weights of all the Fluids we are hitherto acquainted with: Then, possibly, I might have been able to lay down this as a general Rule, which the consideration of many of them suggests, *viz.* that the spaces of expansion from the same degree of Fire, are to one another, as the rarities of the expanded Bodies, or in a reciprocal proportion of their densities. These that follow are found, by Experiment, to succeed one another nearly in the order they are mentioned:

The lightest of all Fluids is the *Vacuum* of *Torricellius*.

Then *Boyle's*.

Air.

Alcohol.

Pure distill'd *Petroleum*, *Boyl. Mech. Qual.* 88.

Spirit of Turpentine.

Water.

Vinegar.

Aqua Fortis.

Spirit of Nitre.

Oil of Vitriol.

Mercury.

See the great *Boyle*, in his *Medicin. Hydrost.*

If seems, therefore, as if the easy expansion of the lightest Fluids, might serve as a certain mark of the presence, increase, or decrease of Fire: For this no ways depending upon our senses, which we find in these inquiries to be so uncertain a guide, will not easily lead us into mistakes. Besides, this will determine to the greatest exactness its very smallest increments, or decrements, which cannot be so nicely adjusted by any other method that I am acquainted with. And there is yet this further advantage in it, that it may most expeditiously be called into use in any place whatever that you have a mind to, even in the inside of Bodies, as well as without them; for it is always and every where equally ready for service. And lastly, it has this excellency in it, that this expansion of Bodies by Fire, if it is effected in a Glass hermetically sealed, cannot be produc'd by any other physical cause hitherto known. We have now therefore at length discover'd that property of Fire which we were in search after; which may, and ought to be regarded as a true, certain, individual, and proper mark of Fire. This then alone is what we shall make use of as we proceed in the investigation of its Nature; and we shall take it for granted, that in every *Phænomenon* where we see this rarefaction excited, there is there a proportionable degree of Fire as the cause of it; by which means we shall have an opportunity of examining it in almost every circumstance, and hence may fairly reason about its hidden Nature, which will discover itself to us in every Experiment of this kind. Now in the prosecution of these inquiries, we shall begin with the most plain Experiments, and proceed in order to those

those that are more uncommon ; and thus lead you by degrees from the simpler, to the more abstruse properties of this Element.

EXPERIMENT I.

Iron is enlarged by Heat in all its dimensions.

Fire expands the hardest Bodies in all their dimensions so long as it is contained in them.

Which I thus demonstrate. You see these two iron cylindrical Rods, which are exactly three feet long, and pretty nearly of the same thickness, as you perceive by their just passing through this iron Ring.

One of these I'll put into the tower of this Athanor, in which there is a Fire ; and when it has been there a sufficient time to heat it, I'll take it out again. You see now that it is almost red hot, and that when I apply it to the other Rod that is cold, it exceeds it in length very considerably since it was put into the Fire.

Decreases again as it grows cool.

You observe farther, very evidently, that as it cools, it grows every moment shorter and shorter : And now it is quite cold, it is of the same length with the other ; its length decreasing in proportion as the cold returns, and the Fire leaves it.

I have now again made the end of the same Rod red hot, and endeavour, as you see, to thrust it through this Ring, but am not able : For you are witnesses, that it is a good deal thicker now than it was when it was cold. But have a little patience till it is quite cold again ; and now you see it will go through the Ring : So that tho' this would not admit it when it was hot, yet it lets it easily pass through now it is cold.

A method by which this increase may be measured.
Pl. I. Fig. 2.

If any person now has a mind to measure exactly the difference there is between the length of a piece of Iron, or any other solid Body, when it comes red out of the Fire, and when it is cool'd to any certain degree determined by the Thermometer, he may do it in the following manner : Let AB and CD be two parallel brass Plates, contriv'd so to move upon the side ones, that their parallelism may be always preserv'd ; and let the side ones be divided into very small equal parts. Take then the Body you design to make your Experiment upon, and fit it exactly, when it is cold, betwixt AB and CD, close to the Plate AC. Then put it in the Fire, and when it is red hot, as nimbly as possible place it pretty near the same AC, and remove AB from CD, till they can contain the heated Body betwixt them ; which must be done expeditiously, that AC may not be too much heated. You will then have the difference betwixt the Rod when it is cold, and after it is heated : But you must take care that the Rod be made sharp at both ends, as you see in the figure EF, that it may heat the Plates as little as may be. The same thing may likewise be determined in the manner following : Let AB represent a straight brass Ruler, the longer the better, at whose extremity B, let there be another pretty long one fixt perpendicularly, and minutely divided into equal parts, and let the brass Hypothenuse AD be made moveable at A, upon the plane ABC : Then if the heated Rod is placed upon AB, it will elevate the Ruler AD, and by the motion of this upon BC, you will have the difference you wanted, which will be the more remarkable, the longer you make AB, and BC.

Fig. 3.

This expansion happens in all Bodies.

1. Now this expansion of solid Bodies by Fire, is so universal, that I have never

never observed it to fail in any one that I have had as yet an opportunity of making trial of: Which is a remark of considerable consequence in our present inquiry.

Take care, however, you don't here fall into an error, by imagining this expansion to be equally great in all kinds of Bodies: For by every Experiment that I have hitherto made, it appears that heavier Bodies suffer a less, and lighter a greater dilatation from the same degree of Heat; so that this rule seems to hold true of all in general. But let it suffice that I have hinted these things to you; you yourselves will easily carry on these observations, by the help of the second instrument, and examine, whether, universally, the dilatations of solids by the same degree of Fire, are in a reciprocal proportion of their respective densities? I did design to have pursued this inquiry farther myself; but the multitude of my affairs, and the little time I had to spare, would not permit it: Those things, however, which I have seen and perform'd, persuade me to believe, that the rarer Solids are always more dilated, and the denser less, by the same Heat.

But is different in Bodies of different densities.

But there are still other causes that produce some variety in the degrees of this expansion of Bodies, besides the difference of their weights; which I came to the knowledge of in the following manner. I desired that industrious and incomparable Artist, *Daniel Gabriel Fabrenheit*, to make me a couple of Thermometers, one with the densest of all Fluids, Mercury, the other with the rarest, Alcohol, which should be so nicely adjusted, that the ascents of the included Liquor in the same degree of Heat, should be always exactly equal in both, as might appear by a scale fix'd on the side. This, after a good deal of intreaty, he endeavoured to do; but tho' he had made his calculations with the greatest accuracy, yet upon examination I found they did not perfectly agree. I acquainted this honest Gentleman, therefore, with my disappointment, and he candidly confess'd that there was a defect, and acknowledg'd frankly that he did not then know the occasion of it. However, not being satisfied himself, he set about more diligently to inquire into the cause of this difference; and upon a nicer examination he discover'd, that the various sorts of Glafs made in *Bobemia*, *England*, and *Holland*, were not expanded in the same manner by the same degree of Heat; but that one sort of it was affected sooner, and with more ease, another with more difficulty, and in a longer time. And hence he found out, that his method of making these instruments would succeed, if they were both form'd of the same sort of Glafs; but would be defective, if one was made of *Bobemian*, and the other of *Dutch*: For it appeared, that that Glafs which requires a stronger Fire to melt it will be less expanded, whilst that which runs easily in the Fire will be more dilated, if they are both exposed to the same degree of Heat. How infinitely careful therefore ought we to be in our searches after natural knowledge, if we would come at the truth? How frequently shall we fall into mistakes, if we are over hasty in laying down general rules? How vastly preferable is that Science, which is form'd with patience and deliberation upon cautious Experiments, to that which is the effect only of rash and precipitate ratiocination?

And varies too from other causes.

2. This expansion always increases in proportion, as a greater quantity of Fire is admitted into the expanded Body; so that this Rod, when it is perfectly white with Heat, is longer than it is when it is not red, tho' it should still continue exceeding hot; and it is shortest of all, when it has laid a good while

The greater the Heat is, the greater the Expansion.

while in the most intense cold. Here, therefore, I would again recommend to you, the making some Experiments upon Iron, (which of all Metals will bear the strongest Fire without being fused) in order to discover the difference of its length, when it is just upon melting, and when it is perfectly cold in the coldest season: For then you will have the action of this expansive power in its greatest latitude.

When Solids
are put in fu-
sion by Fire,
their expan-
sion ceases.

When once Iron is put in fusion, and becomes a fluid Mass, it seems afterwards to continue of the same bulk, tho' the action of the Fire upon it is increased by the assistance of Bellows: And then possibly, if it is not capable of receiving any more Fire, nor consequently, of being farther expanded by the force of any common one: For Metals, when they once are melted, do not seem, as far as one can judge, to admit any more Fire, except it is collected by Bellows, a Mirrour, or Burning-glass, and by this means directed to some particular part of them.

All the parts
of Bodies are
put in agita-
tion by Fire.

3. Hence we evidently perceive, that Fire, as it increases from the greatest degree of known Cold, to the most intense Heat, must necessarily dilate all the parts of the hardest Bodies to which it is applied, and remove them from their mutual contact. It appears farther too, that this extension, and the rarity of the Body consequent upon it, is successively augmented, 'till the whole Mass, supposing it fusible, becomes fluid in the Fire. And hence it follows, that all the constituent parts of Bodies, during the application of these different degrees of Heat, are continually expanded from the centre of their substance, as well as the whole Body itself.

Even in the
very hardest.

Thus then we see, that the particles of Fire which are distributed through the corporeal Mass, act with an equal force upon all its *moleculæ*, or corpuscles; nor is there any Body so hard, or rigid, that it will not submit to the power of this Element, and may be so chang'd through its whole substance by the very gentlest action of it, that there sha'n't any one part of it remain unaltered.

4. Now what is the expansion of Bodies, but a dilatation of them into larger spaces than they took up before? Hence therefore we infer, that their component parts must be constantly in motion during this extension. Nor does it less evidently appear, that Fire moves all the particles of the hardest Mass, both external and internal, towards every point of its surface, and always so much the more, the fiercer it is; till at last, having reduced them into a state of fluidity, it then violently agitates, mixes, and drives them one among another.

Does Fire
melt Bodies
into their
very Ele-
ments?

Does Fire then so attenuate and divide such a Body, that those corpuscles which are thus fluid, are in reality the very Elements of the Bodies, so long as they continue in this state? And is this the reason, that the particles of Metals, when in fusion, are so intimately mingled one among another, that it is impossible to reduce them to the same degree of fineness by any other method? Why certainly, the docimastic Art, which is the truest of all Arts, informs us, that if one grain of Gold is mix'd with a hundred thousand grains of the purest Silver whilst they are fused, so that they may be perfectly melted together, then the Gold will be so dispersed among the particles of Silver, that if you afterwards take the least bit of this compound, you will find the proportion of the Gold to the Silver, as 1, to 100,000: Nor indeed, has there ever been discover'd any limits to this division and distribution of the Gold among the Silver. If
you

you accurately examine, then, the effect of this Experiment, you must readily allow, that the Fire, whilst it gradually acted upon the Gold from its greatest degree of cold, so agitated its elementary Particles, that they continually cohered less and less, till at length their cohesion being perfectly destroy'd, they were separated, and run from one another. And here, Fire, so long as it exerts this force upon them, is the only cause that these Particles, tho' they touch one another, do not coalesce; for that being removed, they are again presently united into one solid Mass.

I confess, indeed, that the parts of pure Metals, when they are put in fusion, retain a tendency towards a union: For I always observe, that Gold, Silver, and other melted Metals, immediately collect themselves into a globular figure, perfectly in the same manner as Mercury would form itself into a sphere, if the weight of its parts did not prevent it. This property, however, cannot exert itself with any effect, so long as the violence of the Fire is continued; which is pretty extraordinary.

The parts of melted Metals attract one another.

Again, it is impossible to unite two pieces of Gold together in such a manner, that they shall regain the tenacity that's peculiar to this Metal, unless you first divide them into their ultimate parts, by reducing them to a fluid state by Fire; but then, as soon as ever they are cold, they immediately recover their former ductility: And what we have asserted of Metals, holds true likewise in other simple Bodies; as we see in fix'd Salts, Glafs, and many others. Lastly, it appears from what has been said, that it is not only possible, but really true in fact, that the most fix'd and solid Body, may be so continually agitated in its constituent Elements, that there sha'n't be any one Particle of the whole Mass, tho' ever so small, that will be absolutely at rest. All which observations follow so evidently, from the consideration of the aforementioned Experiment, that nothing can possibly be clearer. Does therefore the influence of Fire reach even to the most intimate nature of Bodies? Surprizing Power!

Fusion alone perfectly unites the parts of Metals when they are separated asunder.

5. Why therefore should that *Phenomenon*, which is often observ'd to happen, any longer appear so wonderful, viz. that houses built in the strongest manner, frequently tumble down in very hot clear weather, and for the most part in the middle of the day, when there is no wind at all to affect them?

6. From this property of Fire we learn yet farther, that Bodies removed into the torrid Zones, grow bigger in all their dimensions, than they were in a colder climate: That hence they will become comparatively lighter, as they contain the same quantity of matter under a larger surface: That their percussions, of consequence, will be more feeble: That *Galileo's* pendulums, therefore, that are made in the frigid Zones, if they are remov'd into the torrid ones, will increase in their length, of course, and will take up a longer time in performing their oscillations; on which account clocks the best carried thither, will be found to vary from the truth. The same things in proportion hold true likewise in the same climate, according to the various vicissitudes of Heat in the different seasons of the year.

The same Bodies not equally great in all parts of the world.

7. That very ancient observation therefore is most certainly just, that Bodies are principally relax'd and weaken'd by Fire: For as these two words denote that condition of the Solids by which they are disposed to have their parts more easily separated, it evidently appears from what has been said of

The laxity of Bodies, what.

Fire, that this is the very thing it is effecting from the first instant of its acting upon them, and that through every degree of its increase it brings about this dissolution more and more, till at length the most solid parts retain their firmness no longer, but dissolve, and melt away. And this is confirmed by the universal testimony of all Historians, who inform us, that the inhabitants of *Asia*, and *Africa*, who are exposed to the scorching heat of the Sun, have always been of a softer and weaker make, and less fit for hard labour, than those of colder climates. And in like manner we see, that in the most ardent Fevers, our Bodies are quite dissolv'd, and enervated. I confess, indeed, that at that time too they are parch'd up with the heat, and by this means grow dry and more rigid: But then this is not to be attributed to the Fire, as it is dispersed among the Solids, but only as it dissipates the most watery part of the Fluids; and in this sense alone is it true, that Fire ever gives strength to Bodies when once they are debilitated.

EXPERIMENT II.

Cold reduces all Bodies into a less space,

Cold, by which we universally mean the absence of Fire, contracts the hardest Bodies in all their dimensions, so long as it remains in them. This I demonstrated to you so plainly in the latter part of the former Experiment, that it would be paying a very indifferent compliment to your understanding, should I attempt the proof of it again. You'll give me leave, however, to point out to you the consequences that evidently follow from it; of which let this be the first.

Of what kind soever.

1. All solid Bodies are equally affected by this action of Cold; nor was there ever observ'd any one, tho' ever so firm, and closely compacted, but might be still farther condensed by it; even Diamonds themselves, the hardest of all Bodies, not excepted.

This contraction increases in proportion to the cold. And lessens the cavities of Bodies.

2. This contraction of Bodies is always increased, in proportion as the cold is augmented; and the former expansion, which they had in a lesser degree of cold, is diminish'd; which ought to be consider'd.

And, which is pretty remarkable, this reduction of Bodies into smaller spaces, happens even in hollow spheres, and orbicular rings, and is directed towards the center of the Body, or Surface. For when this Iron ring is cold, it will not admit this Iron cylinder, tho' it will receive it within its cavity after it is heated. This glass sphere, with this very narrow cylindrical neck to it, is fill'd as you perceive with a colour'd Liquor, as high as this mark which you see on the Cylinder: I dip this now into a Fluid, that is a good deal colder than the Sphere, and what is the consequence? Why you observe, that the Liquor in an instant rises very discernibly higher than it was before, tho' afterwards, indeed, it sinks down again. And the reason of this is plain; for the external cold being immediately apply'd to the Surface of the immersed Sphere, must of course affect that, before it can reach to the included Fluid; and hence, that being contracted into a narrower space, must necessarily expel some of that Liquor into the neck, which before it was capable of containing: But afterwards, when the cold has intimately penetrated into the Liquor itself, that is condensed as well as the Glass, and so must of consequence descend again. From this Experiment then we learn very clearly, that this power of contraction exerts itself, if I may so express myself, upon the very substance of

of Bodies. In other glass vessels made hot, and then exposed to the cold, this coarctation is much more evident.

3. Again, it appears, that this contraction of Bodies into lesser spaces, proceeds always in proportion to the cold itself; whence it plainly follows, that since they still contain the same quantity of matter in a lesser bulk, it must increase their comparative, or specific gravity: Nor is it less evident, that every Solid is then actually least, when it is affected by the intensest cold. As there is, however, no assignable Body in which there is absolute Cold, or no degree of Fire, hence, it is impossible to reduce any Body, an ounce of Gold for instance, to its least possible size; tho' the proportion of this condensation from different degrees of cold may be nevertheless discover'd.

Hence the specific gravity of Bodies uncertain.

4. From the sole absence of Fire, therefore, there raises in every solid corporeal Mass a very surprizing motion, both in its internal and external parts, by which all its Elements constantly tend towards its center, and by this means become more intimately united with one another. If then we consider cold as a mere privation of Fire, it follows, that this power, by which the Elements of Solids contract themselves into a smaller space, must be look'd upon as something implanted in matter itself, whilst the force by which they are expanded, must be regarded as the action of Fire; which, consequently, being external, and accidental, cannot exert itself upon Bodies, without offering them some degree of violence. Hence, therefore, all Solids would naturally endeavour to form themselves into little compact Masses, and when they were reduced to the smallest ones possible, would enjoy a most fix'd perfect quiet: Whilst on the contrary, they would be so constantly agitated by the action of Fire, that their parts could never possibly come to a state of rest. The last effect of cold, therefore, upon the Particles of Bodies, would be their most intimate union, and absolute rest: That of Fire, their dissolution, and perpetual agitation.

The substance of Body is condensed by cold. Hence a cold is proper to Body.

Does Fire and Cold, therefore, alone, affect the very substance of Bodies, whilst every thing else reaches only their constituent parts? Does perfect rest, in any part of space, produce the greatest degree of Cold? And should any place be perfectly free from Fire, so as not to possess the very least degree of it, would there of consequence necessarily follow absolute rest?

Heat and Cold, the principal agents upon Matter.

5. Hence it appears farther, that Pendulums growing shorter about the Poles of the Earth, will perform a greater number of vibrations within any given time; and their appended weights being condensed, will suffer a less resistance from the Air. And hence too does it not seem probable, that the Cold towards the Pole, and the Heat about the Equator, are one cause of the spheroidal figure of the Earth?

The figure of the Earth from Heat and Cold.

6. Again, Cold condenses all solid Masses, by reducing that very part of them, which we call Body, into a lesser space than it took up before; and hence their whole matter being more closely united, there almost always arises a stronger cohesion of the Mass in general; which is what we call strength, and firmness. From the same cause too, the particular Particles of which the Body is compos'd, are more strongly compacted together, nor suffer themselves to be so easily separated asunder, as they were in their former state; which therefore is a second cause of their stability. And lastly, as far as one can judge, the very constituent Elements of Bodies are render'd more dense by Cold, as well as the whole Mass; and this gives them the greatest degree

Density from Cold.

of strength, and was what we just now called acting upon their very substance. But, Gentlemen, what notion can the most subtle penetration form of ultimate Body? For my own part, I confess, all that I can conceive here is this, that any single Body, supposing it simple, is composed of lesser Bodies perfectly like the greater, and these again in the same manner of smaller, and so on beyond any limits that the mind is capable of fixing: That there is a certain principle implanted in some corpuscles by the great Creator, by which they are united and form'd into little Masses, which it is not possible for any natural, or artificial Power, to separate asunder; and which of consequence remain always the same, notwithstanding all the violence that can be exerted upon them: And lastly, that these may be concreted with one another, and by their reciprocal attraction, produce so firm a union, as will be very seldom destroy'd, and then only by some few particular causes, which will be able to effect nothing more upon them, than barely dividing them asunder, and reducing them again to their original state; for then they will be perfectly immutable as they were before. These few simple things, are all, that upon the most intent inquiry into the powers and operations of Nature, I have been able to come to the knowledge of. Hence we understand what were the Atoms of *Democritus*, the *Monads* of some Philosophers, the *Hylarchic* Principles of others, and the last Principles of Bodies of almost all Philosophers in general. Are those Particles therefore so solid, that they won't admit even Fire itself within them? And hence are they neither dilatable by any natural power, or reducible into a lesser space? And of consequence, does condensation and rarefaction affect only the corpuscles which are compounded of these Elements, and not the very Elements themselves? Be this as it will, this is certain, that both the Philosophers and Physicians have constantly observed, that all Solids in the Animal, Vegetable, and Fossil Kingdom, are strengthen'd by cold, and the condensation that arises from it.

A Dumbvigate and vicissitude of Heat and Cold.

Always and every where alternate.

7. The alternate vicissitudes of Heat and Cold seem to produce a continual motion and agitation in all the Bodies in the universe, and in all their Particles, as often as they succeed one another, inasmuch as the actions of each of them must necessarily bring about the effects already mention'd.

8. Now these seldom continue to act long upon Bodies in the same degree, but are perpetually changing, and when one begins to grow excessive, it is generally soon temper'd by the succession of the other, whose effects are quite contrary to the former. For if we diligently examine into the order of Nature, we shall find nothing more cautiously provided against, than that the same degree of Cold or Heat should reign for any considerable time. Is not the Earth, for instance, disposed in such a manner, with regard to the Sun, that at one time it may receive its rays in a more oblique direction, at others in a more perpendicular one, nor should ever remain for the least space of time in the same aspect? by which means, this perpetual change of Heat in the different seasons of the year, brings about very different effects. Nor is there a less variation produc'd in Heat and Cold by the alternate succession of day and night; for hence it comes to pass, that they seldom continue in the same degree, for so small a time as the space of an hour: Nor are the Meteors we observe in the Air, a less evident proof of this mutability. The Sun again, has no sooner parch'd up the Earth with its scorching Heat, and fill'd the Atmosphere

sphere with vapours and exhalations, but there very soon follow Clouds, Thunder, Lightning, Hail, and Rain, so that instead of that excessive Heat, there presently arises a very considerable Cold. From these considerations then, I can't but infer, that in every solid Body that exists in our World, there is a constant peristaltic or oscillatory motion of all the particles that enter into its composition.

9. It appears evident, now, that this reciprocal succession of Heat and Cold induces very different and more powerful alterations in Bodies, than either of them would do were they continued any considerable time in the same degree. By the same Heat, for instance, acting upon them a long while, Plants and Animals are rendered dry, and the remainder becomes more durable; and a constant Frost effects the same: Whereas if these very frequently succeed one another, there follows an intimate solution of bodies, which are hereby disposed to become volatil, and are in a great measure dissipated into the Air. But there would be no end, should I only hint at the effects that are hence produced.

10. For this reason the wise Author of Nature seems to have ordained that such a vicissitude of things should be fixed, and unalterable; that thus the whole universe might remain in a perpetual motion, not only in the larger Bodies that compose it, but also in their most intimate and ultimate particles, that by this means the production, increase, state, decrease, and dissolution of every thing might be brought about by the same law.

11. But who, now, will pretend to determine the ultimate limits of Cold? Or where is that so intense, that it cannot be increased? There, you'll be apt to say, where there is no Fire. True; but it is impossible for us to find any such place; nor can the subtlest Artist with all his skill ever perfectly extract Fire out of any Body, or any part of space. Upon this head, therefore, we need not trouble ourselves with any farther Inquiries. May the ultimate degree of Heat, therefore, be more easily discovered? Nothing less; for we are here as much at a loss to find out the greatest quantity of Fire that may be contained in any given space, as we were before to assign any place that is absolutely free from it. The violence of that Fire which we see collected in the *Focus* of a large concave Mirrour, or a convex Burning-glass is apt to strike us with astonishment: But who knows how prodigiously this power might be increased, if the concave surface of the *Speculum* was vastly greater, and of a conoidal, or parabolical figure? Or if it could be made of a substance perfectly solid without the least Pore in it? Or lastly could it be formed of some matter of such a nature, that it would reflect the rays exactly in the same manner as they fell upon it?

12. 'Tis sufficient, however, for our purpose, if we can determine the different degrees which happen commonly here upon our Earth. And it is very easy now to inform ourselves, what alterations happen in the increase or decrease of Heat, and when it continues the same, by what has been already delivered: For here (as our surest guide) we have principally to regard the dilatation or contraction of Bodies, which by proper instruments may be readily ascertained without difficulty.

13. In the mean while it must be confessed, that it is both an ingenious and difficult work to determine the quantity of Fire in any given place, so as to be able to express the proportion of it in numbers to any other known Fire.

It

Of great use to the world.

Putting every Body into motion even to its most intimate parts.

The limits of Cold not to be determined.

The degrees of it may be compared together.

And exactly enough be expressed by numbers.

It is easy enough, it's true, to perceive whether it is increased, or not; but to discover the degree of this augmentation, is vastly more difficult. It will appear, however, presently, that even this, hard as it is, is not impossible, but may be attained to by human industry. All these things now, seem so evidently to flow from our first and second Observation concerning the nature and presence of Fire, that I think they may be fairly taken for granted, nor will they be of small service to us in our chemical Inquiries.

EXPERIMENT III.

Common Air, is every way expanded by the least increase of Fire in its whole bulk, and in all its parts.

This the Philosophers were long ago acquainted with; tho' the illustrious *Boyle* principally set about the proof of it: Upon this head therefore we need not detain you.

The Air-
Thermo-
meter of
Drebbelius.

Improved.

Plat. II.

Fig. 11.

The truth of this was sufficiently demonstrated formerly by the Thermometer invented by *Cornelius Drebbelius* of *Alcmar*; for this purely by the assistance of rarefied, or condensed Air, very evidently repels liquors from it, or attracts them to it. You see, for instance, by only breathing upon this Sphere, I make the coloured fluid in the neck to fall lower: But as soon as I leave off it begins again to ascend: And upon the approach of a warm hand towards it, you perceive the same effect is instantly produced. Now these Instruments may be rendered so sensible of the very least degree of Heat, that by the help of them you may plainly discern the perpetual Systole, and Diastole of the Air, which is never observed to be at rest. The construction is as follows. Let your vessel that is to contain the Air be made of thin and very clear glass, and formed of two Segments of a Sphere joined together, and so contrived that the two great opposite Segments AB, CD, may be pretty near one another: And here the larger the vessel is, and the less spherical the Figure, if the Air can but be easily contained in it, and freely pass in and out, the fitter it will be to demonstrate these minute differences. To this vessel then let there be connected a slender pipe EF, open at F, and as narrow as it can be made, without hindering the free passage of the Air with all its force. If this Instrument, now, being full of common Air, as it will be of course if it is exposed to it, has its lower orifice F immersed in a vessel filled with water deeply tinged; and you then gently heat the glass ABCD, you will presently observe bubbles of Air pass out of EF, by the mouth F, which will continue to do so, as long as you keep the Fire near the glass. When, therefore, you have forced out a sufficient quantity of Air, which must be but a few little bubbles, remove the Heat, and the coloured liquor will immediately ascend into the neck; and if you have taken care that too much Air was not expelled, it will get no higher than about the middle of the pipe EF; and then you will have the pleasure of observing the perpetual risings and fallings of the liquor in the neck, at the smallest changes of Heat, and Cold. And this will be always the more evident the thinner the glass is, the larger the vessel ABCD is in respect of the Cavity of the pipe EF, and the nearer the Segments AB, CD, are made to approach to one another; as is easily demonstrated by Hydraulics. You readily apprehend, now, why I prefer the Segments AB, CD to a Sphere in this Instrument, and why I would have them

them but at a small distance : For you see plainly that by this means the surface of the included Air being much increased, either Heat, or Cold will be more readily communicated quite through it. But that the truth of this may appear evidently to you all, see here I take this chemical glass with a large belly, and very slender neck ; which being now full of the common Air, we breath at this time, I thus invert, and immerge into this Water. You observe now, that as I bring the Fire near the glass, the included Air runs out of the neck in bubbles through the Water. You conceive therefore, that there is less Air at present in the vessel than there was before, and that in proportion to the quantity of bubbles that were forced out. I'll now remove the Fire : and you see how instantly the Water ascends into the neck ; and perceive farther, that as I bring the Fire nearer, and remove it by turns, how the Water alternately rises, and falls, so that it scarcely remains a moment at rest.

C O R O L. I.

This expansion of Air by Fire extends to a prodigious space, nor can easily be determined by any Experiments. For a proof of this, heat a hollow spherical glass in a glass-house furnace till it is just ready to melt, then hermetically seal it there, and afterwards carefully cool it by degrees, and you will find that even then it is not perfectly void of Air : For if you sink it under Water, and there break off the end of the neck, the Water indeed will rush in with great violence, but still there will always remain a space at top full of Air, which is able to sustain the whole weight of the Atmosphere.

Hence, therefore, we evidently learn, that though the intense Fire of the furnace rarefied the Air to a prodigious degree, yet it was not able totally to expel it. It is probable indeed, that a greater degree of Heat would still have rendered it more rare ; but it is equally probable that it can never be expanded *in infinitum*, and that therefore, there will always remain some Air in the very strongest Fire. From some Observations made on this head the famous *Des Amontons* has ingeniously inferred that the space into which Air is dilated by the degree of Heat necessary to make Water boil, is a third part greater than that which it took up before. I am aware of a plausible objection, that may be made to the inference drawn from the last Experiment, and that is, that the Air which thus collects itself at the upper part of the glass, when it is immersed in the Water, does in reality proceed from the Water, whilst it is forced into the neck by the pressure of the Atmosphere : For as this repletion is successive, the first portion of Water that enters, is in reality, in a more perfect *vacuum* than that of *Boyle* ; and consequently the Air which is mixed with that Water, will endeavour to disengage itself, will rush into this *vacuum*, collect itself there, and thus hinder the perfect repletion of the vessel. To this I answer, I will allow you indeed that some Air may have come into the glass, in the manner you mention, but then it must be with this limitation ; that all the Air that thus extricates itself out of the Water into the empty glass, will be always again absorbed by that Water from whence it came, and then the whole cavity will be perfectly filled with Water ; for this the accurate *Mariot* has happily discovered, and I shall evidently make appear when I come to treat professedly of Air : Since therefore (in this case) the Air will not be absorbed, and the Sphere be filled, it is plain that the space that will not admit the Water, does really contain

contain a portion of true Air, which the force of the Fire dilated indeed, but was not able perfectly to expel; which was what I asserted.

COROL. 2.

The difference between the expansion of Air, and that of Iron.

If we consider now the dilatation which was before demonstrated in Iron, how very small is that, even in a Fire so strong as to heat it red hot? How great on the other hand do we observe the expansion of Air from a small degree of Heat? We found indeed that Iron is capable of being presently extended by a very gentle Fire; but then, this was not to be discovered without the assistance of an Instrument; whereas the difference of the rarefaction of Air by the same Fire, is vastly remarkable. No Body that we are acquainted with is more easily affected by Fire than Air; nor any one put into fusion with more difficulty than Iron, or which is the same thing, distended to its greatest dimensions.

COROL. 3.

The expansion of Air by the least degree of Heat, discernible.

Hence we may have the pleasure of determining the least increase of the Heat of Air almost to any given measure, that can here be of service: For we have nothing to do, but to make the spherical Segments in the Instrument above described very large in proportion to the capacity of the pipe, and to make this very long; for then, the least difference of Heat will be very sensibly discerned in the pipe.

COROL. 4.

The greatest natural Heat in the Air.
† See Plate V. and VI.

But whereas the greatest natural Heat of the Air, even in the most sultry Dog-days, is rarely observed to come up to the 90th degree in † *Fahrenheit's* Thermometer, hence we know exactly the limits of that Heat, which it will be found hardly ever to exceed. All its natural variation therefore in this respect will consist in its decrease below this degree. Hence therefore the use of the *Drebbelian* Thermometer is very easy, and very serviceable. But then you must take care to have always a Barometer near it, in order to measure the different weights of the Atmosphere at the same time; for that must likewise enter into the consideration. By this means, then, and with very little trouble, you will be able to observe the smallest increases of the least degree of Heat.

COROL. 5.

Air is never at rest.

If we consider, therefore, the very easy dilatability, and contractility of Air by the very least augmentations, or diminutions of Fire, and at the same time remember that these are in a constant vicissitude; does it not evidently appear that this Air can never be at rest, but must suffer a perpetual agitation in all its parts, by which even its very ultimate particles must be kept in a constant oscillation? And this will hold as true in what we call the open Air, which is only kept within its bounds by the weight of the incumbent Atmosphere, as it does in that Air which is perfectly confined in a close vessel.

EXPERIMENT IV.

Air, by the least decrease of Heat, is every way contracted, both in its whole bulk, and in all its parts.

This was evident in all the instances we gave under the third Experiment; for this contraction was always observ'd to follow, in proportion as the Fire was removed.

COROL. 1.

The spaces, into which Air is thus reduced, grow constantly less and less, so long as the Heat decreases; and consequently, there is no such thing as determining the least possible space that any quantity of Air may be contracted into, as it is impossible to free it absolutely from Fire; as has been already taken notice of. In the glass Thermometers of *Drebbelius*, exposed to a successively increasing Cold, this observation appears very evident.

COROL. 2.

The greatest contraction that is observed in any other Body from the most intense cold, is less than the condensation that the Air suffers from the very least decrease of Heat or Fire, that our senses are capable of discerning by any other method. And hence for this reason, likewise, the Air is the fittest of any thing to discover to us the quantity of Fire.

COROL. 3.

Again, any diminution of Heat or Fire, or the least augmentation of Cold, may be rendered visible, and adjusted to any assigned measure: For this is the converse only of the third Corollary of the third Experiment.

COROL. 4.

The use therefore of this Air-Thermometer, will be so much the more excellent, and easy, as the greatest degree of artificial Cold, and the intensest natural Cold of the Winter Season, have been very nicely determined by Observation.

In the most severe Cold in the year 1709, the liquor in *Fahrenheit's* Thermometer was observed, in *Iceland*, as low as the first number; and I myself saw it one morning this year in our University garden almost down to number 5.

As for the contrivances that have hitherto been invented to excite artificial Cold, no body has yet been able by the help of them to produce a freezing Cold in Summer, till there first appeared a congelation of Water, either in form of Snow, Ice, Hail, or Hoar-frost: For though some persons have come pretty near it; yet it would never succeed, 'till the season was grown considerably Cold, and inclining towards the freezing point, and thus rendered the Water cold, and fit for the purpose. There have indeed been a great many, and very laborious Experiments made use of, in order to produce the greatest possible artificial Cold. And it has long ago appeared by chemical Observations, that Salts, the very instant they are dissolved in Water, will excite a greater degree of Cold, than was in either of them before the mixture. Now the principal of these for this purpose, is the common purest *Sal-Ammoniac*; with which I made the following Experiment. I took four ounces of this Salt, and reduced it to a fine dry powder, and let it stand all night in a clean dry glass stopped very close with a cork. In this condition I put the glass with the included Salt, which was so secured that no moisture could possibly come at it, into some fair

Water that had stood a whole night exposed to the open Air; and by this means I brought the Salt, Water, and Glass exactly to the same degree of Cold. In the morning, then, I placed one of *Fahrenheit's* Thermometers in this Water, till the Cold of it had fixed the included liquor at the degree 53 above O; and then at once I threw the four ounces of the *Sal-Ammoniac*, into twelve ounces of this Water contained in a cylindrical glass, and with a stick I briskly stirred them about, and mixed them together; upon which the liquor in the Thermometer immediately fell from the first degree 53, to the degree 25; the same in the Air open standing at the same time at 51. Hence, therefore, it evidently appears, that *Sal-Ammoniac* mixt with Water in a subtriple proportion, will generate 28 degrees of Cold in this Thermometer,

Artificial
Cold for
producing of
Ice.

And of consequence, a Cold that will produce Ice may always be excited by Art, when the Heat of the Air don't make the Thermometer rise above the degree 60. For it is observed, that as soon as ever the temper of the external Air reduces the liquor in the Thermometer to the degree 32, then Water, too being equally cold begins to form itself into Ice. The colder therefore the Air grows from the degree 60 towards the degree 32, the more will the artificial Cold produced by this method exceed that which is necessary to turn Water into Ice.

And a
greater de-
gree.

When the Coldness of Water therefore is about the degree 32, this mixture will excite a Cold, which will sink the Thermometer almost as low as the degree 4. But now if we take some Water in a large vessel, and by this solution make it 28 degrees colder than it was before; and then place another smaller glass full of Water in this cold *Lixivium*, and by this means give this second Water as great a degree of Cold, as this *Lixivium*, which will remain cold a good while, can communicate to it; we may then, by mixing fresh *Sal-Ammoniac* with the Water in this second glass, whilst it stands in the first *Lixivium*, quickly produce even in the hottest weather a greater degree of Cold than was ever observed in our Country. And yet again, if we take the Ice that we may procure by this contrivance, and mix that with new cold *Sal-Ammoniac*, the Cold thus generated will be still more intense: So that by this method, we may, in the middle of Summer, presently excite a sharper Cold than that of the severest Winter.

The freez-
ing point not
easily ob-
servable.

Give me leave, however, to mention one caution, that may here be of service to prevent your falling into mistakes, which is, that it is not so easy to determine that temper of the Air, which is just necessary to the production of Ice, as one may at first imagine. For Heat, and Cold, when they are once communicated to Bodies; remain in them a considerable while before they leave them: And the denser they are, the longer will they retain the Heat impressed upon them; as will be demonstrated in its proper place. And hence it comes to pass, that though the Air is cold enough to reduce the liquor in the Thermometer to the degree 32, yet there will not immediately be Ice upon the Water; for this being more than 800 times denser than common Air, will continue warm from the former Heat a considerable time after the Air has been affected with a new degree of Cold. If any person, therefore, desires nicely to inform himself in what temperature of the Air Water will begin to freeze, let him make use of the following method. First suspend your Thermometer in the free open Air; for I have observed, that if you hang it against a wall, or any other Body, the Warmth that is in them will have some effect upon it
When.

When you have in this manner exactly discovered the Heat of the Atmosphere by your Thermometer, expose a small quantity of Water to the Air in such a manner that the surface of it that is contiguous with the Air may be as large as possible; which is best effected by dipping a fine clean cloth in fair Water, and then hanging it open in the Air, and keeping it there some time. By this means, that upon the first freezing Cold, the cloth will grow stiff, and thus shew that the Water at that time begins to be hardened into Ice. And by this method, I have observed that Water will begin to freeze, if it is as Cold as the Air is when the Thermometer is almost at the degree 33; though it will not do so, if it is kept something warmer than the Air, by any Body that is near it, or by the largeness of its own bulk.

And hence it comes to pass that Hoar-Frost, which is nothing but a moisture congealed on the broad surfaces of thin Bodies, as Grass, Leaves, and the fine asperities of the ground, appears a good while before we see any Ice. And in the same manner as Winter comes on, this white Frost appears on bridges that are suspended in the Air, before there is the least sign of Ice in the Streets, or on the Water. But who don't plainly see that this is occasioned by the arch's not being contiguous to any thing else, and of consequence being every way exposed to the Cold of the ambient Air? And for the same reason it thaws there as suddenly. Whereas Bodies that are thicker, retain their former Heat longer; for as they can only receive the impression of the Cold by their surface that is in contact with the Air, they hence must propagate it gradually through their substance towards their Center of gravity; and by this means they successively acquire a greater and greater degree of Cold, till they have been so long exposed to the Air as to be equally affected by it quite through. And here, how much time is necessary for this purpose it is not easy to determine.

From what has been said, therefore, upon this head it appears, that the limits of the most intense natural Cold that has been observed, have been found to descend to O in the Thermometer; whereas Art, by dissolving Salts in the coldest Water, could never reach below the degree 4, or 3.

The indefatigable industry, however, of the ingenious *Fabrenheit* has discovered somewhat yet farther in this affair, which before seemed quite incredible, and which I think well worth relating in the same manner as it was communicated to me by the Author himself, to whom all lovers of natural knowledge will be ready to make proper acknowledgements for this surprising Experiment.

The severity of the Winter of this year 1729, gave him an opportunity of making some Experiments for the production of artificial Cold; and among the rest, it fortunately came into his mind to try what would be the effect of pouring Spirit of Nitre upon Ice, the Spirit being so strong, that its weight, to that of pure Water, was as 1409 to 1000, when the Heat of both was 48 degrees. He took, therefore, some Ice, and pounding it very small, poured upon it two ounces of this Spirit of Nitre; by which means there was instantly produced such a Cold, that the Thermometer being presently immersed in this mixture, the liquor subsided more than 4 degrees below O. This unexpected and very surprising event raised the curiosity of this excellent Artist, who could not rest till he had made some farther discoveries. He contrived, therefore, a Thermometer with Quicksilver sensible of the very least alteration of Heat, which he very nicely divided into parts that might be easily discerned,

Hoar-Frost
a mark of
it.

Production
of a surpris-
ing Cold.

The great
industry of
M. Fabren-
heit.

and constructed in such a manner, that O in the cylindrical neck should be 76 degrees above the bulb of the glass. The Spirit of Nitre, then, abovementioned being reduced to the same Coldness as the Air which was at that time 16 degrees, he poured seven ounces of it upon some Ice finely pounded; and the Thermometer immediately fell 30 degrees, viz. from 16 degrees above O, to 14 degrees below it. The Mercury in the Thermometer being then at rest, he poured off the fluid part, and to the remainder of the Ice which was not dissolved, and was now so very cold, he put fresh Spirit of Nitre; upon which the Thermometer sunk to 29 degrees below O. He had then no more Spirit by him, and therefore could not at that time prosecute this experiment any farther.

He poured, therefore, Spirit of Sea Salt that was 17 degrees cold upon some Ice beaten very small; and the Thermometer sunk in an instant to the degree 8 below O. Then decanting the liquor, he mixed fresh Spirit with the remainder of the Ice that was reduced to this degree of Cold; and the Mercury subsided to the degree $14\frac{1}{2}$ below O. Being pleased, therefore, with the agreeable success of these Experiments, the curious Author was resolved to carry them still farther, and therefore provided some of the same Spirit of Nitre. But the temper of the Air being then so altered that it thawed, he was forced to contrive a method to preserve an artificial Cold after he had produced it; which he did in the following manner. He got three vessels made of very thin plates of Iron, of a cylindrical figure, and almost $6\frac{1}{2}$ inches wide. In these he placed three cylindrical glasses of $3\frac{1}{2}$ inches diameter; so that the distance betwixt these and the sides of iron vessels was inch and a $\frac{1}{2}$; nor did the bottoms of the glasses come nearer the bottoms of the other vessels than by the same distance. These spaces, then, between the two vessels he exactly filled up with cotton, that the Cold might be retained the longer, nor might be too soon affected by the Warmth of the Air, when once it was produced. These three vessels, then, being thus prepared, the glasses were filled with pounded Ice, and in them were placed three glass Tubes of $\frac{3}{4}$ of an Inch diameter, filled with Spirit of Nitre, which was at that time 32 degrees warm; and the Water that ran from the beaten Ice was carefully poured off. This being done, some Spirit was put upon the Ice; and when the Thermometer applied to it would fall no lower, the fluid part was poured off from the remaining refrigerated Ice, and at the same time the Spirit of Nitre, that was reduced to the same degree of Cold in the other glasses by the affusion of this Spirit, was poured upon the Ice. After this, then, had been repeated in the same manner four times, the spirit of Nitre made use of being thus kept exceeding cold, and the liquor being carefully poured off from the Ice after every affusion of the Spirit, he observed that the Thermometer at last subsided to 40 degrees below O. And then, the very Spirit of Nitre being acted upon by so great a Cold, shot into fine sharp Chrystals about $\frac{1}{2}$ an Inch long, and being frozen as it were itself, required shaking with some force to get it out of the Tube. As soon, however, as this inspissated Spirit came to touch the Ice, they were both presently dissolved, and at the same instant the Thermometer sunk from the degree 37 below 40. By mixing pot ashes with the pounded Ice he was able to produce a Cold 8 degrees below O.

Now what person living could ever have had the least suspicion of such a *Phænomenon* as this? The greatest natural Cold has never been observed to sink

Sink the Thermometer below O; and then, all Animals, and Vegetables, that were exposed to it, died immediately: Art has increased it yet 40 degrees more: But if to 32 degrees, which is the point of freezing, you add 40 degrees, the Heat of the Air will be then so great, that we could not bear it long without the alternate interposition of some refreshment from a greater degree of Cold. Hence we see evidently, which one could scarcely have believed, that Cold, which is able to turn Water into Ice, may still have its power increased by 72 degrees. Now what would be the consequence, should Nature ever generate such a temperature as this? We find, that such strong Spirit of Nitre as was made use of in this Experiment would be congealed. We see Mercury is so condensed in it, that it takes up a space almost $\frac{1}{269}$ th less than it did before. We observe that this wonderful Body, in so vast a degree of Cold, and with this increased density, remains equally fluid, mobile, and expansible, as it was before. We know farther, that the substance of Mercury, from the degree 600, in which it begins to boil, to this degree 40 below O, will be contracted $\frac{640}{10782}$ parts of its whole bulk; and consequently may be rendered $\frac{1}{17}$ th specifically heavier, or lighter, by the Cold, and Heat, that we are at present acquainted with. Now these things we are absolutely sure of from Experiment; and hence we see that Mercury, as it is gradually condensed by Cold, approaches nearer and nearer to the weight of Gold. But who will pretend to determine, what farther degrees of Cold may be still produced, either by the powers of Nature, or Art, that lie hitherto undiscover'd? Who can describe the alterations that both Solids and Fluids would undergo, were they exposed to this degree of Cold? If we have a desire of promoting natural knowledge, let us prepare such a Cold as this, and then try what effect it will have upon the Bodies that we are acquainted with. By this means certainly we might come at an infinite number of useful discoveries, of which at present we must be silent. In the mean while, however, we ought to pay a due honour to the worthy Inventor of this Method, who has thus set us an Example, pointed out the way to us, and furnish'd us with proper helps for carrying on these inquiries to greater perfection.

The weight of Mercury is incredibly altered by Cold.

COROL. 5.

And lastly, the converse of the fifth Corollary of the third Experiment, appears very evident, viz. that the Air is scarce a moment at rest, neither that which is open, nor that which is confin'd in any vessel whatever.

EXPERIMENT V.

Pure Alcohol of Wine is expanded every way in its whole bulk by a small increase of Fire.

For instance: Observe this glass vessel, which contains 1933 parts of this Alcohol. You see it terminates in this narrow Cylinder, which has been made with a great deal of care, that it might be every where equally wide. This whole Cylinder now contains 96 of those parts, of which the lower Bulb contains 1933, and is graduated with numbers corresponding to those parts. In the severe Cold of 1709, in one of the coldest parts of the world, the Alcohol was reduced to number 1: And yet, if the warmth of a Man in health is applied to the Glass, the Spirit will be expanded to the number 96, and fill the Cylinder so high.

COROL.

COROL. 1.

In this instrument therefore, the Liquor, considered in the state in which it was in the greatest observ'd natural Cold, may be dilated by the vital Heat of a healthy person to $\frac{1}{20}$ th part of its bulk. It is necessary, however, to take notice, that we here suppose the capacity of the Thermometer to continue the same, whereas, in reality, it will be increased, as appears by the second Corollary of the second Experiment.

COROL. 2.

The difficulty of determining the rarefaction of Fluids.

If we could exactly discover therefore the proportion of the capacity of this instrument in the most intense Cold, to the same when affected by this vital Warmth; we could then also absolutely determine the increase of the bulk of this Fluid by the greatest degree of Heat contained betwixt these two limits: For then the difference of these two capacities will help us readily to measure this dilatation.

COROL. 3.

Another cause of the figure of the Earth.

Shou'd the most pure Alcohol, therefore, about the Poles of the Earth be compared with the same betwixt the Tropics, what a considerable difference would there be in its hydrostatical weight in these two places? For it is plain, that all these Liquors are heaviest about the Poles, and lightest near the Equator. Is this therefore another physical cause of the compress'd spheroidal figure of the Earth; since a smaller bulk in one place, is equal in weight to a larger in the other, and they both tend with an equal force towards their common center of gravity?

COROL. 4.

Hence the Aerometers are not perfectly exact.

From these observations we learn, that the same vessels fill'd with such a sort of Liquor, will not be so full by a good deal in the cold of winter, as they are in summer; for the firmer parts of the solid vessels are not so much dilated with the same degree of Heat as the contained Fluids are. And indeed, the Chemists have very often experienc'd the truth of this to their disadvantage, when they have in frosty weather fill'd their glasses quite full of valuable Liquors; for when they have afterwards been affected by the Heat of the Summer, they have penetrated through the stoppers, forced them out, and often burst the glasses themselves. Being now therefore made wiser by these inconveniences, they always leave an $\frac{1}{8}$ th part empty, when they fill them in the Winter; or else, warm both the Liquors and Vessels to as great a degree of Heat, as one may reasonably expect in the midst of Summer.

COROL. 5.

The vast rarefaction of Alcohol.

If Alcohol is made so hot as just to begin to boil, it is then observ'd to rise to number 174 in the Cylinder; and therefore is then increased almost $\frac{1}{11}$ th of its dimensions: Nay, in reality, it is at that time more dilated, as appears by what has been remark'd under the first Corollary of this Experiment. And here, by the way, give me leave to take notice, how much difference there is in buying Alcohol by measure in the depth of a hard Winter, and in the sultry

Dog-days, which is certainly very considerable. If we consider now that Alcohol in the most intense cold subsides 40 degrees below 0, and when it begins to boil, rises to 174 degrees above 0; it appears, that there may be a difference in its dimensions of 214 parts in 1933; and consequently, that it may be contracted or expanded to $\frac{1}{9}$ of its whole bulk.

COROL. 6.

If you urge Alcohol still farther, so as to make it boil, there presently arises a vapour from the upper part of it, which expands itself in the superiour vacuum, and grows denser and denser every moment, whence the dilatation of it cannot be conveniently measur'd any farther. And as soon as the Thermometer is open'd at top, the rarefy'd vapour immediately flies off, nor can it be determin'd how much more it may be afterwards expanded.

Ebullition puts a stop to the measure of its expansion.

COROL. 7.

Alcohol, therefore, can scarcely ever be perfectly at rest: For if it is confin'd in a vessel, and has either a *Torricellian vacuum*, or Air above it, it is evident, that it will be continually dilated, and resolv'd into vapours; or contracted, and so condensed into Alcohol again; unless, by chance, the degree of Heat, or Cold, should constantly remain the same: Or on the other hand, if it is expos'd to the open Air, it cannot be at quiet; but, as we took notice in the Air, will suffer a perpetual systole and diastole, so long as there is a succession of greater and less degrees of Heat in the Atmosphere; which is observ'd to happen continually, almost without intermission. But then, however, this agitation will be most remarkable, when either Heat or Cold grows excessive; which state seldom continues any considerable time. Lastly, hence the Physicians understand what certain and frequent oscillations must happen in the human Body from the Particles of Alcohol, when they are mixt with our juices; as they will be at one time compress'd and heated by the action of the Arteries, at another, freed from this pressure, and of consequence, cool'd, in the Veins.

Alcohol impatient of rest.

EXPERIMENT VI.

The most limpid, light, ætherial Oil of Turpentine, is every way expand'd in its whole bulk, by a small increase of Fire.

This you'll see evidently in this spherical Glass, with this long narrow cylindrical Neck. You observe, that the Bulb of this is fill'd with Oil just to the beginning of the Cylinder. I dip this into Water, that is exactly as cold as the Oil, and you see it continues precisely in the same place. I'll now put this vessel of Water with the glass of Oil in it upon the Fire in this Chafing-dish: And now how evidently do you perceive, that as the Water, and consequently the Oil in the Glass grows gradually hotter and hotter, the Oil rises in the Neck, and scarcely remains one moment in the same Altitude? I have now kept the Water, as you see, upon the Fire till it boils; and now the Oil, you observe, is at rest in the Glass, neither ascends nor descends, nor would do so, tho' it should continue a good while in the boiling Water: Nay, I'll put more Fire about the vessel, and make the Water boil more violently; and yet you observe the Oil keeps exactly at the same height: Nor will this mercurial

Ebullition gives Liquors their greatest Heat.

And the
compression
of Liquors.

rial Thermometer rise any higher, when once the Water comes to boil. For this beautiful discovery, the Philosophers are obliged to that very ingenious Gentleman, *Monsieur des Amontons*; the truth of which you have now evidently seen in Water, and it is continually found by Experiment, to hold good in almost every kind of Liquor. And here, the candour, which I feel within my Breast at present, and which I hope I shall always have the pleasure of, obliges me to acknowledge in this publick manner, that nothing has been of greater service to me in discovering the usefulness of Fire in the deepest chemical inquiries, or better help'd me to come at the knowledge of the properties of this Element, than this valuable Experiment of this noble Author. But I refer you to the fountain, the *Mem. de l' Acad. Roy. des Sci.* where you may have the pleasure of seeing what he himself has said upon this subject. There you will find that famous Gentleman has actually demonstrated, that when Water once comes to boil, tho' you urge it with ever so strong a Fire, you cannot make it afterwards grow any hotter. This valuable discovery, however, may be still farther improv'd, by a very curious observation of the industrious *Fabrenheit*; for he has found, that the Heat of the same boiling Water will be constantly greater, when the weight of the incumbent Atmosphere presses heavier upon its surface, and less, when the pressure of that is lighter. If we would therefore at any time nicely determine the degree of Heat in boiling Water, we must have a Barometer by us, to observe at the same time the weight of the Air; or else we shall not be able to ascertain it exactly. In the mean time, however, 'tis absolutely certain, that so long as the pressure of the Atmosphere continues the same, boiling Water will not grow hotter by any increase of Fire whatever: And with this limitation, the rule of *Monsieur des Amontons*, will always be found to hold true. When the difference now of the weights of the Atmosphere is 3 inches, then the difference of the Heat of boiling Water under these two pressures, is found to be about 8 or 9 degrees. Hence this Author evidently infers, that the more closely the parts of Water are compressed together by the increase of the incumbent Weights, the more Fire will be required to make them recede from one another; in which consists ebullition. And hence he makes this elegant deduction, that the Thermometer, by being immersed in boiling Water, will, by the degree of Heat it expresses, discover at that time the weight of the Atmosphere; and of consequence would accurately enough determine it at Sea, where the Barometers are not steady, if every degree of increase was made visible in the Thermometer, which may be accomplish'd with a great deal of ease. And hence, lastly, he observes, that our Atmosphere is so much the more heated by the Solar rays, as it is more compress'd, that is, the nearer it approaches to the surface of the Earth; and the less, the lighter the pressure is, viz. in the regions above us. And this is plainly confirm'd by observation; for the tops of the highest mountains that are nearest exposed to the heat of the Sun, and never obscured with clouds, are found to be so extremely cold, that the Snow lies there perpetually without being melted. Have you a mind to be witnesses to the truth of this yourselves? Under a Receiver in *Boyle's* Air-Pump, place a glass vessel full of Water, heated to 96 degrees, and then gradually draw out the Air, and you will evidently perceive an ebullition excited in the Water, as the pressure of the Atmosphere is lessened, which will intirely disappear again upon the letting in of the Air. Hence, there-

therefore, by a Barometer fix'd in the Receiver, you may be able to determine what degree of Heat is necessary to make Water begin to boil under any given Weights of the Atmosphere; and by this means we may come at an infinite number of beautiful discoveries that we are at present unacquainted with. There is one thing more upon this head, that I think well worth mentioning, before I quit it, and that is this; Put some Water into *Papin's Digester*, and with the included Air stop it in such a manner that nothing can possibly come out, and afterwards make it Oil. The Water then will be expanded $\frac{1}{8}$, and the Air $\frac{1}{7}$; and consequently, the Water will be as much compressed, as if its pressure was increased by 10 inches of a common Atmosphere; and by this means Water acquires 30 degrees of Heat extraordinary purely by being made to boil in this Machine, for I here take no notice of the force it gains by the motion and attrition of the particles of Water and Air against the vessel, and among one another. What wonder therefore is it at all, that by this Machine are produced such prodigious effects? If you have a mind now to examine by a ballance the proportion of the expanded Oil in this Experiment, to the same in its natural state, you may compute it in the following manner: The Oil fill'd the Bulb of the Glass just to the beginning of the Neck, when the Water, Glass, Oil, and Air, had 52 degrees of Heat in *Fahrenheit's* Thermometer. When the Water boil'd, and the Oil would ascend no higher, the Thermometer was risen to degree 212, and the Oil was as high in the Neck as the mark which you see I have fix'd on it. If I now weigh the Glass fill'd to this mark with Oil that is 52 degrees hot, and then empty it as low as the bottom of the Neck, and weigh it again, I find pretty nearly the expansion of the Oil; which upon examination, appears to be a very considerable part of its bulk. I must caution you, however, that I have no regard here to the increase of the capacity of the Glass in this degree of Heat: But I have taken notice of this before, and therefore shan't mention it any more for the future. See *Exper. V. Cor. 2.*

And you need not wonder here, Gentlemen, that I determine the limits of the dilatation of Oil of Turpentine by boiling Water, which I did not do in the former Experiment. The reason is evident. Alcohol boils with a much less heat than Water; and as soon as ever it boils, its expansion cannot be measured any farther. *Exper. V. Corol. 5.* Whereas in Oil of Turpentine, which is much lighter than Water, an ebullition cannot be excited by the greatest Heat of boiling Water, but its surface will always remain at rest in this degree, in which therefore we may measure its dilatation.

Before I quit this Experiment, give me leave to take notice of a pretty remarkable *Phænomenon* that presents itself to our observation in this ebullition of Liquors. Alcohol, which is lighter, boils sooner than Water, in a *Ratio* which we shall afterwards assign; and yet Water, which is heavier, boils a considerable deal sooner than Oil of Turpentine. Is the cause of this the affinity there is betwixt Fire and inflammable Oils? Or is the specific Gravity of the boiling Liquid of consequence here? Or lastly, is it owing to a greater or less tenacity of the parts among one another? You will see by and by, what a vast deal of pains I have taken to resolve these Queries: And I think it will be evident, that they ought all to be consider'd, as well as the different pressures of the Atmosphere, which are likewise concerned in it. See the incomparable *Newton* in his *Opticks*.

Some surprising
Phænomena
in the ebullition of Li-
quors.

EXPERIMENT VII.

The rarity
of boiling
Water.

Pure Rain-water, gradually heated by a gentle Fire, is every way expanded in its whole bulk, by a very small augmentation of Heat.

This you see evidently in this Glass, where its dilatation is $\frac{1}{83}$ of its whole dimensions: For from the degree of Heat 56, it always rises to the degree 214, in which it begins to boil; and then it remains at rest, and has acquired the dilatation mentioned.

EXPERIMENT VIII.

The rarity
of Mercury
in boiling
Water.

Mercury, by the application of Heat, is easily rarefied.

The truth of this is plainly demonstrated by this elegant Thermometer, which was made at my request, by that very ingenious Artist *Daniel Gabriel Fahrenheit*. The inferiour Cylinder of this Thermometer contains 11124 parts of Mercury, which in the greatest Cold observ'd in *Iceland*, reach'd to the mark 0, from whence upwards we compute the increasing degrees of Heat. If I immerge this in the Water in this vessel, and gradually heat the Water, you see the Mercury continually ascends till the Water boils; and then you observe it remains perfectly quiet at one number, viz. 212, and something more. Setting aside, therefore, the dilatation of the Glass, the Mercury at present takes up 11336 little spaces, of which in the greatest Cold it took up but 11124; and consequently, in this degree of Heat, is expanded $\frac{1}{52-25}$ of its whole bulk.

53

COROL. I.

The rarity
of other
boiling Li-
quors.

In the same manner the strongest *Lixiviums* of Sea-Salt, Nitre, and fix'd alkaline Salts, are dilated by Heat; and in short, all Liquids that have hitherto been examined: So that Air, Alcohol, Oils, Water, saline Spirits, *Lixiviums* of Salts, Oil of Vitriol, and Mercury, are all affected by the very same law.

COROL. 2.

The cause that dilates all these Bodies passes through glass, and all other vessels, into the Liquors themselves.

COROL. 3.

And this same cause proceeds from what we universally call Heat, or Fire.

SCHOLIUM.

For the future, therefore, by Fire I shall always mean that Being, however otherwise unknown, which is endued with this property, that it penetrates all Bodies, both solid and fluid, and by this very action, extends them into larger spaces: For as on the one hand I am not acquainted with any Body in the whole compass of Nature that has these qualities, except what by every one is called Fire; so on the other, there never is Fire really present in any Body, but these two effects are immediately produced; and in proportion as this is increased, the extension of Bodies is likewise augmented. Now such a character as this is sufficient in Physics for determining and distinguishing particular natural Bodies: Nor indeed are there any other that will answer the

same purpose, whatever your idle Philosophers may boast of their subtle speculations. It is our business therefore to observe with the greatest care, those properties that we are able to discover in Fire under this notion ; and of these the first seems to be this, that it exists in every point of time, and every part of space ; the truth of which I shall demonstrate by the following Experiments.

EXPERIMENT IX.

Take a thick cold plate of Iron, and in the sharpest weather, and coldest place, lay this upon another of the same kind, and equally cold, and let this, by the help of a weight, be press'd hard upon the under one ; then, let it be briskly rubb'd upon it backwards and forwards, and it will begin to grow warm, then hot, and in a short time will acquire such a degree of Heat, as to emit sparks of Fire, and at last the whole Mass will be as red hot, as if it came out of a large common Fire.

The first
manner of
producing
Fire.

COROL. I.

This production of Fire may be effected at any time whatsoever : Nor does it at all signify, whether the season is hot, or cold : Nay, in reality, the more compact the Bodies are render'd by Cold, you will, *cæteris paribus*, have the strongest Heat.

COROL. 2.

Nor is there any place hitherto known, where the same Experiment will not hold true. On the tops of the highest mountains, in the deepest subterraneous caverns, in the warmest parts of the world, and most frozen climates, the effect will constantly prove the same. I confess, indeed, that the Heat will be sooner and more strongly excited in dry places, than it will in moist ones ; but still, it may be always produc'd in this manner. And the same thing is observ'd to happen in every kind of solid Bodies whatever.

COROL. 3.

Nay even in *vacuo* Bodies grow hot by mutual attrition ; as evidently appears by the accurate observations of the ingenious *Haukesby*, which have since been happily improv'd by my good Friend and Colleague the famous *James-Williams' Gravesand*, a Gentleman so form'd by Nature, and finish'd by Art for these abstruse inquiries, that by his discoveries, the boundaries of natural knowledge are daily enlarged.

COROL. 4.

But there is nothing more remarkable in the Fire produc'd in the manner abovemention'd, than that it penetrates into all Bodies, the densest not excepted, heats, expands, burns, and melts them ; and that it shines, grows excessive bright, and in short, has perfectly the very same effects that we constantly observe in true Fire. And we see here it is thus generated without any *Pabulum*, or any Fire that existed before by which it might be rais'd, which is commonly the case, Fire generally being lighted by Fire, and one Flame excited by another. Hence then, I think, we may fairly conclude, that this Being ought to be look'd upon as true Fire.

COROL. 5.

The first
cause of this.

In the mean time we learn by general observation, that the harder and more rigid the Bodies are that are agitated one against another, the more intense will the Fire be that is produced by their mutual attrition. Hence the very same Body, when it is rigider, or softer, acquires in this respect a very different degree of Heat. Iron, if it is taken out of the Fire when it is just ready to melt, and in the heat of summer suffer'd to cool very leisurely in the Air, will remain very soft and flexible; whereas, if you instantly throw it into cold Water, the Particles, that were before put in motion, and render'd flexible by the Fire, being now compacted together, and driven into closer union by this sudden contraction, the Iron becomes exceeding hard, rigid, and very elastic: But every body knows how much fitter Iron is for striking a light when it is harden'd by Cold, than when it is softer. If the vast hard *Axis* of a Wind-mill lies upon a rigid block, and the sails are whirled rapidly about by a strong Wind, Fire and Flame break out immediately; but if you take care to put Lead between them, there is not much danger of so great a degree of Heat. If you strike a Flint against a very hard piece of Steel, how certain are you of procuring Sparks from it? which would not be the case, should you strike it against a bit of soft Iron. And hence it comes to pass, that if you interpose any soft Body betwixt two hard ones, you can scarcely excite Fire by the strongest attrition, till this is consumed, and the Bodies come to rub one against another, and then you have Fire presently. If you take, for instance, two Plates of Iron, and oil them very well, you cannot by rubbing them together, make them conceive any very great degree of Heat; but when the surfaces of the Iron come to touch one another, they will soon grow excessively hot by the same agitation.

If Bodies, therefore, are alike in every thing else, the denser the matter is of which they consist, the fitter will they be for this production of Fire; which rule holds universally true: I say, if they are alike in all other respects; for Lead which is denser, but at the same time softer, will not by attrition yield so much Fire as Iron, which is lighter, but vastly harder: But if they are both equally rigid, then the heaviest is always most efficacious. Hence it appears, how that exceeding hard, and ponderous Wood, the *Sideroxylon* of the *Indians*, not only furnishes them with weapons, but by being rubb'd swiftly together, serves to kindle their fires whenever they want them.

The harder, then, and more dense the Bodies are, that are agitated one against another, the sooner will Fire be produc'd from them. Hence the collision of Steel and Flint excites Fire in the least instant of time; which is much longer generating from Bodies that are lighter, and not so hard.

COROL. 6.

A second
cause.

The principal physical power, however, that produces Fire by this attrition, consists in the Bodies being press'd very hard together, whilst they are rubb'd one against another. If you lay, for instance, one Iron Plate upon another, so that it may press the under one only by its own weight, and then with a certain reciprocal motion, agitate the upper one over the inferior, you will be able to excite but a small degree of Heat. Lay a ten pound weight now upon the

the upper plate, and then move it with the same velocity as before, and a greater Heat will immediately be generated. And thus if you proceed you'll be surprized to find how the increments of Heat constantly correspond to the augmentations of the weights, if the agitations are performed with the same velocity. So that at last, if the pressure is increased to a very great degree, the strongest Fire may be produced in an instant. And the same also holds true in the Elements of Fluids themselves compressed together, as has already sufficiently appeared.

COROL. 7.

And, lastly, we observe, that the swifter the motion is of these hard Bodies one against another, the Fire excited by this attrition will *cæteris paribus* be so much the stronger, and the sooner produced; so that a slow motion scarcely generates any Heat, though a brisk one will raise a great quantity of Fire immediately. Hold a rope, for instance, very tight, and draw it gently through your hands, and you'll perceive no Warmth at all; but let it run through your hands with a rapid motion, and it will soon conceive Heat, and burn them: Press a steel blade hard against a threshold, or a grindstone, and it will scarcely grow warm if you move it but slowly; and yet if the reciprocal agitations are swift, you may soon produce a great degree of Heat: So that by holding a knife very hard against a grindstone whilst it is very rapidly turned round you may make it almost red hot, whilst the stone itself is hardly warm, because no part of the stone remains long in contact with the blade, but instantly moves from under it. Hence, therefore, the production of Fire may be increased in proportion to the augmentation of this celerity, and that without limits.

COROL. 8.

It follows, therefore, evidently from what has been said, that when the three causes just mentioned unite their power, there then may be the strongest Fire excited in an instant from the coldest Bodies. If two large, thick, circular plates of very hard Iron should be compressed together by a force of ten thousand pounds weight, and then be very rapidly agitated one against another, there would be the most violent Fire produced immediately in both the plates. This is evident in Windmills, where if the *Axis*, and block it lies upon are dry, and the wind is very strong, the attrition quickly generates both Fire, and Flame; though there, the motion is but slow, on account of the smaller Diameter of the *Axis*. Filings of Iron as they fly off burn the Workman's hands, and the raspings of Wood doe the same. In the deep parts, therefore, of the Earth towards the Center, where Bodies are vastly compressed by the incumbent weight, and consequently rendered exceeding dense, does the attrition excited there produce a very great degree of the strongest Fire? and consequently does the Heat there gradually increase more and more? See *Boyle of Cosm. Qual.* This is certain from what has been demonstrated, that it is impossible to determine the ultimate, or intensest degree of Heat, that may be generated by attrition: For though it were possible to discover what kind of Bodies were actually harder and more dense than all others; yet we could never possibly assign the greatest weight by which they might be pressed together, or the swiftest degree of motion with which they might be agitated. There never, therefore, can exist so great a degree of Heat, but that a greater may be still produced.

A third
cause.

This three-
fold cause
united.

The power
of Fire ex-
cited by at-
trition not
to be de-
termined.

EXPERIMENT

EXPERIMENT X.

Fluids inter-
posed be-
tween Bodies
retard this
production
of Fire.

If in the former Experiment any Fluid had been interposed between the Surfaces of the two Bodies thus densed, and pressed together, and had been continually supplied whilst they were in motion, they would scarcely have conceived any Heat; or at least nothing in comparison of what would have been produced by the same causes had that been away; the truth of which is confirmed by universal Observation. If I rub, for instance, the dry blade of this knife hard upon this dry whetstone, it presently grows hot, makes a noise, and often, as you see, emits sparks; whereas if I put a drop or two of Water, Oil, or Spirit between, the same cause, as you observe, repeated, does not produce the same effect. Every body knows that the Axletrees of Wheels hardly ever grow hot if they are well guarded with grease; but if they and the Boxes are dry, they presently squeak, smoke, grow hot, and very often take fire: And for want of being secured in this manner whole Windmills have been frequently burnt down. But this never appears more evident than in the polishing of Glass: Neither the *Lens*, or the plate it is polished on, becomes hot till the interposed oily or watery liquor is consumed, and they both grow dry, but then, a very great Heat is excited immediately.

COROL. 1.

Soft rare
fluid Bodies
unfit to ex-
cite Fire by
attrition.

The softer, therefore, the more yielding, less elastic, and rarer any Bodies are, the less fit they are for producing Fire by attrition. And hence, as Fluids for the most part are possessed of these qualities, they are observed of all Bodies the least capable of exciting Heat in this manner; for they easily yield to any impression, and by this means slip out of the way, and elude the force of it. And this is found to hold true in the whole compass of nature.

COROL. 2.

And bodies
that lie loose
upon one an-
other.

And again, the less the force is by which any Bodies are pressed together, the less Heat will be generated by their rubbing one against another. This too is confirmed by every kind of Experiment without exception.

COROL. 3.

And Bodies
that are at
rest.

And lastly, if Bodies are moved softly one upon another, tho' they have all the other properties requisite to the production of Fire by friction, yet they will not generate any considerable Warmth; and if they are quite at rest, they will be reduced to the common temper of the ambient Air. This we see in vast heaps of Iron, where, though the Body is so hard, and that which lies at bottom is pressed down with such a prodigious incumbent weight, yet it conceives no more Heat than the very soft, rare, light Air, that surrounds it.

COROL. 4.

The absence
of natural
Fire thus
discovered.

From what has been observed, then, it seems to follow, that Fire least of all discovers itself by its effects in those parts of space where, first, there is either no body at all, or exceeding rare ones, whose parts are so loosely connected together that they scarcely cohere with one another; Secondly, where there is no cause to compress these Bodies together in these spaces; and thirdly, where there

there is no power to put them in motion so long as they continue there. With us, the *Torricellian Vacuum* is such a space as this: For if you take a glass Tube 40 inches long and closed at one end, and fill this quite full of the purest, driest Mercury made very hot, and then in an erect position properly immerse the open orifice in some more of the same Mercury, so that there shall be nothing but pure Mercury in the glass; there the Mercury will descend, and leave an empty space in the upper part of the Tube, in which, there does not appear the least sign of any heavy resisting Body; nay, if you compress the Mercury in the under vessel, that in the Tube will ascend and fill it perfectly full. Here, therefore, seems to be a space, where there is not the least attrition of any Bodies; and consequently, here will be the very smallest degree of Fire, so far as it depends upon this attrition. And yet, if you agitate this baroscopical Tube in the dark, a light will be hereby excited, which you will perceive in this *vacuum*, as that excellent Mathematician the great *Bernoulli* has so elegantly described, and explained. Hence every one will be ready to infer that, even there, there must be Bodies also. And indeed, that Being which thus penetrates the Glass, the Mercury, and the Air, must be uniformly distributed through that space; but it does not, however, any ways appear, that this, be it what it will, exhibits the least mark of any degree of Heat generated in this manner. Hence, perhaps, the light, that is thus excited by this concussion, is of the same nature with that which we treated of in our History of Light as a property of Fire. And, hence, we are led to imagine, that Light, and may be Fire itself, considered without the concurring action of any solid Bodies, passes freely through all parts of space, without discovering any effects of Fire that we are hitherto acquainted with. This, at least, is evident beyond all dispute, that as we ascend from the common surface of the Earth, and get to the tops of high mountains, where there are no Meteors to obstruct and disturb the equal action of the Sun, and where, therefore, its rays strike the Bodies opposed to them in the most direct manner, and with their utmost force, I say, there, we are not affected with Heat, but on the contrary always find a greater degree of Cold. And at length, when we are got so far from the Earth, and so near the Sun, that there are scarce any visible exhalations, or vapours observed to rise so high, then, Water, when any does reach thither, is congealed into Snow, and lies at the tops of these mountains all the Summer. So that it hence seems probable, that in those parts of space where there is no hard resisting corporeal substance to withstand the action of Fire, nor any thing which is capable of exciting attrition, there, Fire, though it is actually present, appears most quiet, and acts with the least efficacy: And since the altitude of the highest mountain is scarce equal to $\frac{1}{89}$ th of the Semi-diameter of the Earth, and yet there is so great an increase of Cold there, in this little recess from the Center of the Earth, this small approach to the Meridian Sun, and under this great pressure of the Atmosphere, what must we think would be the case, could these observations have been made a thousand times higher? Why, certainly, as far as we are able to guess by that poor little that we know of Nature, all motion seems gradually to decrease as you ascend higher and higher from the Earth, till at last, the uppermost regions appear to enjoy the most calm, and undisturbed rest. And this seems confirmed by this Observation, that the same

Pure simple
Fire

Scarcely discernable.

sort

Of the pure
Fire of the
Alchemists.

And He-
brews.

sort of trees, sprung from the same seeds, on the same mountain, and in the same situation with respect to the Sun, are always the largest at the foot of the mountain, and grow by degrees weaker and drier, the more you ascend. And this opinion will give us some light into the abstruse writings of the ancient Alchemists, where they tell, that in pure Fire there is the most perfect silence, and absolute rest, and that God resides in it; that from hence, however, are sent forth ministering Fires to quicken and move Bodies that would otherwise die through inactivity, and to dispose them to execute the pleasure, and appointment of the omnipotent Creator of all things. And, indeed, in this, they did but follow the opinions of the most ancient *Hebrews*, and the Sacred Writers. *Exod.* iii. 2, 3, 4. xix. 16, 18. xxiv. 17. *Lev.* x. 2. *Psalms* civ. 2, 4. *Ep. to Heb.* i. 7. xii. 29.

COROL. 5.

An exceed-
ing great
and sudden
Heat excited
by the at-
trition of
Metal
against the
lightest
Fluid.

Lastly, it appears evident from modern Experiments, that a surprizing Heat and Fire may be instantly produced in the coldest, hardest, and heaviest Bodies, purely by their attrition with the lightest, softest, cold Fluids, if the motion is exceeding violent.

If a large ball of solid Iron is fired from one of the biggest sort of cannons in the Winter, it will run through the cold Air 600 feet in a second, and consequently will meet with a vastly greater resistance from the Air, than from the most rapid wind; for when that moves only $22 \frac{1}{4}$ feet in the same time it condenses the Air so violently, that it bears down every thing before it, tears up the trees, and breaks them to pieces, nor are houses, or towers able to withstand its fury, *Maraiotte* pag. 140. Hence it appears, what a very great attrition it must suffer purely from this cause; and yet this must be still increased considering that no part of its surface moves in a strait direction; for as the ball in its passage turns round upon its *Axis*, every point is continually describing a Cycloid. Now this ball, when it has run through its way with this rapidity, and comes to fall, is found to be perfectly hot; although through its whole passage it has constantly been exposed to fresh cold Air, and consequently has lost every moment something of the Heat it had conceived. Some persons may be apt here to object; that the Heat of the ball may be owing to the flame of the Gunpowder with which it is fired; but that can't possibly be, as it remains in it so infinitely short a time; certainly, scarce $\frac{1}{100000}$ of an hour. Now who can believe that in so small a point of time this flame can communicate so great a degree of Heat to so solid a Body? But this may easily be accounted for, from that vast attrition that must arise betwixt the Air and the ball whilst it moves with this prodigious celerity, and acts, and is reacted upon by the Air with $27 \frac{3}{4}$ times more force than that of the strongest wind that was ever yet observed.

The Doc-
trine drawn
from these
premises.

Since, therefore, it appears by every kind of Experiment, that Fire by the friction of any Bodies together may be quickly produced where it did not appear before, and that, at all times, in every degree of Cold, and in every place where trial has been hitherto made, supposing the three physical conditions which we mentioned before; I say, these things considered, I think we may thence fairly make a great many deductions, which will be of service to us in discovering the nature of this Element: Some of which by your leave I will here mention.

In

In the first place, then, by what we already know of Fire, it appears, that it must be always present in every part of space, though we are not at all times able to discover it, if we search for it only in the common methods: For the most accurate Thermometer evidently shews us, that there is always, and every where actually existing, a Heat greater than the intensest degree of Cold that we formerly described, though people are very apt wrongly to imagine, that there then remains no Fire at all in that place where the Thermometer is fallen as low as 0.

Fire always
present in
every place,

Nor does Fire thus exist only in every part of space, but it is likewise equally diffused through every Body, the most solid, as well as the rarest: For if in the hottest day of Summer, or the coldest of Winter, you apply the most sensible Thermometer to a glass in which there is a *Torricellian Vacuum*, where one might possibly suspect there was nothing but mere Fire, and at the same time apply the same instrument to Gold, which is the solidest Body that we are acquainted with; you will find the degree of Heat and Cold perfectly alike in both, if they have both remained long enough in an Air that has in the mean time neither grown hotter or colder. These things seem strange, it's true, nor have I met with any Body that at the first proposing them, could readily come into them; but yet this just, and indeed, infallible method of making the Experiment, most evidently confirms the truth of them. In cold frosty weather I examined in this manner the *Torricellian Vacuum*, that of *Boyle*, Air, pure Alcohol, express'd Oils, distill'd Oils, Water, *Lixiviums* of various Salts, Spirits drawn from Salts by Distillation, Mercury, Feathers, Filings of Metals, Sand, and Lime, after they had been exposed to the cold Air, and found the degrees of Heat and Cold perfectly alike in all, without the least difference. This seems a surprizing paradox; but it is, nevertheless, absolutely true.

And in every
Body.

I have not, therefore, hitherto been able to discover, that in all nature there is any part of space, in which there is not Fire. Nor yet, has it ever appeared to me after the most laborious Inquiries, that there is any kind of Body, that has a power implanted in it by the Divine Being, by which it is able to attract this Fire thus equally diffused, and so unite it to itself, as to make the excess discernible to our senses. On the contrary, all the Observations that I have had an opportunity of making seem to evince, that where there is neither any degree of attrition, nor motion from the mixture of various Bodies together, there, Fire is most equally distributed through every part of space: Nor does it in the least signify whether these spaces are empty, or full, or with what kind of Bodies they are filled. I am sensible that every body will be here apt to cry out, that these are all Chimeras of my own brain, and that I assert things that are absolutely false, and contrary to common sense, which plainly teaches us that Iron in the Winter is colder than Feathers, and Mercury than Alcohol. But, Gentlemen, I have already given you a caution, that I am not here treating of Fire as it manifests itself to our senses by Heat, or Cold, but purely with regard to its property of rarefying Bodies, which after a good deal of diligent inquiry we have found to be its peculiar character. How it comes to pass that Alcohol in Winter appears warmer than Mercury, or rasped Ice, we shall endeavour to explain, when we have treated of the solidity, or rarity of Bodies with regard to Heat or Cold; nor can we do it now without breaking in upon the order of our subject.

The quan-
tity of Fire
as the
spaces it is
diffused
through.

Q

The

Seldom discovered as it exists in this manner.

The second thing I lay down in our doctrine of Fire is this, that this Fire, which is thus equally, and for the most part quietly diffused through every part of space, is scarcely ever taken notice of: For those things which constantly remain perfectly the same, nor discover themselves by any alteration, are commonly no more regarded than if they did not exist at all. If, for instance, there should at any time be such a degree of Fire, as should not produce the least change in either Fluids, or Solids, then no body would think at all of Fire, Heat, or Cold: But as soon as ever there was a small increase of Heat, so that Wax should become a little softer than it was before, then every one would immediately suspect that there was a new production of Heat, and Fire supposing them to know before that Wax would be reduced from its solid form to a fluid one by the application of Fire. And from this prejudice it happens that people generally think, that Fire is really generated by Art, or chance, whenever its effects are so remarkable as to render it more apparent than it was before.

And yet in this condition is always in motion.

In the third place, from what has been said it seems evidently to follow, that this Fire that is thus diffused through all space and every Body, is continually both moved itself, and puts other things in motion, although you suppose it ever so small. For what person living can assign the ultimate point of absolute Cold, or which perhaps is the same thing, the perfect rest of Fire? But the very least degree of Fire, Heat, or this rarefying power, immediately begins to expand every kind of Body, to remove their parts from their spontaneous cohesion, and, so long as it remains in them, to keep their Elements from their proper and natural union; which evidently demonstrates that a real motion is there excited. And hence it seems exceeding probable, that this Fire is contained *in vacuo*, and in the vacuities that are dispersed through the most solid Bodies, as in a kind of vessel, where it is frequently agitated, and always in action; and that hence it is of necessity continually producing certain Operations, the effect of all which principally tends to remove the Elements of Bodies from one another, that so the Fire may expand itself more equally. In the mean time, however, it is not less certain, that the Elements of corporeal matter constantly endeavour to unite themselves together more and more, to lessen the vacuities between their impenetrable particles, and consequently by the excess of their power to expel the Fire that is there continually endeavouring to dilate itself. Here, therefore, will be a constant action and reaction, between the Fire contained in these Pores, and the constituent Elements of the Bodies; the former tending always to separate these Elements from one another; the latter from a natural propensity perpetually attracting one another into the strongest union. On this account, therefore, the whole System of natural Bodies which the Almighty Creator has formed and disposed in infinite space, may be divided into Fire, which has a power of expanding every thing else, and the remaining Bodies which have a virtue implanted in them, whereby they constantly resist this separation of their Elements. And thus these two principles, the one of expansion, the other of attraction or association, exert themselves through the whole compass of nature, and are the cause of a vast number of corporeal effects. The energy, however, of these principles we cannot at present rightly understand from the ideas we have hitherto been able to form of them: This is the sole prerogative of that infinite

And repelled.

infinite Being, whose supreme Wisdom, at one view, perfectly takes in these and all other things, which his Almighty Power has created in such a manner as is not possible for mortal minds to comprehend.

The more intently, now, I examine this mysterious subject, the more plainly I am convinced, that Fire is not able to insinuate itself, into what we call the ultimate impenetrable Elements of Body, but that it is repelled thence whenever it exerts itself upon them, and always the more so, the greater the force is by which it endeavours to penetrate them: that some degree of attrition therefore may, nay, and must arise betwixt Fire and other Bodies: And that Fire itself does in reality never reside in the proper substance of Bodies, but only in the vacuities that will be left betwixt their Elements, let the Bodies be ever so solid. And certainly, the ἀντιτοπία of *Democritus*, or impenetrability as it is called by others, seems so proper to Fire, and every other Body, that it appears by every kind of Experiment to be perfectly inseparable from them.

Never penetrates the substance of Bodies.

As a fourth position in this doctrine we observe, that whilst this Fire thus residing within the Pores of Bodies, is not acted upon or moved by any other cause, so long it does not discover itself by any effect; for since it can go out of these passages again with the same ease with which it enters into them, it will not much vary its action upon the Body that contains it, as it seems to exist, and act every where in an equal quantity. That you may more clearly understand what it is I would here inculcate, observe the degree of Heat that this Thermometer, which is extremely sensible of Warmth and Cold, indicates at this time. I'll place this, now, against the mouth of this great Bellows, and you perceive what a prodigious wind comes directly upon the Thermometer. Don't you all expect now, that the force of this wind will produce a considerable degree of Cold; and that hence there will be a variation in this infallible Instrument? And yet you observe it remains perfectly at the same height. Here, then, we see evidently, that there was no degree, either of Heat, or Cold, generated by this means, which our senses were capable of discerning: For Fire, by reason of its exceeding rarity, is almost as easily conveyed through Air, when it is in motion, as when it is at rest. Indeed, was this Air agitated with an extraordinary violence, such a one as this Bellows is not capable of, in that case, by the attrition arising hence, might be excited a greater degree of Heat, as has already appeared; but then, this would be owing intirely to attrition. And hence perhaps it comes to pass, that the greatest storms, a few cases excepted, do generally *cæteris paribus* rather raise than sink the Thermometer. This, at least, I have long ago observed, that we have generally a very warm Air at the same time we have the highest winds, and the sharpest Frosts when every thing is perfectly calm. But you'll be apt to say, why then does the wind, and indeed the Air itself, appear so cold to our Bodies, especially when they are heated, so that every one very justly ascribes to them a power of cooling? And do we not find by undeniable Experience, that in a cold high wind, the Cold is vastly more injurious to us *cæteris paribus* than at other times, so that no person is able to bear it, but would soon have his limbs destroyed by a Gangrene? In answer to this, I acknowledge the truth of these facts, but at the same time assert, that the cause of them is very different from what people generally imagine. To account for

Wind don't produce Cold,

But rather Heat.

And yet it cools the Human Body.

this,

this, then, we must observe, that no body is able to endure an Air that is heated to 90 degrees, but it soon becomes fatal to all sorts of Animals that we are acquainted with ; whereas the vital Warmth of the Human Body, as *Fahrenheit* has observed, will raise the Thermometer to the degree 92, and that of children often to 94. Hence, therefore, we are always warmer than the ambient Air ; and of consequence the garments that encompass our Bodies have a greater degree of Heat in them than if they were every way exposed to the open Air. Again, this natural Warmth heats the Air that is contiguous to our Bodies ; and therefore, if it is not disturbed by any wind, but remains quiet about us, this Atmosphere of our Bodies will be warmer than the Atmosphere of the common Air, and consequently we shall feel it warm, as it really is. When this warm Air then, that every way surrounds us, is dispersed by the wind, and a colder Air is applied to us in its room, there immediately is excited a real Cold both in our Lungs, and on the surface of our Bodies, that are exposed to it : And besides, the Heat that is communicated by us to our clothes is at the same time blown away, and fresh Cold is continually received by them, and thus applied to our Bodies : So that, in reality, we are nearly in the same circumstances as if a man should perpetually shift his clothes, and put on fresh ones that were just come out of the Air. It appears, therefore, from these considerations, that though wind does not actually generate any degree of Cold, yet it is capable of cooling the Human Body by thus carrying off the warm Air with which it is encompassed, and bringing fresh colder Air in its room. But as this Observation may be of exceeding service in Medicine, give me leave to illustrate it yet farther by an Example. Let us suppose then by exercise, disease, or some other cause, the heat of any person in his clothes, and in a serene Air to be 100 degrees ; and that of the common Air at the same time to be moderate, *viz.* about 48. Now you easily conceive that the clothes that are about his Body, will in a little time be pretty near as warm as his Body ; and that the Air which remains quiet about his clothes, and his head, will be considerably warmer than the degree 48 ; for I have often observed, that the Thermometer has been raised at the distance of 4 feet purely by the Warmth that has exhaled from a man that was hot, and fallen again when the person removed farther from it. Suppose, therefore, the person's clothes, and the surrounding Air, to be heated to the degree 60 : His Body then will be perfectly encompassed with this temperature, his vessels, and humours relaxed suitably to this degree of Heat, and his exterior Nerves will be just affected with a sense of the same. Let him be exposed, now, to a wind that moves 6 feet in the second of an hour ; and then all this heat of the ambient Air, and his clothes, will be removed in that time, and a Warmth of only 48 degrees will be applied to his Body on every side, and consequently his external parts will be 12 degrees colder than they were before : And since we suppose this wind to continue constantly the same, his Body must in a little time grow cold in its inmost parts ; as the constant application of this external Cold must every moment necessarily destroy as much of that Heat, which is generated by the vital actions. Thus, therefore, we have an evident solution of this *Phænomenon*, which otherwise, indeed, appears a paradox.

Not a
Thermom-
eter.

For if now, instead of a human Body, you place a Thermometer in this Wind, the Heat of the Liquor in the Thermometer, and that of the ambient Air,

Air, will be exactly the same; and hence, whether the Air that encompasses this Instrument remains perfectly at rest, or is constantly changed, the Liquor will still continue exactly at the same height; and consequently, the greatest Wind will not produce the least degree of Cold in the Thermometer; unless there is at the same time some alteration in the temperature of the Air in the place the Wind blows from. Now, from what has been remark'd, you, Gentlemen, who consider the human Body in a medicinal view, will easily understand, how nothing produces severer diseases, or is more quickly fatal to the healthiest, nay and the stoutest Bodies, than exposing them to the Wind, when they have been heated with motion, and are ready to dissolve with Sweat; especially, if they are grown hot by a violent exercise in a cold Wind, and then remain quiet. Hence often arise Asthma's, that are never got rid of, *Angina's*, Pleurifies, Peripneumonies, Gout, and Rheumatism. A plain proof of this, likewise, we see too plainly in those persons who unhappily labour under an exceeding weak and tender habit of Body: How prodigiously do these suffer from the slightest Wind, or least breath of Air, if it comes only through a crack of a window, and is but little colder than the temperature of the chamber in which they live; especially, if that has been always kept pretty nearly the same by the help of a Thermometer, than which I know nothing more injurious to a good constitution.

The use of
it in Physic.

In the fourth place then, from what has been now said, and which we shall not repeat for the future, we may reason something of the nature and action of Fire: For if two dense, hard, and very elastic Bodies are rubb'd one against another with a great force, and a brisk reciprocal motion, then all the parts of these Bodies will every moment be closely compress'd; and as they are rigid, they will strongly resist this pressure, whence will arise an exceeding swift, and very powerful contraction and expansion, or a kind of quick vibration, such as we observe in Chords when they are very tense. How great these vibrations are, we see evidently in an elastic metal Bell, if it receives but one stroke upon it. Does not the whole Body of this, vastly large, as it is sometimes, expand and contract itself through all its substances in an infinite number of *Ellipses*, and that, for a very considerable time? And when the attrition that we just now described is excited, with what force, violence, and celerity, are the elements of the Body compressed, agitated, and relaxed, to their very inmost Particles? What a *stridor* is produc'd from this attrition, so acute, that the Ear is not able to bear it; a certain demonstration of the greatness of the vibration? We conceive, therefore, that whilst the Body suffers this agitation, compression, and relaxation, there must be an exceeding rapid motion in all its Particles, as all Chords perform their vibrations so much the quicker, the more elastic, and shorter they are, and the harder they are strained: But those three circumstances concur here all together. Now as this is beyond all dispute confirmed by Experiments, so I think it is not less evident, that the Fire, which in the mean time resides in the pores of these Bodies, and exerts there a power of expanding them in all their dimensions, and is likewise repelled by the contractile, resisting force of the expanded Body; I say, that this Fire must now, by the action of this attrition, be necessarily every moment most violently compress'd and relax'd in these vacuities. Hence, as from that property of expanding every thing which we took notice of before, Fire seems of all Bodies

The action
of Fire ex-
cited by at-
trition.

to be the most elastic, it appears that its proper force and motion must thus be prodigiously increased. For this reason, therefore, we conceive, that both in the Bodies thus agitated, and in the Fire contained within their Pores, there will be excited a motion exceeding great, and that will continue a considerable time. But farther, this cannot happen, but the surrounding Fire from both these causes must be agitated likewise, and that, so much the more violently, the nearer it is; for it has already appeared, that Fire is equally diffus'd through quiescent Bodies, and Space, which is neither capable of motion or change, and perhaps acts equally too. The ambient Fire, therefore, must likewise follow the concussions of that intercepted in the *Meatus's* of the Bodies thus rubb'd together; and of consequence, must be driven backward and forward. And this vibration seems to continue as long as that which is produc'd in the Bodies by this attrition, or till the oscillations of the Fire itself are reduc'd to rest, or a motion equal to that of the Fire in the Spaces or Bodies round about it. But since the same causes that agitate these Bodies must add a new motion to the Fire also, besides what it had before in common with all other, hence its force must be likewise increased: And as the expansion of Bodies is the proper effect of this force, it will of consequence presently discover itself by this effect. Thus far, therefore, we may comprehend the power of Fire, consider'd purely as excited by attrition: And the solution of a great many *Phænomena* we meet with here, will be hence easily understood.

By which
some *Phænomena*
are
understood.

1. Why do elastic Bodies chiefly generate Fire by attrition? Because they alone oscillate in their Elements. 2. Why do the most elastic Bodies produce most Fire, as we see in the hardest Steel briskly struck against a rigid Flint? Because the vibrations here are the swiftest and greatest. 3. Why do the softest non-elastic Bodies generate the least Fire? Because they have no spring in them, nor restore themselves again, nor oscillate backwards and forwards. 4. Why then will Lead rubb'd forcibly against Lead produce a very great degree of Heat? Because the ultimate Elements of Bodies are expansile and contractile by Fire, and from their own nature, tho' the larger Bodies that are composed of these Elements, have a cohesion of parts that is less resisting, and will easier give way. Hence it appears, that the elasticity of these Elements, which is common to all Bodies, and may be changed by Heat and Cold, is different from that by which Bodies resist an impulse, and restore themselves to the same form they had before the stroke. 5. Do not Fluids, therefore, generate Heat by attrition? Most certainly, if they are elastic; but with difficulty, if they are not. Hence Water will not easily grow warm by attrition. Nevertheless, if non-elastic Fluids are forc'd through very narrow canals with a vast *impetus*, they will conceive Heat by this attrition; because the ultimate Elements of these seem likewise to be somewhat elastic: But if the Pipes are elastic through which the Fluid is impell'd, then a still greater degree of Heat may be excited. Hence, our elastic Blood being violently propell'd through elastic Arteries, is hot whilst it circulates in a healthy Body: But when the Blood by any means becomes of a more watery disposition, and consequently less elastic, the Heat that is produced by its circulation will not be so great: Which is likewise the case, if the spring of the Arteries becomes weaker. 6. Why does the interposition of a Fluid, when Bodies are rubb'd together, hinder, or diminish, the production of Heat? Because the force impressed is

eluded

eluded by the slipperiness of the Fluid. 7. Does therefore an elastic quality in Bodies increase the action of Fire upon them? Vastly; as appears from what has been just observed. 8. If the power of gravity determin'd Bodies less towards one another, what would be the consequence with respect to Fire? Then, we should scarcely perceive any of its effects: This we experience in the deepest pits, and on the tops of the highest mountains. 9. How does it happen then in very deep places, where the Air is always at rest? Why there, at the same depth, there will always be the same degree of Heat and Cold, tho' it will be different, at different depths, according to the various nature of the Earth that in those particular places surrounds and warms it: The truth of this is confirm'd by some elegant observation made in the Well of the Observatory at *Paris*. 10. Why does the percussio of Steel against a Flint, yield the largest and most vivid Sparks in the coldest weather? But there would be no end, should I mention every thing that is constantly occurring, whilst one's thoughts are engag'd on this subject. In short, therefore, Gravity, Elasticity, and Fire, seem to be the three principal of the universal or common causes of the actions of natural Bodies; and when to these, likewise, is added attrition, a great many *Phænomena* that are common to them all, may be easily understood.

From what has been premised, we infer, Fifthly, that if the densest, and most elastic Bodies of all, lying in the deepest parts of the Earth, and vastly press'd together by the weight of the incumbent ones, should be agitated one against another with the utmost degree of celerity, there would by this means be generated the most violent Fire. And hence it seems exceeding probable, that at the center of the Earth the Heat is most intense; and that it decreases gradually as you remove farther from it, till it becomes least of all at the boundaries of the two Planets. Let us suppose the Earth and Moon to be Bodies of the same nature; then in the center of the Earth and Moon will be the greatest degree of Heat, which will lessen by degrees, till you come to that part of space between these spheriodal Orbs, which terminates the action of both their powers. It appears, therefore, absolutely impossible, that any Birds can fly from us to the Moon, or from thence to us, as some Philosophers have asserted; or that they can exist in the profound Abyss. And what we have said of the Earth and Moon, will hold equally true in all the rest of the Planets. And hence it seems likely, that heavy Bodies are disposed only about the Planets, and perhaps about the Suns or fixt Stars, and thence by degrees grow so rare and light, that at last the resistance they yield becomes inconceivable, if any at all: That the quantity of Fire there, however, is equally great: That this Element, therefore, may possibly not be affected by the power of Gravity, but be absolutely indetermin'd to any part of Space: That hence, of itself, it may have no other power than that of an equable expansion every way, without any particular direction to one place more than another: And that on this account, it may scarcely produce any effects in those superiour regions, as there is no agitation of dense, elastic Bodies one against another, to cause there any attrition. And as the motion and tracts of the Comets are not yet accurately determin'd, does not the path of these wonderful Bodies lie through these Spaces between the Planets, and Suns, where they meet with scarcely any resistance?

The Ratio of Fire, and where it is greatest and least.

Birds can't bear the temperature of the highest part of the Atmosphere.

Some other
circumstan-
ces increas-
ing the Heat
rais'd by at-
trition.

It appears, farther, in the Sixth place, that those Bodies which have such large Pores interspersed through them, that Air, Water, Spirits, and Oils, may easily enter into them, and be expell'd again, are the least fit to generate Heat by attrition: Whereas those on the other hand, whose substance is so closely condensed, that their vacuities will admit nothing but pure simple Fire, must, if they are thus agitated, give a great degree of motion to the Fire contained within them. If we suppose, then, the Surfaces of two Bodies in contact to answer one another so nicely, that nothing but mere Fire shall be able to insinuate itself between them, when they are thus fitted together and put in motion; then, if they are rapidly mov'd one upon another, the Fire, which can alone interpose itself, will be agitated too: And from this cause again, the Heat will be augmented. And farther, if the agitation of these Bodies is so excessively rapid, that neither Air, nor any thing else can keep up with it, except the Fire that is dispersed through the Air, and other places; then, it seems exceeding probable, that this Fire will rush into these Spaces that are thus alternately empty, and fill'd again with this prodigious celerity; and thus more Fire will be collected in that Space which is nearest the Surface of these Bodies, than was there before; which will therefore be another cause of the production of Fire by attrition. And lastly, if the Elements of any hard Bodies are connected together by the firmest cohesion, and at the same time the Fibres and *Strata* form'd of them are exceeding short, and very tremulous; then, their vibrations will cause in Fire a very swift and strong agitation, and they will be able by a brisk attrition, to produce a vast degree of Heat in a very short time. The motion, therefore, that Fire acquires by these means, must certainly be prodigiously great.

Why does
Fire quit a
rarer Body
sooner than a
dense one.

It remains, now, carefully to inquire in the Seventh place, whether there is really observ'd in Bodies, any power by which they are able to attract Fire, so that the more solid substance they contain, the more Fire will of consequence be united with them? In quiescent Bodies, that this is not the case, is past dispute; for by Experiment, it constantly appears, that there is neither more nor less Heat or Fire in the *vacuum* of *Torricellius*, than there is in Gold, when they have both continued a good while in a place of the same temperature. But by the attrition we have spoken of so often, do Bodies acquire a kind of magnetic virtue, by which they are then capable of attracting Fire, and retaining it a considerable time when it is once united with them? I have taken a great deal of pains to answer this question; and this at least, I have evidently observ'd, that the rarer a Body is, the sooner it will be heated by the same degree of Fire; and that when once a Body is heated, the denser it is, the longer it will be before it is cold; and the rarer it is, the sooner. Hence, then, it seems to follow, that there is, in reality, in the solid Mass of Bodies, something like an attractive power, with regard to Fire; especially, as the same observation holds equally true in elastic Bodies, and those that are not so. In *Tschirnhausen's Focus*, the Fire is vastly intense; and yet, if with an Umbrella you cover that side of the Glass which is towards the Sun, the Heat will at once vanish from that place in the Air, where the moment before it was so excessive: Whereas, if a piece of Metal had been heated by the same Fire, it would have retain'd its Heat for a long time. If one vessel full of Air, and another of Water, had been exposed to the same Heat, the Air, may be, in this
Heat,

Heat, would be a thousand times rarer than the Water heated to the same degree; but then the Water would retain the Heat so much longer, as it was longer in acquiring it, so that possibly the Air would grow cool a thousand times sooner. From these observations, however, I think we can fairly conclude no more than this, that the denser the Bodies are that are exposed to Fire, the greater difficulty it has to penetrate into them, and to disengage itself from them again; for this is all that experience certainly demonstrates: Nor does it appear with sufficient evidence, that this *Phænomenon* is really the effect of any other cause. Indeed, if one might be indulg'd a conjecture on this head, one would be apt to surmise, that when Fire enters into denser Bodies, it causes a concussion in their very Element, and puts them into vibrations, which are larger if they are less dense, and of longer continuance, if they are more so; and that these, as long as they are in action, agitate the Fire that is contained within them, in the same manner as it happens to elastic Bodies by attrition: Upon the most careful examination, however, of this matter, I have not been able hitherto to discover by observation any such thing as a magnetic power in Bodies with regard to Fire.

In the Eighth place, I observe farther, that the hardest, and most solid Bodies being penetrated by a very small degree of Fire, and heated through all the Particles of their whole Mass, are mov'd and agitated to their very inmost substance; as appear'd plainly under our first Experiment. When, therefore, the same Bodies are heated perfectly through by attrition, they will be constantly agitated in the same manner. And hence again, these *Stamina* being thus all tremulous together, we conceive that they must produce a friction among themselves so long as this motion continues; and consequently, must be agitated in the same manner as if this attrition was external. On this account, therefore, they must move the Fire contain'd within them, and attract, collect, and retain it a good while within their solid Mass. And then again, these filaments of the Bodies are reacted upon by the Fire, and thus too, suffers an attrition from it. From all these causes then, Heat will be sometime retained in Bodies when once it is communicated to them. And indeed, that great Philosopher *Robert Boyle*, long ago made it appear by Experiment, that a solid piece of the coldest Iron, laid upon a cold Anvil, and briskly hammer'd with cold Hammers, would, purely from this compressive force, and its own recoiling elasticity, grow so hot, as to kindle Sulphur that was thrown upon it: And again, that an iron Nail driven up to the head in a piece of hard Wood, would, by being struck upon with a cold Hammer, immediately grow exceeding hot, when once it could enter no farther, tho' the Hammer itself would continue cold. And he farther demonstrated the same thing in filing of Iron, where the Iron will acquire Heat, tho' there appears none at all in the File. See those valuable Treatises of his, *Of the Mechanical Production of Heat and Cold*.

Heat excited by percussion alone.

From these observations, therefore, we see in the Ninth place, that there may, by this means, be a great deal of Fire produced, where we are certain nothing more happens than the elastic Iron's being compress'd by other elastic Iron, and its restoring itself again between every stroke of the Hammer: And yet there will be here so great a collection of Fire, that Sulphur being sprinkled upon the Iron, will be kindled into a Flame.

Purely by the vibrations of elastic Bodies.

R

Tenthly,

From a simple stroke.

Tenthly, then, we conceive, that when once such an elastic Body is thus heated by percussion, it will for some time retain this oscillation in its compressed and recoiling Particles, and by this means continue the motion of Fire: As we see a Chord, when once struck, will tremble a good while; and a Bell, from one single stroke, will continue its sonorous undulations a great deal longer.

Fire is not actually generated by this means,

In the Eleventh place, it seems of consequence to examine whether this Fire that we have thus mention'd, as produc'd by attrition and percussion, is really generated *de novo* by these vibrations of the Particles, and did not exist before: And again, whether the parts thus vibrating do so wear away their own substance, that the Particles of the Body itself, thus abraded and agitated, become real Fire; and consequently, whether other Bodies may thus by attrition, percussion, and vibration, be actually chang'd into true Fire, and thus Fire be created of what was not Fire before? For my own part, I confess, this, to me, seems impossible. For I have demonstrated, that Fire exists in all places. I have made it appear, that it is equally diffused through every part of Space. I have prov'd, that it may be produc'd by the attrition of any Body whatsoever. And it is evident, that when it is once excited, let the manner of its production be what it will, it is always absolutely the same, and discovers immediately that property, which is peculiar to Fire and inseparable from it, and belongs to no other Body in nature besides. It is not at all probable, therefore, that Fire is continually generated *de novo*: But it seems likely, that when it is once created, it then continues always to exist, and that in the same quantity; tho' in all the actions abovemention'd, it undergoes such changes, in respect of its motion, rest, collection, dispersion, and direction, that it sometimes discovers itself to our senses, whilst at others it lies concealed beyond their penetration. And if a person carefully considers the things I have already offer'd concerning the marks and production of Fire, both as they stand separately, and as they give light into one another, I can't but believe, he will find they plainly confirm my opinion, and shew the fallacy of the other: For who does not see, that by the attrition and percussion of a hard elastic Body, Fire may be put in a greater motion, than it was in before? And who will deny, that this will likewise agitate other Bodies in a greater degree, when it is thus put into a swifter agitation itself? Who don't easily perceive, that Fire alone is able to keep up with the exceeding rapid motions of the most solid Bodies, and of consequence, must be there collected? And who doubts, but that in all these cases, so much Fire is really brought hither from the neighbouring places in particular, as now exists in this place more than did before? For the motion of Fire from one place to another, don't seem at all more difficult than that of any other Fluid. But as soon as ever it is collected from a larger Space, and more closely reduc'd into a less, it must of consequence appear to our sense, as tho' it was really created a-new, both on account of its quantity, and of its effects.

But is put in motion and collected, and so discovers itself.

The conclusion.

In the Twelfth, and last place, give me leave to mention what I have taken notice of already, *viz.* that in every part of the known world, where there is the greatest degree of Cold that either Nature or Art produces, Fire does actually exist, and that in a very great quantity: For either by attrition, or percussion, the strongest Fire may be excited there in the least instant of time. This we see evidently by striking a Flint against a piece of Steel; and this the

Thermo-

Thermometer infallibly demonstrates, which we know certainly never suffers the least variation, when it is apply'd to Spaces, or Bodies of the same temperature. I think, therefore, Gentlemen, I have now, by Experiments, and the Corollaries drawn from them, pretty intelligibly explain'd to you the first physical manner, by which that Being may always and every where be certainly excited, which has a power of penetrating, and expanding or rarefying every thing we are acquainted with, Space only excepted: But this we plainly made appear before to be universally called Fire. We now, therefore, begin to get a little light into its hidden and mysterious Nature, and consequently, have some encouragement to prosecute our inquiries.

EXPERIMENT XI.

If Fire, explain'd as above, and now known by its power of rarefying, putting in motion, and insinuating itself into every kind of natural Bodies, is collected in any Space, or Body, so that it becomes perceptible to our senses, it then immediately begins to move itself by this power, and expands itself every way from the center of this Space, or Body.

That you may the better conceive what I mean, and at the same time see the proof of it, let this leaden Bullet be immersed in boiling Water, and after it has remain'd there till it has acquired the same Heat with the Water, be pulled out again by this Thread by which it is suspended. It then throws out the same degree of Heat from every point of it, with regard to our senses, has exactly the same effect upon the Thermometer plac'd at the same distance on any side of it, and by every circumstance indicates an equable dispersion of this Heat or Fire. Again, observe this red hot Iron just taken out of the Fire, does not the Fire look equally lucid and bright, and exhibit the same Colour in every part of it? And it warms us all equally, that are at the same distance all around it. It has evidently, likewise, the very same power of fusion, exsiccation, and burning, on every part of it. And which is the strongest proof of what I asserted, all Thermometers, let them be immersed in what Liquors they will, if they are plac'd at the same distance, will immediately discover the same temperature, by either expansion or contraction: And indeed, this is evidently confirm'd through the whole compass of Nature.

COROL. I.

It appears, therefore, that this is the property of Fire, that its parts, whilst they expand or move themselves, tend equally towards every part of Space, and consequently, are not determined to one point more than another. This, I confess, seems somewhat surprizing, and not easily intelligible; and indeed, this idea differs very little from the idea of rest. I'll endeavour, therefore, by a simple Example, to explain what I mean, a little more clearly. Suppose a hollow Sphere perfectly empty, and then conceive another Sphere a hundred times less to be plac'd in the center of it, and its parts to have such a power, that by equably receding from one another, they may perfectly fill up the larger Sphere: By this means then, you will have a true motion in all the parts, and yet the whole Mass thus mov'd, will be perfectly indifferent, and indetermined to any particular side. We conceive, therefore, from the

The proper
nifus or ten-
dency of
Fire.

foregoing Experiment, that the Fire that resides in our Air always expands itself, and is compress'd by the same law, if no other cause intervenes.

COROL. 2.

The computation of this Fire, with regard to its force and quantity.
Pl. III.
Fig. 1.

If you'll give me leave now to call the circumstance of Fire, describ'd in the preceding Corollary, its State of Stagnation; then the force of stagnating Fire will be as the Spaces in which it is contain'd; and consequently, the communication of this force from it, will be as those Spaces. Suppose the Globe A full of Air, hotter than the other surrounding Air contain'd in the larger concentric Sphere B; then the quantity of Fire, and its active force upon any part of the circumscrib'd Sphere, will be to the whole, as the Space on which you suppose it to act, is to the whole Space circumscrib'd: But this, in any case, the Geometrician may easily compute; and therefore, with regard to this property of Fire, the case is very evident.

COROL. 3.

By an Example.
Fig. 2.

For the easier conceiving of this, let us suppose the geometrical Globe A full of Fire, and in contact with another equal one B. From the center of the first C, draw the Tangents CD, and CE, to the Globe B. Then it is plain, that none of the Fire in the Globe A can, upon our supposition, come at the Globe B, except through the Sector CFG. Now the proportion of this to the whole Globe may be geometrically found *quam proxime*, as also the magnitude of the Cone CDE, and the spherical Segment DIE; and consequently, the quantity of Fire communicated to this Segment. These demonstrations we may be easily furnish'd with from the Geometricians: It is sufficient to our present purpose, just to have mentioned them.

COROL. 4.

An exact determination of it.
Fig. 3.

These things being understood, let us now suppose some physical cause to arise, which has a power of impelling all the Fire contained in this Sphere in parallel lines, and so of determining it towards one particular part. We then immediately conceive, that its whole efficacy will be directed that way, so that it will pass through the Cylinder EFGI, and all of it fall upon the Sphere KGBI; and consequently, will exert its whole force upon that Sphere. The effect of it, therefore, in this direction, will be to the former, as the whole is to that part, and as this parallel direction is to the diverging one; from the combination of both which causes, its force will be very considerably increased. But the quantity of Fire being doubled, its efficacy will be vastly augmented: For in 32 degrees of Heat, Water will freeze; in double the number, *viz.* 64, the Air grows very hot; in 92 degrees, which is tripple the first, the Heat will exceed that of the Blood of a person in health, and an Air so hot would be fatal, perhaps, to every kind of Animal; in 192, which is 6 times the first, the Heat will come near to that of boiling Water, and would be able to dissolve and destroy all the parts of every Animal whatsoever. Since now the Area of a great Circle of this Sphere is to the whole Surface of the same, as 1 is to 4; hence the Fire in the Basis of the Cylinder abovementioned, will be 4 times more condensed than it was in the Surface of the Sphere before; and therefore, its force thus united, will be so much augmented. If we could

nicely

nicely, therefore, discover how the expansive power of Fire is increased in proportion to the smallness of the spaces into which it is condensed, then we should be able to finish the computation: For if this was as the *Areae* themselves, then its force would be four times greater on account of the quantity, and four times on account of the expansion, and consequently, sixteen times more violent from both causes together. We must endeavour, therefore, to determine if possible, by Experiment, this expansive power of Fire in respect of its density; for it is probable, that this is exceeding great; and consequently, that this direction of it in parallel Lines is of prodigious efficacy.

EXPERIMENT XII.

Now, if we turn our eyes every way to discover a cause that is able thus to determine the action of Fire into a Parallelism in our Air, the Sun certainly seems principally to offer itself as a being endued with a power sufficient for producing this effect. For that vast Globe, which the learned discover to be 13431 times greater than the Earth, and almost 12543 diameters of the Earth distant from it, as it appears by every kind of argument to diffuse its Light and Heat in right Lines, must in respect of its vast distance be considered as acting upon us in parallel Lines. It is not necessary here to cite those Arguments from Optics, Catoptrics, and Dioptrics, which no doubt you are acquainted with, by which the Rays of Light that flow from the Sun are demonstrated to proceed in right Lines, if they meet with nothing to interrupt them; and that then they are directed again in the same manner from that point of the obstacle upon which they fall. Give me leave, however, to mention one Experiment that occurs to me, which I think is an absolute proof that all the Rays, that either proceed from, or are determined by the Sun, affect the most strait direction; and that is this. Suppose it to be twelve a clock in a cold Winter's night, the Moon to be at the change, and the Heavens to be perfectly serene. Let any one then look up to the Sky, and he will see nothing lucid in that immense space, besides the Stars. Of the Heat, and Light of the Sun, there will nothing at all appear in the whole Hemisphere, except that inconsiderable quantity which the Planets borrow from that Luminary, and reflect to the Earth: And yet we are certain, that the Rays of the Sun at that very time, strongly enlighten all this Hemisphere, except that small Cone, whose Base is a great Circle of Earth, and its *Axis* 114 Diameters of the same; which small portion is all, of that vast space, that is included within the shade of the Earth, and consequently is not illumined by the Light of the Sun. It appears evident, therefore, beyond all dispute, that let a place be ever so brightly enlightened by the solar Rays, yet the Light will not be discerned by a person situated in such a position, that a right Line cannot be drawn from the Body of the Sun to his eye; except these direct Rays should first fall upon a Body by which they might be reflected to it. And the same thing is, nearer at hand, perceived in a chamber so nicely shut up that the least discernible Light cannot enter. For if you then make a very small hole towards the Sun, and by this means let its Rays into the room, you will in this place have only one lucid Cone, whose *Apex* in the hole, and its base projected in *infinitum*. Now if you take any Body perfectly black, and oppose it to the Base of the Cone, there will, then, no Light at all appear in the room,

The Sun determines
Fire into a
Parallelism.

room, except to an eye placed within the illumin'd Cone; for if it is placed on one side it will be nothing at all, though at the same time the Cone is exceeding lucid. I confess, indeed, if we look at it sideways we may discern a kind of weak Light in the Cone; but then you will easily see, that this must proceed from the dust that flies about in the Air, and so reflects the Rays of the Sun that fall upon them; which was it away there would not appear the least Light at all. And this is evidently observed to be true, when by chance, for this has been the case, these particles are so disposed that they will not repel the Rays of Light. By this argument, then, we are induced to believe, that the Sun has a power of making the particles of Fire, deflect from their natural tendency, which is from the Center to the Circumference, and determining of them in parallel Lines.

If we consider, again, that all objects which are visible by the means of Light, though obscure of themselves, immediately begin to shine, or appear, as soon as ever the Rays proceeding from the Sun fall upon them in a right direction, and grow invisible again the instant that this is prevented, then the same thing will be still farther confirmed. And again, if we rightly conceive, that the solar Rays falling upon a perfectly plain *Speculum*, and reflected thence by certain laws, only illuminate that part towards which the reflexion happens, this doctrine will be more fully established. But this Catoptrics certainly and evidently evinces; and moreover teaches us, that one Ray of Light, proceeding from the Sun in a right Line, and falling upon a pure *Speculum*, will be thence reflected to such another Glass in a right line, and repelled again by this in the same manner, and so on, and that this single Ray, after so many reflexions, will still retain its lucid property, though it will never be seen but in a right Line drawn from the lucid point of the last reflecting *Speculum* to the eye. Since, therefore, this happens in the whole image of the Sun, as well as in one single point, it is evident that that power of the Sun by which it determines Fire in parallel right Lines must always exert itself so long as this emanation and reflexion continue. But as soon as ever this luminous Body withdraws itself, this rectilineal direction immediately ceases, and Fire is then again left to its proper tendency, and enjoys its own natural expansive power. For this reason, therefore, the Sun ought to be looked upon as the director of Fire.

But, again, if we consider, that the vast Body of the Sun on account of its prodigious distance appears only a lucid Orb, whose Diameter takes up but $\frac{6}{1000}$ or $\frac{1}{166\frac{2}{3}}$, or $30'$. $30''$ of a great visible Circle of the Heavens, we shall easily see, that the Rays projected thence in respect of that little space which falls under our Observation, may be fairly regarded as parallel. And lastly, as a farther confirmation of this Doctrine, let us observe that in Optics, Catoptrics, and Dioptrics, we always suppose the Rays to come from the Sun in a parallel direction, in computing their refractions, reflexions, and the directions they move in; and yet, we can hence very accurately determine the true points of their *Foci*, reflexions, and directions, so that the *Phænomena* we observe in them, very nicely correspond with the demonstration.

From all these Observations, therefore, thus succinctly collected, it appears very evident, that the Sun is such a cause as will instantly determine the

matter of Light residing in our Air into a Parallelism, as often as it can exert its power upon it without any impediment.

But it has been always observed, that these lucid parallel Rays of the Sun produce Heat in the Bodies to which they are thus directed. And, hence, what has been just now demonstrated of Light, will appear as evidently true of Heat. And since we here speak of that Heat which is discovered by the Thermometer, we infer farther, that the same things will hold good of true Fire likewise, as we have hitherto explained it. We have now, therefore, found out the true reason why the Sun can very considerably increase the power of Fire, discoverable by its expansion, purely by this parallel determination, without any addition of new matter, without any supply of Fire from the body of the Sun itself, or any production of Fire from something that was not Fire before. And this, if I am not mistaken, is a discovery of the utmost consequence in a chemical Treatise of Fire.

Perhaps you may ask, now, why don't a lighted Candle then, since it emits its Rays of Light in a right direction, warm the place too that it illuminates? To this I answer, because this little radiant Cone does not act in a Parallelism, but diffuses its Rays in a kind of Sphere, and hence does not propel the Fire in the room to one part more than another, but every way equally. But even in this case, if you approach so near to the candle, that, on account of the small distance, the Rays may be considered as almost parallel, you will then immediately be sensible of Heat.

Thus, then, I think this difficulty intirely vanishes; especially if you consider at the same time, what I have observed already concerning the wonderful diversity of Light, and Heat.

COROL. I.

Whenever, therefore, this rectilinear impulse of the solar Rays, which thus give Fire its parallel direction, is by any means impeded, this Parallelism immediately ceases too, and that very moment the parts of Fire are equally expanded towards every side: Hence it easily appears, that this Parallelism was the only cause of all its former power. For let *Vilett's Speculum* be directed to the Sun at noon in a perfect clear day, and an iron rod be placed in its violent *Focus*, and be actually melted down; and then, whilst it acts with this vast power, let such an opaque Body be interposed between the *Focus*, and the Sun, as will shadow the whole *Area* of the Glass, and that intense *Focus* will instantaneously be destroyed, though the Air between the *Umbrella* and *Speculum* remains equally warm, that is, contains as much Fire as it did before, the Sun continues to shine equally bright, and nothing more happens than this parallel direction being prevented. Nor was there, as persons may imagine, more Fire between the *Focus*, and the *Speculum*, whilst the Rays of the Sun fell directly upon it: For in fact, one does not discover there any greater Heat, except what proceeds from the reflexion. There is a prodigious difference, therefore, betwixt that Heat which Fire yields from the attrition of Bodies, and that which is produced in the Air by this solar Parallelism: For the former continues a good while; the latter vanishes immediately. If a solid Body, however, is heated by the Sun, it will by reason of its solidity retain the Heat a considerable time.

When this Parallelism ceases, Heat ceases likewise.

The

The proper
manner of
building
Green-
houses.

The truth of what I have asserted, some Gardiners have experienced much to their prejudice, in their Greenhouses where they preserve their Plants in the winter season: For if the windows of these, by which they let in the Warmth of the winter Sun betwixt the hours of ten, and two, are so disposed that the Rays cannot reach to the ceiling, but tending downwards leave a space between the ceiling, and that part which is shone upon, that does not receive any of the solar Rays; then *cæteris paribus* there will be always in that place the greatest Cold. And, hence, there will be a cold moisture continually collected there, which falling upon the Plants frequently destroys those that are of a more tender nature. These Winter-houses, therefore, being built full South, should be furnished with windows (which, if possible, should reach quite down to the pavement, and be very clear) erected at an Angle of 34 degrees 30' from a perpendicular; and the ceiling should be built sloping in such a manner as to make an Angle of 20 degrees 30' with a Line drawn horizontally from the top of the windows towards the opposite wall; in those countries, I mean, where the elevation of the Pole is $52\frac{1}{2}$ degrees. The reason of this construction may be easily come at by the help of Astronomy, and the doctrine of Dialing: Brevity obliges us here to omit it.

COROL. 2.

The propor-
tion this Fire
bears to the
former pro-
duced by at-
trition.

The greatest Heat that the Sun ever naturally produces in our Air, and the Bodies heated by it by means of this Parallelism, is considerably less than that which is generated in a healthy man by the vital actions. For this frequently raises the Thermometer to the degree 92; that hardly ever to 84, and then never continues long in that degree, but quickly abates. It is necessary, however, to caution you, that I here speak only of that Heat which is observed in open places purely from the direct Rays of the Sun, without their being any ways reflected, or collected: For clouds, by reflexion, and aqueous Globules formed in the Air, by refraction, may very much increase the action of this Fire. But, however, even in this case, Fire never was known to be raised to such a degree by means of this Parallelism, or these natural reflexions, or refractions, as to be able to set Fire to Alcohol, Oil, Sulphur, or Gunpowder; unless, perhaps, Lightning may be an instance of it, of which, hereafter. And these Observations hold true of the natural Heat under the Equator itself, and every part of the Torrid Zone. Hence, therefore, it appears, that the greatest power of the Sun is not capable of heating any Bodies we are acquainted with to such a degree as to kindle them into flames, and consume them, and thus to produce spontaneous Fires, except, by means of Lightning alone. And it is farther evident, that the most scorching Sun cannot excite so much Fire in the hottest parts of the World, as may be quickly generated by a moderate attrition of very cold Bodies in the coldest: For if Iron is rubbed against Iron, it will soon grow so hot as to be able to set fire to Sulphur, or Gunpowder that is thrown upon it; and yet, even then, the Iron does not begin to emit any Light. Hence, again, we perceive it is not at all strange, that some Bodies are very lucid, though they give very little Heat; nor is it, we see plainly, a necessary consequence, that a Body is very hot, because it gives a great deal of Light: For the Light of the Sun, when it is upon the *Meridian* in a clear Winter's day affects the eyes so strongly, that it renders them quite blind for a considerable

a considerable time ; and yet its Heat, at that very time, is so weak, that it is not able to melt a thin piece of Ice suspended in the open Air, and directly exposed to it, as I myself have observed this Winter. The image of the Sun reflected from polished Gold, Silver, Brass, Iron, Tin, or Glass, is intolerable to our eyes by reason of its excessive brightness ; and yet it does not excite the least degree of Heat, that we can perceive, either by our senses, or the Thermometer. And hence, again, I infer, that there is a vast deal of difference betwixt the nature of Light, and Heat ; Lustre, and Fire.

COROL. 3.

The Supreme Being, therefore, has wisely provided that the Bodies of Animals, and Vegetables, even the tender ones, should not be destroyed by the direct force of the Sun. Direct I say, lest any one should imagine that I design to include that too, which proceeds from the reflexion, and collection of its Rays, which may thus be prodigiously increased ; for by this means it sometimes becomes so intense, that it renders places uninhabitable : Of this the Island *Ormus* has long been an instance, where the high mountains of white Salt, in a certain position to the Sun, by their whiteness so reflect, and unite its Rays, that at that time no body is able to live there. The same excessive degree of Heat, however, does not continue a great while, but is in a short time tempered by a succeeding Cold.

Scarcely
destroys
Bodies.

COROL. 4.

If the Sun should ever irradiate the Atmosphere of our Earth, at a time, when all the Corpuscles that float about in it, were disposed to an equable transmission of its Rays, it would then drive all the Fire in the Atmosphere into parallel Lines, except that portion that was included within the conical shade of the Earth. But there are a great many different reasons that makes it incredible that this should ever be the case, and, therefore, it appears exceeding probable, that very extraordinary reflexions, refractions, collections, and dispersions of the solar Rays perpetually happen there. And hence, the force and action of the Sun, both upon our Atmosphere, and Earth, will every where be found surprizingly different : But, in those places, that lie beyond the limits of our Atmosphere, the Fire thus directed by the Sun, seems to be always as the spaces themselves, if they are not at too great a distance from one another.

Is not the
same in dif-
ferent places.

COROL. 5.

Hence it seems exceeding likely, that the same degree of Fire is scarcely ever observed in different places : For whether you consider the various aspects of the Sun with regard to the Earth ; or the different nature, and motion of the Bodies that float about in the Atmosphere ; or the different properties of the very same, at different heights ; and many more such like circumstances : you will find that nothing seems more cautiously provided against, than that there should be the same force, and effect of Fire in different places. The efficacy, now, of these causes will be manifest by the following Experiments.

On various
accounts ;

EXPERIMENT XIII.

Chiefly from
the various
Colours of
Bodies.

If this Fire, thus determined by the Sun, falls upon Bodies that are exceeding black, its Heat will be retained there a considerable time. On this account, therefore, such Bodies grow sooner hot, and acquire a greater degree of Heat from the same Fire, grow dry in a shorter time when they have been wetted with Water, and burn much more readily than any other. We need go no farther for the proof of these assertions, than daily Observation. Take a piece of cloth died a very deep black; another piece of the same cloth, but white; a third, scarlet; and others of different Colours; and hang them up in the Air, and Sun, and you'll find that the black will grow warmest, and much sooner than any of the rest. And of the others of different dies, those always acquire Heat slowest, whose Colours are most vivid, and affect the eyes most strongly: for the white, and scarlet are longest growing warm; and the rest so much sooner as their Colours are less bright, as we see evidently in the weaker Green. And this, those people that live in the hottest countries are well acquainted with; for they find, that if their outward garment is white, it best secures them from the Heat of the scorching Sun, whereas if it is black, it suffocates the Heat, and makes it more troublesome. And it is a common Observation of the manufacturers of Woollen-cloth, that if a parcel of wet cloths are hung up at the same time, and are equally exposed to the Sun, the black will presently grow warm, reek, and dry; the white will retain its wet a long time; and the others will dry so much slower, as their Colour is brighter. Hence, again, white garments, when they are exposed to Heat retain their dampness much longer than others, and thus too keep the Body cool.

It has, yet farther, been observed that black Bodies take fire, flame, and burn, much easier with the same Fire than Bodies of any other Colour. Shavings, for instance, of very white wood will scarcely receive a spark struck upon them, so as to keep it in; but if you burn them to a black coal, the powder of this will easily support it, and be soon kindled all over by one single one. In the same manner a spark won't keep a-light any considerable time in a piece of very clean white linnen; whereas, if it falls upon the same when it is reduced to tinder, which is a sort of exceeding thin black coal, it will spread itself all over it. Nor would even Gunpowder itself, so soon take fire, were it not for its blackness; as we see evidently in the powder of very white Nitre rubbed with Sulphur. The Gardeners too have long observed to their disadvantage, that white Earth will hardly grow hot, except just on the surface; whilst the black conceives so great a heat, as to burn the very roots of their Plants. The Chemists, likewise, long ago informed us, that black Bodies committed to digestion, or reduced to it by Art, grow warm with the same Fire easier than others; different degrees of Heat being required in the head of a Crow, the neck of a Swan, and the tail of a Peacock. And lastly, the Philosophers have confirmed the same by ocular demonstration. If you hold a piece of very white paper in the *Focus* of a burning Glass, it will be a considerable time before it grows hot, and much longer before it takes fire; and when it is just going to kindle, it first loses its whiteness, grows brown, then black, and afterwards flames in an instant. See upon this head the remarkable Observations in the *Memoirs of the Acad. del Cimento*. 266,

Hence, then, we get some light into a good many *Phænomena* of Meteors: for every one knows that there never happens more terrible Thunder and Lightning, than when the face of the Heavens is first obscured with the blackest Clouds, and thickest darkness; whence too, there often suddenly follow prodigious Whirlwinds, occasioned by the rarefaction of the Air from this Heat thus instantly generated, and retained in it.

EXPERIMENT XIV.

Black Bodies do not reflect igneous Light, or Light that gives Heat, though it is impressed upon them by the Sun ever so strongly. This we saw evidently by covering a *Speculum*, which burnt very powerfully, with the thin smoke only of a Candle; for when by this means it was grown black all over, and then directed towards the Sun, an eye placed in the *Focus* perceived neither Light, nor Heat; nor did there appear by any Experiment the least sign of Fire there, though as soon as ever the soot was wiped clean off, and it was restored to its former brightness, it immediately, upon being exposed to the Sun, regained both its shining, and burning faculty. For this reason, eyes that are inflamed are not injured by black Bodies; and when they are affected with a painful Ophthalmia no colour gives them more ease, than darkness does, which is a perfect privation of all. Even *Tschirnhausen's* glasses themselves, if they are thus blacked with the smoke of a candle, do not produce the least Light, or Heat in their *Focus*, though they are directed towards the hottest Sun.

Black Bodies scarcely reflect the Light they receive.

From these Observations, therefore, it evidently appears, how little a matter is often necessary in the Air, to suffocate, and destroy the most powerful effects of Fire, that depend upon the action of the Sun; and how very different a Heat may be suddenly excited in different places from the same cause. And, here certainly, there is nothing more surprizing, than that this should be effected by a black crust, so exceeding thin that the external surface only seems to be concerned in it, without any thickness to assist it.

But, now on the other hand, Bodies that are exceeding white, reflect this igneous Light almost with the same power as they receive it. This is very evident in white Metals, as in the most solid pure Silver, if it is formed into a plain *Speculum*: For that will return the image of the Sun very nearly as vividly as it falls upon it, and for a time hurts and blinds the eyes; and when they are inflamed, and painful it is perfectly intolerable. Look through a plain clear glass towards the Sun, and it seems to transmit the Rays, almost, without any alteration: Let then your eye be placed directly betwixt the glass, and the Sun, and then look in the glass, and you'll scarcely perceive any thing; but if the back part of the glass is covered over with a very white composition of Mercury, and Tin mixed in a certain proportion, the reflexion of the image of the Sun from the *Speculum* will be so strong that the eye will not be able to bear its brightness.

White Bodies reflect it very powerfully.

In like manner every body knows, that the solar Rays reflected by the yellow colour of Gold are vastly refulgent. But this was never more remarkable, than in that instance of a concave *Speculum* in Saxony, which being formed of wood very carefully hollowed into a spherical form, and then polished, and nicely covered over with leaf Gold, burned with an incredible power.

Yellow ones likewise.

And lest any one should imagine that the efficacy of this was owing to the metal-line quality, let him take notice of that other more surprizing one, which too had an exceeding caustic quality, that was made of pieces of yellow straw very accurately fitted together.

In the same manner we may examine the rest.

And thus the red, and all the other capital Colours, so nicely distinguished by the singular penetration of the incomparable *Newton*, may in the same manner be examined, both with regard to the Light that they collect in a *Focus*, and the caustic power they exert there: For if the *Speculums* are made of the same matter, size, and figure, and are polished in the same manner, but are of different colours, then, the difference of the Heat in their *Foci* will give us the doctrine of Colours with regard to their power of generating Fire; and at the same time will shew us what Colours heat, cool, yield a moderate degree of Heat, reflect, retain, and dissipate the Fire that is impressed upon them. But we must hasten to our farther examination of Fire; we can only, therefore, hint at these things at present. Let us see, then, what are the consequences of this Experiment.

COROL. I.

Burning
Speculums.

From what has been observed, the true doctrine of burning *Speculums* may be easily understood, with regard to their efficacy as it depends upon the Colour of their polished surface: For if all other circumstances are alike, a few Experiments carefully made will readily determine the proportion of their focal powers in respect of their Colour.

COROL. 2.

Pigments
heating, or
cooling.

And if we want to know what will be the effect of laying such and such Colours on Bodies with regard to their power of heating, and cooling, we may from the same principles as easily inform ourselves. With respect to the ground that we walk upon, or look at, we know certainly, that black Earth burns the Feet, but is more favourable to the eyes; whereas white scarcely warms the former, but by its bright whiteness dazzles, inflames, and burns the latter. The same thing is easily conceived of pictures, and tapestry. And the knowledge of these things will assist us in a particular manner, in making coverings to secure our Bodies from Heat, and our eyes from the Light. Houses, for instance, that are externally white will be coolest within; and those on the other hand that are black will be hottest; if the walls are made of the same materials, and are of the same thickness. And hats that are very white on their upper surface, and black on the under part of the brim are a vast relief to the Heat when the Sun is exceeding hot.

COROL. 3.

The cause of
Heat in the
Earth, and
Air.

From the same causes the Heat of the ground in some parts of the World grows intolerable, when being very black, it is exposed to a scorching Sun: Whilst in others, the Air is rendered so hot that it cannot be born. This we see particularly in the Island *Ormuz*, where the solar Rays are so strongly reflected from the white mountains that run East and West, and the Air is so excessively heated by them, that the people perish in it, if they don't lie covered in Water all but their heads, which are kept above it by proper supports;

ports; as likewise in *Gamron*, where the same thing happens from a sandy, white mountain, which reflects and collects the Rays in such a manner, that the Heat of the Atmosphere is scarcely any where so violent as it is there: And yet both these places lie beyond the Tropick in north latitude. See *Nieubof. Itin. Terr. & Mar.* from p. 80 to 91. and other Authors.

COROL. 4.

Water, and other Liquors, are raised into the Air by the power of terrestrial and aerial Fire. And the less they are press'd by the weight of the incumbent Atmosphere, the more easily their Particles recede from one another by the same degree of Heat. The higher, therefore, they ascend, the farther they are separated asunder; both on account of their increased Spaces, and their lesser reciprocal attraction. Hence, of consequence, they collect less Fire, grow cooler, and float about through vast Spaces, in form of exceeding fine corpuscles, whose resistance always increases in proportion to their altitudes. And whilst they are thus driven about, the parts of Water may, possibly, be resolved into their ultimate, exceeding hard, immutable Elements, which, tho' very rigid asunder, yet being united together again, may constitute the same soft Body they did before. When by any means now whatsoever, a considerable number of these aqueous Particles are brought into union in this upper, and consequently, colder region of the Air, it is very probable, that the Air is immediately filled with very small icy Bodies; and that these, now they begin to descend, (and thus coming nearer to the Earth, are reduced into smaller Spaces, and hence are more closely united,) by their reflections of the Solar rays, form those Clouds in the Heavens, which to us appear so exceeding white, whose whiteness, the greater it is, the more certainly we can foretell, that we shall soon have Snow, Hail, cold Showers, or cold Winds. But the whiter that side of the Cloud is, that is directed towards the Sun, the colder, of consequence, must the other side be in proportion, as it wants at that time the Solar Heat. Hence it evidently appears, that such Clouds may increase the Heat of the Air in a very short time, especially, if from their different positions with respect to the Sun they should be so situated as to reflect the Solar Rays into one small Space, and thus form a kind of *Focus* in the Air. On the other hand now, if at the same time that the Sun shines, we see exceeding black Clouds in the Sky, there generally very quickly follows Thunder, and Lightning.

COROL. 5.

If we rightly understand, therefore, what has been said, we sha'n't wonder at the vicissitudes of Heat and Cold that sometimes happen so suddenly in the same place of the Atmosphere. For if we consider, that as soon as ever the Solar Rays fall directly upon the Air, the Fire, that before tended equally every way, is immediately determined into a Parallelism, we perceive, that on this account the Heat must be much increased. Again, the ground we tread on being thus instantly exposed to these parallel Rays, must of consequence soon grow hot. And lastly, all the Bodies in the Air, or above the Earth, will be affected with the irradiation of the Sun now shining upon them, and therefore must continually grow warmer and warmer. From these causes, therefore, tho' there should not be an addition of one particle of Fire more than there was before,

fore, yet the Heat of any particular place may be considerably augmented. And thus we have now discovered in Nature, another manner of exciting Fire, which before did not appear, and that is, the action of the Sun, thus determining the particles of Fire in a parallel direction.

EXPERIMENT XV.

The collection of Fire parallel in a Focus.

If we conceive, now, certain Corpuscles perfectly white, exceeding smooth, and very small, to be so fitted together, that the Fire, thus render'd parallel by the action of the Sun, and impress'd upon their Surface, may be so reflected, that all the Rays may meet together in a very small point; then, all this incident Fire will be collected in that place, which, had these Corpuscles been situated in the same plane, would have pass'd on in parallel lines, as it fell upon them.

Hence, therefore, the Fire in this place of collection, which for the future we shall call the *Focus*, will purely, from its quantity, be so much more intense than it was before, as this Space where the Rays are thus united, is less than the whole Surface from whence they were reflected. But the force of it was likewise much augmented before, on account of the parallelism already mentioned.

Perfect in a concave Parabola.

Was it possible, therefore, by Art, to construct a concave *Speculum*, whose cavity should be formed by the revolution of the most perfect first *Parabola* of *Appollonius*, and hence would have any exact conoido-parabolical hollow figure; if the matter of it likewise was the densest we are acquainted with, as Gold; and the colour the whitest, as that of the finest Mercury; if it, farther too, like the purest Steel possess'd the most elastic quality; and lastly, if the aperture of its Base was very great: Then, if you placed the circle that terminated the *Bas*is of this parabolical Conoid parallel to the apparent Disc of the Sun, all the Fire that enter'd in a parallel direction through this circle, would be collected within the *Speculum*, in a point of the *Axis* $\frac{1}{4}$ of the *Parameter* distant from the *Vertex*: And consequently, by enlarging the capacity of the *Speculum*, this force might be always farther increas'd. But the most industrious Artists have never yet been able to discover such a kind of matter, or to give any hollow Body this exact parabolical figure; and hence, tho' we easily conceive of this efficacious power, yet it has never been reduc'd into practice.

But this could never be formed exactly.

The next thing, therefore, was to try, whether it was not possible to give some exceeding solid, white, hard, and elastic substance a spherical figure, and so to polish it, that there should be no unequal vacuities left in the concave polish'd Surface; and this, it was imagin'd, might be effected by the attrition excited in the action of turning: But this upon trial, was not found so easy to accomplish, by reason of the difficulty of the Polish. The Heat, however, that has been by this means generated, has been found to be so violent, that it almost exceeds all credibility.

The incredible power of Fire in Vilett's Speculum.

Not to mention many others, it is sufficient to take notice of the most perfect one hitherto known; and this is that, which with a good deal of experience and labour, was made by those excellent Artists, the Father, and his two Sons, the *Vilett's* of *Lyons*. This Mirrour is form'd of a metalline substance, nicely compounded, after a great many trials for this purpose, and is of a concave spherical figure, the Chord of the Segment of the Circle, by the revolution

revolution of which it is constructed, or the diameter of the Circle which measures its Aperture, being 43 inches, and consequently, the *Area* of the plane through which the Rays are admitted, 1452 $\frac{11}{14}$ French inches. Both the concave and convex side of it is spherical; and both Surfaces are polish'd as nicely as possible. The whole Mass of the *Speculum* weighs 400 French pounds; and lastly, the Rays which fall upon the *Speculum*, through the aperture above-mention'd, when it is directly oppos'd to the Sun, are collected in the Air, within a circle of half an inch diameter, which is $3\frac{1}{2}$ feet distant from its *vertex*. Hence, therefore, if all the Rays that come parallel from the Sun, and are receiv'd by the *Speculum*, were reflected into this *Focus*, then the Space they took up in the circle of the aperture of the *Speculum*, would be to the Space into which they are thus contracted in the *Focus*, as 7396, is to 1; and consequently, there would be seven thousand three hundred ninety six times more Fire in this *Focus* than in the Air heated at the same time by the Sun; which is, certainly, a prodigious difference.

We must, however, caution you here, that we suppos'd all the Rays, that fell upon the *Speculum*, to be reflected back again into the *Focus*; but this, by Experiment, is evidently found to be false: For neither is the figure exactly spherical, or is it perfectly polish'd, or without vacuities in its Surface, as the Microscope informs us, and as you may be sure, from looking obliquely at it, for you may see its concave Surface on every side of it. But let that be as it will, if the *Ratio* of the reflected Rays to the incident ones, should ever be discover'd, the proportion may be easily computed: In the mean time, however, this we are sure of, that the Fire, which is generated there, is vastly intense. For by a multitude of repeated Experiments, it evidently appears, that every body, that is combustible by any Fire, will, if it is plac'd in this *Focus*, burn furiously in a moment's time. And even those combustible Bodies, which by reason of their aqueous moisture, won't burn easily, except they are first dry'd by the Fire, will here kindle into a Flame instantaneously. This was evident in a branch of green Wood drawn backwards and forwards through the *Focus*, which flam'd in a moment in every part upon which it fell, tho' the branch was then moist and thick, and did not remain at all in the *Focus*. Within the space of a minute, the six Metals were put in fusion in the same *Focus*; as also, all the Semi-Metals that have hitherto been try'd; even stony and rocky Bodies, are melted and vitrified by it in an instant. And how violent its effect must be, Gentlemen, you may see from this instance, that even Bones themselves, whose Ashes you know, in the cupelling test, so powerfully resist both Fire and Lead, are melted by it in the twinkling of an eye; as are likewise Bricks, Clay, Sand, Crucibles, Marble, Jasper, and Porphyry, which are turned into Glais. And lastly, the very Stones which the Masons make use of for building the Furnaces design'd for fusing of Iron, and separating it from its vast hard fossil Ore, melt and vitrify in this *Focus* immediately; which no person, let him understand these things ever so well, or let him have seen ever so much of the violence of confined Fires, could ever have imagined; for these same Stones would have remained many years without alteration, in the intense Fire to which these Furnaces are always expos'd: So that the power of this focal Fire, is able to effect that in the least instant of time, which the other,

Difficult to determine a priori,

But by its effects, appears to be very great.

tho' the strongest we know of besides, could hardly accomplish in the space of some years. And yet this Fire resides in the liquid Air, nay, perhaps, *in vacuo*, the Air being expelled by this vast Heat, and that, without the least *Pabulum* to support it; and it always remains there, so long as the Solar Rays continue to fall upon the *Speculum*.

Some remarkable circumstances in this *Speculum*.

Now the colder the matter is of which the *Speculum* consists, the more intense will be the Heat of the Fire in the *Focus*; and therefore, the denser this metalline substance is, the more powerful will be the effect. But by this coldness, the elasticity is considerably increased, and hence, too, its efficacy will be so much the greater: Whereas on the other hand, as soon as ever the body of the *Speculum* grows warm, its action becomes feebler; and as it gradually grows hotter and hotter, its caustic power is continually diminish'd. Hence, in a very clear, cold, Winter's day, it exerts its force much more powerfully, than in a fine Summer's one. But farther, from what has been already laid down, we know, that the cohesion of the Elements of all Bodies, is constantly weakened by Fire, and that always, in proportion to the degree of it; that hence, the Pores that are left between their Elements are enlarg'd; and that their power of contraction, and of consequence their elasticity, which depends upon it, is hereby weaken'd. Here, therefore, again, is a large field open'd for inquiry; but it is impossible for us to enter into all these things at present. Give me leave, however, on this occasion, to take notice once more, that when this *Speculum* was directed towards the Moon at the full in a clear Winter's night, and the Bulb of a very sensible Thermometer was placed in the center of its *Focus*, there was not the least indication either of Heat or Cold, but the Glass remained exactly at the height it was before, tho' at the same time the *Focus* was so excessive bright, that no-body was able to look at it. And this, upon consideration, seems the more surprizing, because these Rays that thus come from the Moon, were received, by that, from the Sun; and yet we know, by Experiment, that if the image of the Sun is reflected from a very perfect plain glass *Speculum* directly upon *Violettes's*, the Fire generated in its *Focus* will be vastly intense, and near as strong, as if the Solar rays had fallen directly upon it. Hence, therefore, again, is demonstrated a plain difference betwixt Light and Heat, as was before taken notice of. These, now, are the principal physical effects of this *Speculum*, with regard to our present purpose, which I have exactly related, as they are delivered by the worthy Author himself from his own observation, and which will be of service to us presently in treating of the nature of Fire.

Generates no Heat by the help of the Moon.

A very great one by the rays of the Sun reflected upon it by a plain *Speculum*.

Inconveniences of this *Speculum*.

This noble Instrument, however, has this one inconvenience, that as the Sun must be pretty high to communicate its power to it, and this concave *Speculum* must be so directed to the Sun, that the *Axis* of the lucid Solar Disk, and that of the *Speculum*, must be in the same right line; hence, the Bodies too that are to be examined in its *Focus*, must be in the same line also: For which reason, it is impossible to prevent their falling, when once they come to be melted; and hence, as soon as ever they are put in fusion, they run from the action of the Fire, so that no trial can be made of them farther, which, you easily conceive, would be of the greatest consequence. But this inconvenience is, in some measure, compensated by this property of it, that the external Surface of this polish'd Metal, reflects all the Rays that fall upon it, and hence does

Conveniences.

does not much dissipate or change them; whereas your glass *Speculums*, that reflect by means of Mercury incrustated upon the back part of them, must necessarily cause a great dissipation of the Rays, on account of the multiplicity of images that arise from the position of the pellucid Particles of the Glass. And as for the other manner of burning with convex Glasses by refraction, this is still less powerful; for these must reflect a great quantity of the Rays towards every part; and a great many more will be suffocated, and extinguished, whilst they pass obliquely through their substance.

COROL. 1.

From the consideration of what has been now laid down, I think it evidently follows, that the celestial Bodies, as well Planets, as fix'd Stars, make no alteration in our Fire, with regard to Cold or Heat, that we are capable of discerning. For setting aside the Sun, whose effects we have just explain'd, the Moon is the only one of any consequence; but when the image of this is received on this *Speculum*, and reflected into this very small *Focus*, it does not produce the least sign of expansion, or contraction, no, not even in the Air itself. What then can the Light do that comes from the other Planets? Certainly, nothing at all. Nor has the Light of the fix'd Stars any greater effect. If these Bodies, therefore, are endued with a power, by which they are able to act upon the Heat and Cold of our Earth and Atmosphere, which I don't pretend to deny, they must necessarily do it in some other manner, than by the vibration of their lucid Rays. Nor will the Astrologer's referring us to the various Aspects and Conjunctions of the heavenly Bodies, and to the Constellations, make any thing against what we advance; because it always appears by Experiment, that there is no alteration produc'd by any of these causes, in the case we are at present considering. We may venture, therefore, to assert, that all the Heat that flows from the heavenly Luminaries, and is transmitted to us, depends intirely upon the Sun alone, without receiving the least augmentation from any of the rest that has hitherto been discovered.

None of the heavenly Bodies, except the Sun, cause any increase of Fire, either by determining it in a parallelism, or by reflection.

COROL. 2.

These things, then, being well understood, we can't clearly conceive how any considerable alterations can be produc'd in the Bodies of our world by the Stars: For in most of these changes, that we are acquainted with, either Heat or Cold, is concerned, whether new motions are excited, or former ones are altered; but upon Heat and Cold, the Stars have no effect. The influences, therefore, that these heavenly Bodies are supposed to have upon these lower ones, must depend upon some other causes; and consequently, these changes are not owing directly to any communication of Fire, or any alteration of it, that the Stars are capable of producing. Nor in reality, has it hitherto appeared by Experiment, that these superiour Bodies do exert any force upon these lower regions, except what is to be ascribed to the power of Gravity alone; which is vastly different from Light, and Fire, nor has the least dependence upon them. That this power, indeed, on account of the various positions of the heavenly Bodies, must be liable to frequent changes; and hence, from these different degrees of attraction and repulsion, may produce a great many alterations in the Bodies of our world, no-body that is acquainted

Gravity alone seems here to make some alteration.

with these things will deny; but at the same time that they have any other power, with respect to us, besides that of Gravity, we never have yet had sufficient evidence to induce us to believe.

COROL. 3.

Surprizing
Meteors
from reflect-
ed Light.

These things then being premised, we may again venture from Experiments to account for a great many *Phænomena* that we observe in the Air, which relate to our physical inquiries, which sometimes mightily disturb our chemical operations, and which may be easily understood from what has been said. The famous *Halley* has demonstrated, that there is an incredible quantity of Water perpetually carried up into the Air: That this ascends to the greatest height in very serene weather, appears by the clearness, and increased weight of the Atmosphere at the same time: Nor is it less certain, that it will be there turned into Ice, if its Elements happen to be brought into union in those upper regions. Now what hinders, but that these particles of Ice thus produced, may in like manner be brought together there, and being gradually united into large globular Bodies, may appear in the form of Clouds? And why may not these, from an infinite number of causes, be perpetually changing their figure, be sometimes plain, then spherical, and so of all other figures by turns? Supposing, then, this to be the case, will not the action of the Sun irradiating the Air, and shining upon these *Speculums*, be thence reflected, so as to produce very sudden and surprizing appearances of Light? And again, may they not, by being disposed in a different manner, suffocate and extinguish the Rays of Light, and thus in an instant bring on thick Darkness? Whenever the Clouds in the Heavens appear exceeding white from the irradiation of the Sun or Moon, there generally follows very quickly, either Snow, or Hail. And after long drought and fine weather in the hottest part of Summer, I have observed little white Clouds to appear aloft in the Air, which increasing in magnitude very fast, become constantly less white, as they grow bigger and bigger, and a little afterwards, from a large base descending towards the Earth in a pyramidal form, make a perfect shade, and burst into showers with a great violence; the largeness of the drops at the same time evidently shewing, that they were Hail in the upper, colder regions, but suddenly melted as they came down into the lower and warmer ones: Or if the Hail-stones happen to be so big aloft, that they cannot be thus thaw'd in their descent, then they fall to the ground in a solid form, and both ways quickly render the lower Air in the places where they fall, much cooler than it was before. Now these *Phænomena* may be easily accounted for from the simple causes already mentioned: For the higher the particles of Water are raised, the more they will be frozen; and from the greater height they fall, the more violent will be their descent, their celerity being constantly increased in the proportion which *Galileo* has demonstrated. Hence those little Clouds that are seen in *Asia* in very fine weather, and on account of their smallness are compared to an Ox's eye, when they fall from the Sky, come to the ground with a prodigious force, put the Air, that is condensed in that place, in a violent commotion, and thus raise Winds, and Whirlwinds, and sometimes produce Storms that exert their force from a center equally towards every part of the Horizon, their apparent magnitude, during their descent, always increasing in a reciprocal proportion to the squares of their distances.

distances. Does, therefore, the very bright whiteness of the Clouds always depend upon Snow or Ice, that is generated in them? Certainly, Water itself never appears white when irradiated by the Sun, unless it is first form'd into Froth, Snow, or Ice, or receives the Rays and transmits them very obliquely to the eye. But again, suppose this frozen Water to be driven together by the Wind, and to be so collected into one Body, as to reflect the Solar Rays by that part of its Surface that is oppos'd to the Sun; and hence, to heat, rarefy, and put in motion the Air that lies betwixt the Sun and this icy Cloud, whilst at the same time the action of the Light, and Heat, continually varies on every other part of it; suppose farther, the Globe to be large, pretty solid, and not pellucid, and of consequence, the Cold on the part averse to the Sun to be so much the greater, and the Air there so much the denser: From these causes, then, there must necessarily follow an extraordinary rotation of this globular Body, which will be so much the swifter, as the Heat of the Sun is stronger, the density of this icy Globe is greater, the Cold on the hinder part is more intense, and as it falls from a higher very light Air, into a lower one growing gradually denser, and yielding a greater resistance.

I am persuaded, now, Gentlemen, if you will but weigh these few things with attention, you will never wonder at those terrible storms that often happen, when the Weather has been a long time calm and serene; especially, if you consider at the same time, what Attrition, what Heat, nay, what Fire, may be instantly produced, by Bodies falling from aloft through the heavier Air that lies underneath them. These considerations now lead us to take notice of those intolerable Heats that suddenly happen in particular parts of the Earth, and very soon after end in horrible tempests; and which upon reflexion, we shall find to happen generally when the Heavens are full of distinct, scattered Clouds. For if any quantity of snowy, or icy Clouds, especially if they are large ones, are so disposed in the Atmosphere, as to form reflecting *Speculums*, and exert their united force upon one certain place, which you will grant me may be, nay, and often must be the case, pray what must be the consequence? Why, certainly, an incredible Heat will immediately be excited there; the Air will be vastly expanded, so as sometimes to occasion a very large *Vacuum*; about this *Vacuum* thus heated by such a collection of Fire, the expell'd Clouds, and Air, will be agitated in a surprizing manner, and with a great noise; whirling *Vortices* will be hereby produced; and presently after, this *Focus* being destroy'd by a different situation of the Clouds, the Air, Snow, Hail, Water, and whatsoever else is nearest, will rush into these *Vacuums* with prodigious violence. And for my own part, I have long been of opinion, that this reflection of the Solar Rays from icy Clouds, and their being hence collected into large *Foci*, are the principal causes of those terrible *Phænomena*, which frequently happen in so violent a manner, as to make human Nature shudder, and be almost afraid of present destruction. A learned *Englishman* has ingeniously demonstrated with what force the common heavy elastic Air would rush into a perfect *Torricellian Vacuum*, which he proves to be so great, that the celerity of the most rapid Wind, which moves 22 or 23 feet in a second, can by no means be compared with it, as this would run 1305 feet in the same time. *Phil. Transf.* 1686. N. 184. p. 193. Now, only consider, what quantities of these cloudy *Speculums* may be at once produced in the Heavens; and at the same time reflect on

their possible magnitudes, solidities, and situations; and you will easily see, that they may be able to form Spaces of stupendous efficacy, with regard to the Fire that may be generated in them: To which, therefore, Lightning, Thunder, Whirlwinds, Storms, Winds, and the other Meteors, may owe their production. And hence, perhaps, we may understand, why, tho' the Weather is exceeding hot, yet, if the Heavens are serene, and free from Clouds, these things are seldom observed to happen; whereas, when once the Sky grows obscured with Clouds, very extraordinary alterations often immediately follow.

COROL. 4.

Especially
when it
thaws.

But these are never more frequent, or more violent, than when it has been a sharp Frost for a considerable time, and the Earth is grown hard to a pretty great depth. For if it then thaws on a sudden, there generally follows Clouds, uncommon Heats, Thunder, and Lightning: And the reason seems to be this: All the Vapours, and pinguious Exhalations, that in warm Weather arise from the Earth, were, during that time, lock'd up within this hard crust, and there agitated by a subterraneous Heat; which appears evident from hence, that if in the hardest Frost, you break the Ice in the ditches, there immediately exhale from them warm Vapours, the quantity and warmth of which are so much the greater, as the Frost is harder, and the Ice thicker. Now as soon as ever the upper frozen Glebe comes to be resolved by the warmth, these Fumes that were thus confined, instantly disengage themselves, and being carried up into the Air, form smaller, and then larger Clouds, which being afterwards roll'd up together, and irradiated by the Sun, very soon bring on the *Phænomena* we have mentioned. Hence, in *Russia*, *Sweden*, and *Denmark*, such excessive Thunders generally follow a thaw. It might be added too, that the Particles that were exceedingly consolidated by the Cold, do still excite a very great motion of attrition.

COROL. 5.

The Heat
peculiar to a-
ny place,
whence?

But let us consider farther, that the reflexion of the Solar Rays from the ground, buildings, and mountains, may be the occasion that some particular places, in the same position to the Sun, may be much hotter than others. For it is easy to conceive, how all these things may either accidentally, or on purpose, be so disposed as to make a very great alteration in the Heat in the center of the place. And then besides, the diversity of the colours of the Bodies round about, may, as has been before observed, very much increase the force of this Heat. But we ought particularly to remember, that in different seasons of the year, the direction of the rays of the Sun upon these Bodies, is continually changing in a very remarkable manner, and hence the reflexion of them, and the Heat of their *Focus*, will be increased, diminished, and perpetually varied. From these principles then, we may easily understand, how it comes to pass, that some places at certain times of the day, or year, are so different from themselves with regard to their Heat, Colour, and Light, (as it is a common observation, that some places are hottest with the morning Sun, and others with the afternoon) for we have nothing to do but to have recourse to the three circumstances just mentioned, and examine them with regard to the places under consideration. And it will then appear, which

is.

is much to our present purpose, that a greater or less degree of Fire, may be produced in any particular place, without any other cause than mere reflexion, and the collection, and dispersion of Rays that depend upon it. People generally imagine, that, *cæteris paribus*, the Heat is greatest in places that are levelled and most open; but the contrary is always observed to be true: For in calm, dry, hot Weather, the Air on large plains is always more temperate, and refreshing; that in the vallies, more sultry and troublesome. And hence it comes to pass, that Horses, and other Cattle, are brisk, and run on the plain heaths without being tired, or losing their Wind; whilst, at the same time, they grow languid with the heat in other places. And the reason is evident; for in these level places, there is no Heat but what is owing to the direct rays of the Sun, or the reflexion of them from the Clouds alone. These observations, now, are of great service in helping us to form a right notion of Fire, which, otherwise, is falsely imagined to be peculiar to some particular parts of the Earth; to account for which, many extraordinary causes have been mentioned very different from the true nature of Fire. If we examine this affair, however, in a proper manner, it will always appear, that Fire considered absolutely in itself, is equally diffused through all Bodies, and every part of Space.

COROL. 6.

And here let me observe, in one word, before I quit this subject, that the Meteors in the Air, the Heat on the Earth, and the Effects that are thence produced, owe their origin, degrees, changes, and effects, principally, to the various reflexions of the parallel rays of the Sun.

Conclusion concerning Meteors.

COROL. 7.

But it is a matter of vastly nicer inquiry, and would be of extraordinary service, could human industry and penetration ever arrive at it, to determine the true proportion between the quantity of Light falling upon a reflecting Body from a given Space, and the same when it is collected in the *Focus* after reflexion. Suppose, for instance, the Light contain'd in a circle of 2 feet diameter, to fall upon a concave spherical *Speculum*, and to be thence reflected into a circular *Focus* of an inch diameter; we can then easily, by the help of Geometry, find the proportion of the *Area* of this lucid Circle, to that of the collecting *Focus*, since these are to one another, as the squares of their diameters; and hence the Mathematicians presently infer, that the incident Light is to the reflected, in the same *Ratio*. But whoever examines this affair as a Philosopher, will find much greater difficulties in resolving this problem, than he is at first aware of.

The proportion of the Fire collected in a catoptrical *Focus*, difficult to determine.

For in the first place, Gentlemen, how will you be able to determine the proportion of the vacuities or pores in the concave Surface of this *Speculum*, to the solid parts of it that cause this reflexion? Every thing that has been hitherto made use of for this purpose, has been considerably lighter than Iron, and consequently, much more porous than Gold; but the solidity even of this, with respect to its magnitude, has never yet been discovered. Hence, therefore, we see, that it is impossible to settle this first circumstance; and yet this is absolutely necessary to the satisfying our present inquiry. Perhaps only a thousandth

First, as we don't know the true solid part of the *Speculum*,

part

part of the bulk of this Body is perfectly solid and impenetrable ; the rest, with regard to the matter of which the Body consists, intirely vacuity or pores. How great a quantity of the incident Light then must necessarily be lost ?

Not the exact figure.

But suppose now, which is however by no means the case, that the matter was absolutely solid, by what method will you determine the figure of the *Speculum* ? You imagine, for instance, it is spherical. How do you know it is so ? Certainly, if it was perfectly so, its concave Surface would then appear black, except to an eye placed in the *Focus*, or in the lucid vertical Cone produced from the *Focus*, or a little on the sides, on account of the diverging coloured Rays, according to the elegant doctrine of the incomparable *Newton* ; Whereas we find, on the contrary, that its bottom may be seen in every oblique position. But if this don't satisfy you, and you still fancy such an exact polish may be given to Metals, take a concave *Speculum* that is looked upon to be finished in the nicest manner, and examine it with one of the best Microscopes ; and you will soon see how rough, unequal, and porous that Surface is, which you imagined so smooth and equable ; and will be forced to confess, that there is but a very small part of this Surface that is similar, but that the figure is every where perfectly irregular. How, then, can any person think it possible to determine the quantity of the reflected Light from the figure of the *Speculum* ?

Not the homogeneity of the matter.

But again, supposing we could get clear of these difficulties, there is another as considerable still behind : For we must be certain, whether the matter of this caustic *Speculum* is every where perfectly homogeneous, and has, in every point of its Surface, the same power of equably reflecting the rays of Light ; since it appears by the *Newtonian* doctrine, that in this respect too, there is a vast deal of difference in different Bodies. It evidently appears, therefore, that we can come to no certainty in this inquiry, till this is likewise determined. It is possible, for instance, that, in the substance of which the *Speculum* is composed, there may be some matter that we are not at present acquainted with, which may have no power of reflexion at all, and which, consequently, will suffocate and extinguish the incident lucid Fire, in proportion to the quantity of it that is contained in the reflecting Surface. But, now, tho' we could in these three respects certainly demonstrate the proportion of the power of the Fire in the *Focus*, to that of the parallel Fire that fell upon the *Speculum* ; yet this will regard only the efficacy of it, as it depends upon the quantity.

Fourthly, because the force of Fire don't depend entirely upon its quantity.

But hence, we shall never be able justly to determine, what proportion the vertue of this focal Fire bears to the same, when it was directed by the Sun through the Circle that measures the aperture of the *Speculum*, and that, for the following reason. We are not certain, whether the *impetus* of Fire is always proportionable to the number of Particles contained within the same Space ; and consequently, whether this rule will always hold good, that a double quantity of Fire constantly exerts itself upon Bodies with a double Force ; for notwithstanding this is generally taken for granted, yet there is a great deal of room to dispute it : And tho' it is certain, that a larger quantity of Fire in a smaller Space, will always be more efficacious ; yet, it still remains matter of doubt, whether its active power receives no augmentation, except purely from its quantity.

This suspicion is grounded upon the following observation. It is evident from

from Experiment, that there are certain Bodies in nature, which whilst they are separate produce no effects, but as soon as ever they approach one another within a determinate distance, immediately excite new motions which did not before exist, which grow continually greater the nearer they come to one another, and cease again in an instant, when they are removed so far asunder, that their reciprocal vertue can exert itself no longer. For an instance of this, let us take two very good Loadstones: Let one of these be at rest in any particular place, and it will always of itself continue so: Bring, then, another gradually towards it, and you will find by gently proceeding the most distant point in which this latter will be able to put in motion, and agitate the former; and as you successively bring it nearer and nearer, the motion of them both will become more remarkable, the power that generates it always increasing as the distance between them grows less, though in a proportion that is not yet determined. The great *Newton*, indeed, for very weighty reasons suspected it to nearly in a reciprocal triplicate *ratio* of the distances.

As appears
by an in-
stance in
other Bodies,

For the discovering of this the famous *John Muschembroek*, Professor in the *Academy of Utrecht*, has taken a vast deal of pains, and that with very good success. Let us suppose a number of Loadstones equally powerful to be suspended so as to be in the same a spherical surface, and so near one another as to be just ready to feel each other's reciprocal attraction: Let us then imagine them all to be brought very gently towards the Center of the Sphere, and consequently nearer to one another. Would not they then, if there was a hundred of them, be all put immediately into a surprizing motion? Suppose again, that at a certain distance they were all perfectly at rest; and then conceive one Loadstone situated in the Center of the Sphere: certainly, in that very instant of time there would arise a very extraordinary motion in all the others together, not one of them keeping their position, though they were all absolutely quiet before. And when these, again, began to come towards the Center, the motion would grow greater at every distance, and be very different from what it was just before; since the action produced between the attracting, and repelling Poles, would continually vary in every point of approach. The same thing might be demonstrated in the Air, and a great many other Bodies, but this Example is sufficient. Supposing, now, such a power as this, or perhaps a greater, to be implanted in the Elements of Fire; it will, then, be possible, that the force, which they scarcely had at all when asunder, may be exceedingly increased when they are collected together; and hence the Fire in the *Focus* may be vastly more intense on account of the nearness of its particles, than of their number. And, indeed, the truth of this doctrine has been a good while certainly confirmed by the following Observation. If the Thermometer, in an open place, irradiated by the Sun at noon in a cold Winter's day, stands at the degree 20; and at the same time your furnace stones instantly melt, and vitrify in the *Focus* of *Vilett's Speculum*; what do you imagine would be the consequence, should the Thermometer be placed in the *Axis* of the *Speculum* five inches distant from the *Focus*? In all probability you would expect some extraordinary effect; and yet by Experiment we find that there is scarcely a Heat there of 190 degrees. Does it not, then, hence appear evident, that this vast difference of Heat cannot arise from condensation alone, but that there must likewise some new agitation be excited in the particles themselves

And in Fire
itself.

selves from the nearness of contact? But since we have made it clear, from what has formerly been laid down, that it is the peculiar property of Fire to expand both itself, and all the Bodies it acts upon; it is possible, that this quality may be vastly increased by this collection of the particles of Fire into one place: And hence, perhaps, its caustic power may in a moment be so prodigiously augmented.

Lastly, because we don't know the efficacy of the curvature in different parts of the *Speculum*.

But lastly, we are not yet certain whether the power by which the parts of the *Speculum* reflect these igneous Rays, is as great about the *Axis*, to which the Rays fall parallel, as it is in the other parts of the surface that are more distant; and hence, till this is ascertained, we may fairly doubt, whether all the Rays reflected from the *Speculum*, and collected in the *Focus*, meet there with so equal a force, that we may venture to assert, that the Fire excited there is proportionable to the number of the united Rays.

COROL. 8.

A method of determining this Fire.

I have taken a great deal of pains to discover, if possible, a method by which we might determine something certain in this point: And at last it appeared, that if any part of the *Speculum* is covered with an opaque black Body, the Rays from all the other parts of the *Speculum* that are open, will nevertheless, be constantly collected in the *Focus* without any aberration; nor does it at all signify which part of the concave is covered. If we conceive, now, the whole aperture to be covered with a circular brass plate; then nothing will be received, nor any thing reflected. But as we can divide this Circle from the Center into as many equal parts as we please, we may by this means exclude, or admit, what quantity we have a mind of the rays that fall upon this circular *Area*. And, hence, the proportion of the admitted Rays, to the whole that were before received upon this plate, we can determine at pleasure. Thus, therefore, we can collect in the *Focus*, half, a third, a thousandth, or any other part of the Rays; and then, by comparing the degrees of Heat produced in the *Focus* by these different quantities, may be able to discover, whether the force of the Fire thus generated, is always in proportion to the number of Rays united in the *Focus*, or depends upon some other law. By this method, then, all the Rays of Light that fall upon the whole aperture of *Vilett's Speculum* may be divided in any *Ratio*, in which we can geometrically divide a circle; and the efficacy of the Fires they excite in every proportion may be thus examined.

COROL. 9.

In order to determine its power.

If by proper Experiments, therefore, it was known, what part of this brass circular plate must be open to admit just Rays enough to make Water boil when placed in the *Focus*; and this aperture should afterwards be very gradually enlarged till the focal Fire would raise the Mercury in the Barometer to the degree 424: Then, this degree of Heat would be double the former, as far as it discovers itself by this dilatation of the Mercury. We might, then, examine the proportion of this last aperture to the former, which produced only half as much Heat; and, hence, by comparing the *Areae* of these apertures thus discovered, and the effects of the caustic powers we observed from each of them, we might at last be able to determine, how much of this force depends

pend upon the quantity of the Rays, and how much on this coarctation of them into a smaller space, and the reduction of the Elements of Fire into a nearer union. And this, as it would be of very great service in furnishing us with proper materials for a History of Fire, it seems plainly to demonstrate that the intenseness of this Fire, is not owing only to the number of the Rays, but to their proximity likewise, by which the force of the particles of Fire is continually increased: A few Experiments, at least, that have been made with this view with concave glass *Speculums* induce us to be intirely of this opinion. Thus, then, we have sufficiently explained the greatest force of Fire that has ever yet been discovered; which, in very cold weather, is produced in one simple manner by that quantity of solar Rays that passes through a Circle of three feet seven inches diameter. Had these Rays, now, proceeded on without meeting with any obstacle, they would have excited but a small degree of Heat in the Air; and if they had constantly kept on in the same direction through an Air growing gradually finer and finer, the Heat caused by them would have grown less and less by degrees, till at last perhaps it would have been diminished to a greater degree of Cold than was ever yet discovered. Hence, then, we see plainly what wrong notions persons generally have of the nature, and action of Fire; since it evidently appears, that the difference betwixt the intensest Heat that we are hitherto acquainted with, and the extremest Cold, is caused purely by the action of a resisting Body. And, hence again, we may almost venture to infer, as we did before, that Fire is equally diffused through all Bodies, and every part of space; and that its activity does not appear, except when it meets with some resistance. As, the aperture, now, of the *Speculums* we have been treating of may be constantly increased; hence, the strength of the focal Fire may be augmented *in infinitum*.

COROL. IO.

No body has ever yet discovered a stronger Fire in any place, than that which is collected by *Vilett's Speculum*; for that which is generated by *Tschirnhausen's* burning glasses is not so great. Hence, the effect of the greatest Fire that we know of, is the turning Flint into Glass in a moment, in *Vilett's Focus*. A greater effect than this has never yet been observed; for though Lightning, has sometimes instantly melted Iron, yet it never has, to my knowledge, vitrified either Stones, or Metals. The vast violence, therefore, of the Fire in this *Focus* we cannot consider without wonder, and astonishment: And yet I assert, that this very same effect of vitrification, may be at once produced in the coldest places, and by the coldest Bodies, without the assistance of any Sun, Light, *Focus*, or combustible matter; and, hence, that the ultimate effect of the most intense Fire is always and every where producible, even in the darkest and coldest parts of space. And this is evident; for if in the sharpest Winter-night, you strike a choice Flint against a piece of well tempered Steel, you may by that means always procure exceeding lucid, vivid sparks, which make a whizzing noise as they fly through the Air. Now if you catch the Corpuscles thus struck off, upon a clean paper underneath, you will find them to be glass Spherules, composed either of the melted Flint, or Steel, or both together, and formed into this figure by their rotation through the Air. Hence, therefore, we are certain, that the force of the Fire generated here,

Attrition
produces the
effect of the
greatest Fire.

must have been strong enough to have reduced these exceeding hard Corpuscles to such a fluid state, that they might by this equable rotation through the soft Air be reduced into these spherical Bodies, which, upon examination, we find to be perfectly of a glassy nature. But the turning Stones and Metals into Glass, is almost the greatest and ultimate effect of the strongest Fire; so that hence it appears, that the action of this momentaneous percussive is as efficacious, as that of the most violent caustic *Speculum*. If a prodigious large choice Flint, therefore, should be struck against an exceeding great Body of Steel, what a Fire might be instantly produced? Thus, then, I have explained a second method by which the greatest degree of Fire may be readily generated; viz. by collecting the parallel Rays of the Sun into a very small point by reflexion.

EXPERIMENT XVI.

The production of Fire dioptrically.

If the same Fire, thus determined into a Parallelism by the Sun, falls upon a very pellucid glass, nicely polished, and perfectly spherical, it will be collected in a *Focus* that burns very violently.

The truth of this has a long time been discovered; but it never appeared more accurately than by the glasses of Mr. *Tschirnhausen* in the possession of the Duke of Orleans, which were made use of in the Palace Garden on purpose to try some Experiments concerning the nature of Fire. An historical account, therefore, of this affair can't here be omitted; as it will give us a considerable light into the properties of Fire, the effects produced by these glasses being the greatest that were ever produced by any of the same kind. See *Mem. de l'Ac. Roy. des Sc.* 1699, 90, 1700, 128. 1702. 34.

The greatest known.

The biggest glass is of a circular figure, four feet in diameter, and convex on both sides; and if it is directly opposed to the Sun in the summer time betwixt nine in the morning and three in the afternoon, when the Air is clear, and freed from its Water by preceding Rains, it produces a *Focus* at twelve feet distance from the glass, whose Diameter is an inch and a half. This is what Mr. *Tschirnhausen* made use of himself.

If combustible Bodies are placed in this *Focus* they take fire immediately; Lead is soon melted; and Bricks are vitrified, if they continue there a good while. Now from these effects compared with those of *Vilett's Speculum* we may draw the following Corollaries.

COROL. I.

The catoptrical, and dioptrical Fire compared.

The Diameter of the circular aperture of *Vilett's Speculum* is 43 inches; hence, the circumference, $2\frac{4}{7}$ inches. The Diameter of the Circle of *Tschirnhausen's* Convex, is 48 inches; its circumference, therefore, $1\frac{2}{7}$ inches: Consequently, the quantity of the incident Rays upon the Circle of *Tschirnhausen's* glass, is to the same upon *Vilett's Speculum*, as 2304. to 1849; and yet the action of *Vilette's Speculum* is much quicker, and a great deal more violent, than that of this glass *Lens* of *Tschirnhausen*.

COROL. 2.

The catoptrical more powerful,

Hence it appears evident, that Catoptrics rightly improved is better suited to give us the incident Rays in their full force by reflexion, than Dioptrics, with the utmost advantages, is by refraction; and, therefore, that a great many Rays are lost when we endeavour to collect them by diaphanous burning glasses.

COROL. 3.

But how great now, likewise, is the difference of their *Foci*? The *Area* of the circular aperture of *Vilett's Speculum* is $42\frac{1}{2}\frac{1}{8}$ square inches; its *Focus* $2\frac{9}{2}\frac{2}{8}$ square lines. The *Area* of the Circle of *Tschirnhausen's Lens* is $10\frac{6}{2}\frac{1}{8}$ square inches, the *Focus* of it, $2\frac{1}{2}\frac{2}{8}$ square lines: And, therefore, the *Focus* of the *Speculum* is to the *Focus* of the *Lens*, as 1, is to 9; whence it appears, again, that the method of generating Fire by reflexion, is more powerful than by refraction. This caustic power, therefore, may be carried to a greater height by opaque *Speculums* than by transparent *Lens's*: For an orbicular *Lens* of four feet diameter, is almost the greatest that the Workers in Glass could ever yet make, on account of the construction of their Furnaces; whereas the formation of *Speculums* is not as yet, perhaps, arrived to its greatest perfection; though we have no very great reason, indeed, to expect otherwise. For who, that judges justly of things, don't reflect with some regret, that no Prince should think it worth while to reward the industry of these consummate Artists in a handsome manner, and encourage them to farther Improvements? But this is the hard fate, that the most beautiful Arts are frequently exposed to.

Because it unites the Rays more closely.

EXPERIMENT XVII.

The noble *Tschirnhausen*, however, not being satisfied with the preceding Experiment, began to think of contracting the former *Focus* into a narrower compass, and by this closer union of the Rays rendering its caustic power more intense. For this purpose, therefore, he made use of a smaller glass *Lens*, the Segment of a lesser Sphere, which being placed directly parallel to the former, received all the Rays that were collected by that larger one, and were proceeding on to its *Focus*, and contracted them into a circular space of only eight lines diameter; and consequently, by this new contraction, reduced these Rays from an *Area* of 81 lines square, to one of 16. But though by this method he brought them into a nearer union; yet he lost a great many Rays by this second refraction; though this, however, did not hinder but that the caustic power of this latter *Focus*, was stronger than the former. And this was the ultimate effect of the skill of the celebrated *Tschirnhausen*. Thus then, Gentlemen, I have endeavoured to explain to you as fairly and clearly as possibly, the most efficacious methods, hitherto discovered, of generating Fire by the assistance, both of the catoptrical, and dioptrical Science. I imagine, however, that you'll expect as Chemists, that I should lay before you the surprising alterations that Bodies undergo when they are exposed to the power of these Glasses, for producing of which, you will perceive there is no need of any gross Fire, though these effects are much greater than ever were brought about by the most violent Glass-house, Docimastic, or Metallurgic Furnaces. Nor let any one take it amiss, that I relate here those things, that may be found in the *Memoirs* of the Academy of Sciences: These Books are not in every body's hands, and I am at present professedly treating of Fire. The chief, then, are as follow.

The greatest dioptrical Fire.

1. Moist boughs of green trees, or wood soaked in Water, held in this *Focus*, take fire in a moment, and consume in Flame, Smoke, and Ashes.

The principle effects of such a Fire.

U 2

2. Water

2. Water contained in a small vessel, begins to boil in this *Focus* immediately. And I wish it had been tried by *Fahrenheit's* mercurial Thermometer, whether whilst it boiled in that place it was hotter than usual; that thus we might have seen whether the intense force of this focal Fire, could communicate to boiling Water a greater degree of Heat, than any other Fires, in all which it is constantly observed to grow equally hot.

3. Thin plates of Metal placed in this *Focus*, do not melt immediately, but gradually, after they are heated to a certain degree. And if they are so thick, that the force of the Fire can't penetrate quite through the plate, they won't very easily be melted at all.

4. Bricks burnt, or dried in the Sun, *Talc* itself, and other Bodies, grow red in a moment, and soon after run into Glafs.

5. Sulphur, Pitch, and Resin are melted though they lie under Water.

6. A thin piece of wood covered with Water, and exposed to the strongest *Focus* a good while in summer time, seems perfectly intire if you look on the outward parts of it, but if you break it, it appears burnt within, and turned to a coal. Now this very extraordinary *Phænomenon* seems to me evidently to indicate, that this intense Fire cannot heat Water beyond a certain degree; which being less than that which will set fire to wood, it prevents the *Focus* from burning the wood in those parts that are contiguous to the Water.

7. If the substance to be examined is fixed upon a very black Body, the power of the *Focus* is vastly increased.

8. If Metals, or other Bodies, are laid upon charcoal made of green wood, and not thoroughly dried, they will be melted in the twinkling of an eye, throw out sparks, and fly off. Lead, and Tin, melt soonest of all, fume, calcine, vitrify, and disappear.

9. The Ashes of all kinds of vegetable are turned to Glafs immediately.

10. If a pretty large Mass is exposed to this *Focus*, it frequently happens, that this Fire won't put it in fusion; but if you reduce the same to Powder, it generally melts pretty easily: If it should still, however, obstinately resist fusion, it may readily be effected by mixing of some sorts of Salt with it.

11. All Bodies, that are black, and continue so in this *Focus*, suffer the greatest alterations there: Those that are white when they are put into it, and afterwards grow black there, are chang'd with more difficulty, and not under a longer time: Those that are black when they are exposed to this *Focus*, and afterwards grow white in it, resist its force still much more powerfully, especially if they become white after they are put in fusion: But those that continue perfectly white in this intense Heat, undergo the least alteration of all; as Lime, *English* Chalk, and Flint.

12. All Metals plac'd in this *Focus*, in a *China* vessel that is not glaz'd, vitrify immediately, if you take care to heat the vessel leisurely, that the sudden force of the Fire don't break it, and it is itself so thick, that it won't be melted.

13. If the matter to be examin'd by this Fire is placed in a large glafs *Mattrass*, and the *Focus* is so carefully directed, that it shall affect this matter, but not the Glafs through which it passes, then the *Phænomena* that are produced upon this matter within the Glafs, will be very surprizing.

14. Nitre contained in such a vessel, and acted upon by this Fire, grows perfectly volatile in the least instant of time, and then is intirely changed into

a volatile Spirit of Nitre. This effect now is so much the more wonderful, because Nitre, when it is melted by other Fires, scarcely undergoes any alteration, but runs just like Water; and before it can be reduced by Fire into a Spirit, it always requires a mixture of some earthy Body with it, or an addition of true Oil of Vitriol, or its *Calx*, in which there still remains some portion of Oil: Here we see the same thing effected without any mixture at all.

15. The light of the brightest full Moon being collected by this Glass, gives an exceeding lucid *Focus*, but not the least indication of Heat.

16. It moves, agitates, and drives about almost all Bodies, even in *vacuo* itself, tho' sometimes not without exceeding great danger.

From these Experiments, then, and a great many more, it appears, that this *Focus* of *Tschirnhausen* is weaker than *Vilette's*, but that, nevertheless, it is much better suited to the examination of Fire by its effects.

COROL. I.

If Water, or pieces of Ice in the Atmosphere, should by any physical causes be so roll'd up into a globular Cloud, as to form a pellucid Sphere, tho' its figure continued ever so short a time; then, this being irradiated by the Sun, might in an instant produce a *Focus* much more violent than *Tschirnhausen's*; which would be at the distance of a semi-diameter of the Sphere on that side averse to the Sun: The Air, therefore, would be there vastly rarified, and hence, again, must arise very sudden and surprizing *Phænomena*. For whoever considers the perfect transparency of Water raised into the upper regions, and reflects at the same time on the vast quantity that often falls in showers in a very short time, will easily understand from Dioptrics, what must be the consequence, should it be formed into a very large Sphere. If we imagine, again, the Rays thus falling upon such a Sphere to pass through it, and by this means to cause a vast Light and Fire, behind the Sphere, in a line that passes through its center and that of the Sun; whilst at the same time there appears nothing but thick darkness on that part that the Sun shines upon: Perhaps, it will not seem improbable that this is the case, when some parts of the Heavens appear terrible black, and soon after break out into prodigious Thunder and Lightning. But this spherical figure of these Clouds will in a particular manner produce a very considerable difference in the Light and Heat of the Spaces intercepted betwixt these Spheres and that of the Spheres themselves: Hence, therefore, very sudden and extraordinary appearances must arise one moment, and vanish again the next, from these swift changes that happen in the Air; which in some places will be rarefied and ignited, whilst in others, at the same instant, it is condensed and refrigerated. But these hints are sufficient; if you'll carefully attend to the *Phænomena* of Meteors, by means of this principle, of yourselves, you will easily understand them.

COROL. 2.

On this occasion, Gentlemen, I can't help reminding you again of what I have taken notice of elsewhere, *viz.* that Metals vitrify much sooner, and more intimately by the sole attrition produced by striking Flint against Steel, than by this double Dioptrical *Focus*, which is the strongest of this kind, that we are acquainted with. The truth of this is evident: For *Vilette's Focus* is much more powerful.

Dioptrical
Fire in the
Air.

Fire greater,
and more
readily ex-
cited by at-
trition than
Dioptrical
Glasses.

powerful than *Tschirnhausen's*; and yet iron is sooner turn'd into Glass by percussion, than it is even by that. Hence, therefore, we see plainly, that the power of attrition in elastic Solids is vastly great.

COROL. 3.

No need of
any matter
from the Sun
to the most
intense Fire.

And hence, I infer, that there is no need of any action of the Sun, that we are at present acquainted with, to produce the strongest Fire, that has ever discovered itself by the quickest and most powerful effect; nor is there any inflammable matter necessary to put into fusion, intimately, and in an instant, that Metal, which, of all others, is melted with the greatest difficulty, especially, if when the Experiment is made, it is exceeding cold, and in a very cold place: Nor for this purpose do we stand in need of any melting Furnace, or so much as a vessel to contain it. All which paradoxes are plainly confirmed by this common way of striking Fire.

COROL. 4.

Perhaps the
Sun does not
emit such
Fire.

I have been a great while in doubt, whether I should venture to publish an opinion, which I have long revolved over and over in my own mind; in dependance, however, upon your candour, I'll take the liberty to do it. It seems probable then, that the Sun does not in reality emit any igneous matter, to which we can ascribe any of the actions of Fire that fall under our observation; but that it has only a power of determining the pre-existent Fire into parallel right lines, without making the least addition: And hence, that the very same quantity of Fire being, after it has obtained this direction, collected, either by reflexion, or refraction, produces all the effects by this union of the Rays that were before dispersed, and the new power which they gain in consequence of it. But before I proceed, give me leave, by an easy Example, to illustrate this affair, which it is possible, to persons that are prejudiced against this opinion, may appear something obscure. Let us take, then, a hollow brass Cube, whose sides are three feet square; three of which suppose close, and the other open: Let the open side of this Cube be turned directly to the Sun, but be covered with a white paper; and in its cavity let there be placed one of *Fahrenheit's* Thermometers, made with Spirit that's very easily affected with the least degree of Heat. So long, then, as the Paper hinders the Sun from shining into the Cube, so long will there be a great degree of Cold there, if the season at that time is very cold. Let the Paper, now, be at once taken away, and that very moment the whole cavity of the Cube will be irradiated by the Sun, and the measure of the increased Heat will be determined by the Thermometer that's fix'd there. The Philosophers now assert, that the Fire that produces this new Heat, is emitted from the Body of the Sun with an inconceivable velocity. On the other hand, it seems probable to me, that the Sun does no more now, than it did before, and indeed, than it always does, and that is, it determines what we call Fire into right lines, when it meets with no opaque Body to intercept its power: And hence, that the Fire in this Cube remains exactly the same that it was before, and has only received a new rectilineal direction towards that side of the Cube that is opposite to the open one; whereas the Fire, whilst the Cavity was cover'd with the Paper, exerted its force equally upon all six. In this manner, then, I imagine the Sun equably heats this whole Space, this side in particular, and

and causes this difference in the Thermomer, purely by this determination, without the least addition of any new matter. But again, suppose *Vilette's Speculum* to be directed to the meridian Sun, but to be cover'd with a very white linnen Cloth; then, there will be no more Fire or Heat in the Cavity betwixt this covering and the *Speculum*, than there is any where else. Now remove this Vail, and in an instant the Fire that was in the cavity of the *Speculum*, and tended every way equally, is driven in parallel lines upon its concave Surface, and thence being reflected into the *Focus*, produces a most violent Fire there, which, in reality, did not proceed from the Sun: Nor is there, indeed, either more or less Fire than before, but only it is determined in a different manner. In a refracting *Lens* too the case is exactly the same. Hence, then, neither the Fire excited by attrition, or produced by this *Speculum*, or *Lens*, would upon this supposition depend at all upon the Sun with regard to its matter.

COROL. 5.

What now is the greatest degree of Fire that human skill, and industry, can at present produce? Why, from what has been laid down, it plainly appears, that it would be in that place where the *Focus* of *Vilette*, and the strongest of *Tschirnhausen* should be made to meet together in an opposite direction, and coincide. For since the *Focus* of the *Speculum* is in the open Air, and in a point of its *Axis* three feet and a half distant from its *Vertex*; hence, this *Apparatus* of *Tschirnhausen* may be so placed between the *Speculum* and the Sun, in the *Axis* of both of them, that this dioptrical *Focus* shall exactly unite with the former catoptrical one, and that without at all preventing the Solar Rays from falling upon the *Speculum*. In this place of concourse then will be found the most intense Fire, that human art at present is capable of exciting. I confess, indeed, that the force of this vast Fire can't conveniently be directed upon any Bodies placed in the *Focus*, for more than a moment; since as soon as ever they are melted, they will drop out of it: The greatest possible Fire, however, is thus determined. If, then, it is no ways repugnant to nature, that the globular and concave Clouds of Ice may have their *Foci* united together in the manner just mentioned, what prodigious effects may thence be produced?

A physical manner of producing the greatest Fire.

COROL. 6.

Suppose, now, this greatest Fire to be really excited in the place described; it will then continue there so long as the *Axis* of the Sun, dioptrical Glasses, and *Speculum*, remain in the same right line, and the distance between the *Speculum* and the Glasses is not altered. And, hence, if these instruments could be kept in the same situation, and at the same time be contrived to move in such a manner, as to be always directly opposed to the Sun; then this immense Fire might, in a clear Summer's day, be kept up from nine o'clock in the morning to three in the afternoon; nor would it, during all that time, want the least *Pabulum* to support it, but would persist in the same manner as it was produced. Thus, then, we form an *Idea* of the greatest Fire, very different from what any body ever had before: For from the laws of Nature thus discovered, we see it is possible that Fire and Light, of a determined power and magnitude, may exist, and continue in any place of the universe without the least *Pabulum* to sustain it.

Which continues a great while without any *Pabulum*.

COROL.

COROL. 7.

And instantly acts with vast force.

And what is principally surprizing in this Fire, is this, that the very instant that its cause begins to act, it immediately exerts itself with its full force, and with as great a degree of violence, as it ever acquires afterwards: Except, perhaps, you may look upon it as still more wonderful, that upon covering the *Speculum*, there don't remain in the *Focus* the least physical signs of that Fire which existed there, and acted with immense power but the moment before; nay, on the contrary, the Light, Heat, expulsion of the Air, and every other effect, disappear at once, without leaving any marks behind. Who could have believed these things? May, therefore, the brightest Light, and the strongest Fire in the Universe, be generated, and destroy'd again, in an instant? But the Fire now in the *Focus* thus described is not visibly bright, except in the *Axis* of the Sun and the *Speculum*; on the sides there is no Light to be seen at all; and, hence, it gives no indication of its presence by any lucid appearance, except to an eye placed in this *Axis*, where the immense brightness confounds and destroys the sight in a moment.

COROL. 8.

A new position concerning the nature of Fire.

Now, whilst I examine these things carefully, I think I discover a farther confirmation of that surprizing physical property of Fire, by which when it is left to itself, it constantly, like the *Radii* of a Sphere, expands and diffuses itself uniformly and equably from the center of its magnitude. Since, therefore, this Fire exists every where alike, its power, of consequence, will be every where in *equilibrio*, and, hence, will so long produce no sensible effects; but as soon as ever this *equilibrium* is by any means destroy'd, then, immediately it may appear by its operation to be infinitely powerful. In which cases, perhaps, we shall be mistaken, if we imagine, that any new fire is produced, or that there is any increase in the power of that which existed before.

EXPERIMENT XVIII.

Fire may be united with Bodies, and fixed for a time.

True Fire may be united with every solid Body on which trial has hitherto been made; and when it is once communicated to it, it will adhere to it a considerable time; and therefore, does not instantly disappear in Bodies, as it does in the *Foci* we have been just treating of.

For if we commit any of these Bodies to a pure strong Fire of any sort, we find that they may be heated so as to shine, grow refulgent, and melt. This, the Experiments of *Tschirnhausen*, *Homburg*, *Hartsoeker*, and others evince; as likewise, those of your Smiths, Cooks, and all others that are conversant about Fires; as well as those which the Earth itself irradiated by the Sun offers to our Observation: In all which the same thing is found to hold good by every kind of Experiment. And this, the trial upon all fixed Earths, all kinds of Stones, Gemms, rocky Substances, Glass, fixed Salts, Wood, solid Fossils, and Metals, confirm the truth of. And hence the great *Newton* very justly observes, that if Water itself could be converted into Earth, it might be so impregnated with Fire as to become lucid. Now there is nothing in this affair that deserves more to be taken notice of than this, that there must be some cause, by which the Fire is connected to these Bodies during this time, besides the

the Fire itself. This is plain; for in *Vilette's Focus*, that intense Fire is destroy'd the very moment that the parallel irradiation ceases. Fire, therefore, in that place, does not hold together and detain Fire: On the contrary, all those Fires now fly afunder, and leave one another, which the instant before were so closely united together. But now, if an iron Ball, whose great Circle, suppose equal to the Circle of the *Focus*, had been held there so long till it was quite hot through; then, the Fire of this *Focus* being associated with the matter of the Ball, would be detain'd in it a considerable time, and thus this focal Fire, which would otherwise have vanished in a moment, will, now it is received within this body, remain united to it a long while, and be secured from this instantaneous extinction. What now is properly the cause of this effect? Body. By what means does it thus retain Fire? By its corporeal Mass. Was there, therefore, no other corporeal substance in this *Focus* but Fire, the Air itself being expelled by the force of it? And did the Fire, therefore, vanish so suddenly, because there was no other Body to secure and detain it? Do the particles of Fire, then, when collected together, immediately restore themselves to their former *equilibrium*, if they are not kept together by some dense Body? And, hence, is there no mutual attraction between the elements of Fire? Or don't they, rather, repel, and fly from one another?

EXPERIMENT XIX.

When this pure elementary Fire is thus communicated to Bodies, it discovers itself to be real Fire by a true physical effect, which it produces all around them from every point of their surface, so long as it remains in them. And that very pure.

In this case, certainly, we observe the principal mark by which the Thermometer demonstrates that Fire is actually present: For if, as you see, I hold this Thermometer at a certain distance from this red hot Iron, you perceive the Spirit instantly rarefies in the Tube, and so much the more, the nearer I bring it; and again, you observe it is condensed, as I remove it back again. Nor does it at all signify on which side of the Iron I hold it, if I take care to keep it always at the same distance. This Fire, therefore, that now resides in the Iron, and acts upon the Thermometer, is, in reality, the very same as the former; but it now persists in this place without any attrition, or parallelism, and produces the very same effects there, as elementary Fire does. Observe, now, this Brimstone Match; as I bring it very gradually from some distance towards this red hot Iron, you see it begins to smoke, melt, sparkle, shine, and kindle into a Flame. But, again, pray take particular notice of this surprising Experiment that follows. This small Vial in my hand, contains some very pure Alcohol; a little of which I'll pour very gently and cautiously upon this red hot Iron. What do you imagine, then, will be the consequence? That it will take fire? to be sure no body doubts it. But the case is far otherwise. For observe, as soon as ever it falls into the hollow of the Iron, it forms itself, like Mercury, into a globular figure, and runs up and down in that manner, without the least appearance of any Flame; and yet you see the moment it comes to the colder part of the same Iron, it is then in an instant dissipated into the Air; tho' then too, without flaming. What now, Gentlemen, should be the cause of this? Sulphur, Gunpowder, Wood, and other Bodies, when apply'd to this Iron, flame immediately: And yet Alcohol, which being gently

ly heated, fires sooner than almost any thing, is able to bear the Heat of the same Iron, without taking fire. The solution of this Paradox is worthy your penetration.

EXPERIMENT XX.

Without any
increase of
weight,

As appears
by an Expe-
riment made
upon Iron
with a Bal-
lance.

Another up-
on Brass.

Since, therefore, it is certain, that this Fire may be thus detained in a solid Body, and that, during so long a time, and in such a degree; it is our principal business to enquire, of what kind this Fire is, which in this manner remains there: And as weight in particular is one of the chief, and most general properties of Bodies, I have taken pains to examine whether this Fire does in reality add to fixed Bodies any weight that our senses are capable of discerning. To this purpose, then, I made choice of a Body, that would bear a strong Fire without losing any thing of its weight; and at the same time, should be able to receive a large quantity of Fire into it, and preserve it there a considerable time: And I made use of a very accurate ballance, that moved very easily upon its *Axis*. Observe then, this paralleliped, made of the best sort of Iron, which weighs 5 pounds, 8 ounces, *Amsterdam* weight, now it is cold. I'll put this, as you see, into this large Fire, which shall be blown till the Iron is perfectly red hot all over: Thus bright, then, as it is now it is taken out, when I have struck off the dust, I'll put it into one scale, and at the same time put weights in the other, till there is a perfect *equilibrium*. You observe now the beam is perfectly at rest, and upon examination, you find, that the weights in the scale make exactly 5 pounds, 8 ounces. I'll leave it now in the scale till it is quite cold, and the *equilibrium* will still be maintained: For after letting it alone thus for twenty-four hours, I have found, that even in this large Mass, there was not the least difference in the weight of the Iron when it was red hot, and after it grew cold. I made the same trial with a large solid piece of Brass; and the event was exactly the same. It is necessary, however, to give you this caution, that in making these Experiments, the heated Body sometimes seems to be lighter than it was when it was cold; and this happens when the scales are fastened to the beam with ropes, or any thing of that kind, that is capable of admitting moisture into it; for when the Metal is put into the scale, the heat of it makes the moisture evaporate, and by this means the strings on that side grow lighter than they were before. On this account, therefore, we must always, for this purpose, make use of chains made of Metal.

COROL. I.

Fire is free
in Space and
Body heated.

The Fire, therefore, thus adhering to a heated Body, diffuses itself all around just in the manner of an Atmosphere: For from every point of the Body it exerts its force to a considerable distance, and thus produces those true physical effects that are peculiar to Fire: and these are found always to be the greatest, the nearer you approach to the heated Body. If a Globe, therefore, was thus heated, it would form a Sphere of Heat round it, whose center would be hottest of all.

COROL. 2.

And, hence, we understand, that there is great quantity of true Fire in such a Body;

Body ; and that it continues there for a very considerable time. For if we consider, that round such a Ball of Iron or Brass, there is a great degree of Heat on every side to a considerable distance, as appears by its proper effects ; and at the same time reflect, that during the continuance of this Heat, it must be constantly diminished by the cold of the ambient Air : We shall then easily see, that the quantity of Fire in this heated Ball must at first have been exceeding great. And, hence, the greatest quantity of Fire must be in the Body itself, with respect to the surrounding Air that is heated by it. And again, if such a Sphere is kept in the Fire so long till it is perfectly red hot quite through ; then, in its center the Heat will be most condensed, and greatest of all : The truth of which is confirmed by all its effects.

Greatest in the Center, and decreases towards the Surface,

C O R O L. 3.

But from this center towards the surface, the Fire grows gradually weaker and weaker ; for its surface that is contiguous to the Air, will first be affected with the coldness of that, and, hence, will first grow cold. And this is equally true of the Atmosphere of Air that surrounds the Sphere, for those Orbs which are nearest it, will be hottest, and thence grow successively cooler, till they come to that which determines the boundaries of the Heat, and is itself as cool as the ambient Air. Hence, again, we are certain, that in this whole heated Sphere, the center expands itself every way with the greatest violence. This is the nature of Fire, which is here greatest in the center. But the contiguous Orb will be less expanded, and therefore will confine the expansion of the center, and in some measure repell it ; for this Orb is not quite so hot, that is, it is a little less expanded, or a little more contracted. And, since this same expansion and repulsion will hold true in all the Orbs that compose this whole heated Atmosphere ; hence it appears, that so long as the Heat, communicated to the Sphere, continues greater than that of the common Air, so long there will be a continual dilatation and repercussion throughout the whole Sphere, as well in the solid Mass itself, as the Air that is heated round about it. And this vibration, considering the violence of the Fire, must of necessity be very great. Does therefore the vibration and repercussion in this case agitate the particles one amongst another ? And is there by this means new Fire excited, as we have explained already in the first manner of generating Fire by attrition ?

So that at last it comes to the common temperature.

In a heated Sphere a continued oscillation.

C O R O L. 4.

It were here much to be wished, that we could find a way of determining the proportional quantity of Fire, that is contained in such a Body, with regard to its very substance ! But this is not so easy to accomplish as people generally imagine : For tho' we are able to discover the force of the Fire by its sensible effects ; yet we cannot from its force make a certain judgment of its quantity ; and for this reason in particular, because we don't yet know how much its power may be increased, purely from the near approach of its Elements. So long, therefore, as we are ignorant what proportion the power that depends upon this condensation of Fire, bears to that which arises from its quantity, so long we can't pretend to make use of the effects of Fire, as a certain measure to

The measure of the quantity of this Fire difficult.

determine its quantity. These niceties may to some persons seem unnecessary; but a great deal of caution will never do any harm in physical inquiries.

COROL. 5.

This Fire does not become a con-
creted Mass
with the
Body,

This Fire, however, tho' it thus continues in a heated Body, does not seem to be concreted with it into one corporeal Mass; for notwithstanding the Body grows bigger than it was before, yet it don't become at all heavier; unless you will suppose, that the Fire may be concreted with it, so as to increase its bulk, without making any addition to its weight. This, in the mean time, we are absolutely certain of, that the Body is constantly extended in its bulk, so long as the Fire remains in it.

COROL. 6.

Nor renders
it lighter;

Nor does the Fire at all lessen the weight of the Body, whilst it is in it, and the Cold restore it again: For the contrary is always found true by Experiment.

COROL. 7.

Nor as to its
weight
makes any
alteration.

Hence, therefore, we may conceive of the Fire, in a red hot Globe of Iron, for instance, as a Fluid, dispersed, both through the Body itself, and all round about it, whose Particles are mov'd every way freely, and without any particular tendency: For if you suppose any determination of them one way more than another, it seems necessarily to follow, that the Mass, when it is thus heated, must be either heavier, or lighter, than it was before.

COROL. 8.

The cause of
the continu-
ance of Fire
in any Body.

There must, therefore, be some cause, by which the Fire is during all this time detained in the heated Body, and which prevents its being dispersed again, as soon as ever it is produc'd. For the Fire in the *Focus of Vilette*, or *Tschirnhausen*, is as strong, nay stronger, than this in this iron Globe; and yet we see that that vanishes in an instant, if it is not every moment renew'd in the same place. Hence, therefore, Fire is not able to keep possession of the place it exists in, but must be retain'd there by somewhat of a quite different nature.

COROL. 9.

First the
Mass itself.

Let us examine now this affair ever so nicely, we find nothing here that can effect this but the Body itself, considered as it stands in opposition to Space, viz. as it is somewhat resisting and impenetrable, or, as it is a real corporeal Mass: For it appears by Experiment, that if Fire is communicated by the same cause to Bodies of different densities, they will indeed acquire exactly the same degree of Heat; but then it will afterwards be retained in them so much the longer, as they are denser, heavier, or contain a greater quantity of matter under the same bulk. If you immerge, for instance, bodies of different specific Gravities in boiling Water, and keep them there till they are equally hot; then those that are very heavy, will keep hot for a considerable time, whereas the light ones will grow cold immediately. And as far as we have been hitherto able to judge by Experiment, this seems to be almost a general rule: *Toricellius's Vacuum* loses the Heat generated there instantaneously; Air heated in a vessel,

a vessel, very quickly; Alcohol still slower; Water retains its Heat yet longer than Alcohol; and Mercury longest of all. In the same manner among Solids; Wood, Stones, Metals, if they are made equally hot, are exactly so much the longer before they grow cold, as they are denser than one another.

But again, a greater degree of Fire is longer disengaging itself from Bodies to which it is united, than a less: So that it seems to hold almost generally true, that the greater the degree of Heat is, that is communicated to the same Body, or the more it is expanded by the force of the Fire till it begins to be melted, so much the longer will it always be, before it grows cold: For if you take two Bodies, that are perfectly alike, and give them different degrees of Heat; then the hottest, after it has lost the surplus of Heat by which it exceeded the cooler, will still remain as hot as the other was at first, and consequently will then require as much time to grow cold in as that did. But it still remains nicely to be examined, whether there is not some other cause, besides the density of Bodies, and the degree of Heat, that is capable of preserving Fire for a considerable time, when once it is generated? If Water, for instance, and Oil, should be heated to the same degree, supposing the Oil lighter than the Water, which of these two would grow coldest within the same time? Why, certainly, the Philosophers would generally imagine, that the Fire being intangled by the tenacity of the Oil would remain longer there, than it would in the Water. To determine this, therefore, I took two vessels of the same size, one of which I filled with Water, and the other with Oil of Olives. These I put into boiling Water, and kept them there till I was sure, that both of them had acquired the same degree of Heat with the Water which was kept continually boiling. I then took them out, and placed them both in the same Air, in order to discover the time in which they would be reduced to the same temperature with it, and I found it to be exactly in proportion to their comparative weights.

Secondly,
the quantity
of Fire.

There seems, in the mean time, to be some very abstruse cause, why Fire itself, nay a very strong one too, is not able to heat Bodies beyond a certain degree; as we see in Water, Alcohol, Oil, and Mercury, when they are once made to boil. As ebullition, however, does not happen equally soon in all, hence lighter liquors are very often capable of receiving a greater degree of Heat than heavier, if they take up a longer time before they boil. Water, for instance, is heavier than Oil of Linseed; boiling Water has 213 degrees of Heat in it, and can, then, with the strongest Fire be made no hotter: This Oil, which is so much lighter, requires a greater Fire, and is longer before it boils, and has then acquired almost 600 degrees. Who, now, is able to account for this? Mercury, we see, which is 15 times heavier than this Oil, arrives only to just the same degree of Heat when it is made to boil. Hence, however, it appears evident, that there is something else besides the corporeal mass, that makes some Bodies susceptible of a certain quantity of Fire only; whilst others are capable of receiving a great deal more. The true cause of this, perhaps, no body is able to assign.

Of which a
greater may
be commu-
nicated to
some parti-
cular Bodies
than others.

From these considerations, however, we see plainly the reason, why Fire that is raised by combustible matter, may be extinguished by Water; for by this means it is compassed with a less degree of Heat than is necessary to set these combustibles on fire, which is always greater than 213.

Why does
Water ex-
tinguish
Fire.

And.

Why does
Water keep
Tin from
melting.

And for the same reason, a strong Fire won't melt a tin vessel when it is full of Water: For this requires a greater degree of Heat to put it in fusion than that of boiling Water, which is all it can receive so long as the Water remains in it. But set, now, this same vessel on a Fire with Oil in it, and you will find it will soon be melted before the Oil begins to boil. The same thing is true, too, of Lead if you put it on the Fire with Water in it. From a careful examination of all these circumstances it seems probable, that when the Fire has so disposed Bodies, that it can pass, and exert itself equably through their Pores, then, no more Fire can be united with them, than what is actually in them at that time; and this seems to be the case in Fluids as soon as ever they begin to boil; in Solids, when the force of the Fire has perfectly melted them, so as to make them run in the form of a sparkling, or boiling Fluid, which we find happen in Metals, Glass, Salts, and other Bodies thus put in fusion.

By the help, then, of these useful Observations, we learn at last, that there is in reality some *nexus*, or connexion between Fire, and Bodies: That the greater it is the longer it adheres to them: That the same degree of Fire remains longest, in those that are densest: That a greater quantity of Fire may be united with some certain Bodies, oily ones in particular, than other: That these require a stronger Fire, and a longer time to acquire this greater degree of heat: That the denser bodies are, the longer they are before they grow actually hot with rarer Bodies, when they are exposed to the same degree of Heat: And that when they are heated they require so much the longer time to be reduced to the same temperature with these rarer, which grow cold sooner. Now whoever rightly considers these things will understand a great many of Nature's laws with regard to the properties of Fire, which are confirmed by Observation, and if carefully attended to, will be of excellent service in our Philosophical Inquiries. And it is my opinion, if this doctrine should be still farther improved, we may at last from Experiment be able to solve the following Problems: *To fill a given Space with such a Body, as cannot be heated by the greatest Fire beyond a determined degree:* And again, *To fill a given space with such a Body, as shall be able to retain in it the greatest possible Fire.* Is not Iron, which is fused with more difficulty than Gold, hotter when it is in fusion than melted Gold, though that is denser? The thing is worth inquiring into.

COROL. 10.

Heat presently disappears upon the application of a dense cold Fluid.

But whilst we are engaged upon this head, there is another *Phænomenon*, that offers itself to our Observation, *viz.* that when Bodies have a greater quantity of Fire in them than the ambient Fluids, or neighbouring Bodies, then, the denser the Fluid is into which they are immersed in order to be cooled, the sooner will they lose their Heat. My meaning is this, Take three vessels, one full of Air, another of Water, and a third of Mercury, when they are all three exactly of the same temperature: And let three equal pieces of iron be made perfectly red hot. Let, then, the degree of Heat in the Air be observed, and let one of the pieces be left in that; let the other be immersed in the Water, which is exactly as cold as the Air at that time; and let the third be thrust into the Mercury, of the same temperature, too, as the former: What then will be the consequence? In the rare Air the Iron will keep

keep its Heat a long time; in the Water it will lose it sooner; but soonest of all in the Mercury. And, indeed, it seems to grow cold so much sooner in the Water than in the Air, as the Water is denser than the Air, that is, 800 times. And that in the Mercury, perhaps, 14 times sooner than that in the Water. And this, your Workers in Metals are well acquainted with, who, when they would soften their Metal for particular uses, make it perfectly red hot in the summer time, and then leave it in the Fire which will gradually moulder away to Ashes, and thus let them all grow cold together: But on the other hand, when they want it hard for other purposes, they chuse the Winter for this work, and instantly throw it into the coldest Water they can get.

Thus then, we see there are two causes that hasten the cooling of Bodies when they are heated; viz. the Coldness, and Density, of the Fluid into which they are immersed. But there is yet a third which promotes the same end, and that is, the moving the hot Body about in the cold Fluid; which is the most expeditious way of cooling it; for by this means it is continually exposed to some new cold part of the Fluid. Hence, then, we see the physical reason of that method which is made use of, when we would render Iron as hard as possible, viz. the drawing it swiftly through very cold Water when it is just ready to melt, so that it may be perfectly cooled in an instant: For by this means the Elements of the Iron, which were vastly relaxed, and softened by the Fire, are now intimately united, condensed, and compressed together by this sudden Cold that is on every side applied to them; and, hence, after they grow cold they remain most closely compacted together, and exceeding hard, though at the same time very brittle.

The cause of refrigeration three-fold.

COROL. II.

Whence, then, does it come to pass, that the denser Fluid should so soon cool the hot Body that is put into it? Before this was immersed, the Fluids were all equally cold, and consequently, one's cooling the hot Body sooner than the other cannot proceed from any difference in their coldness. Does the denser matter, therefore, of the cold Fluid attract more Fire out of the hot Body, and that, in proportion to its density? For the determining this question we must again have recourse to Experiments. To this purpose, then, take two equal quantities of the same Fluid (Vinegar, for instance, Water, Alcohol, or Oil) and give them different degrees of Heat; and you will find if you put them together at once, and mix them intimately with one another, they will acquire a degree of Heat, which will be half the excess of the hotter above the cooler. For example, If a pint of boiling Water 212 degrees hot, is mixed in this manner with a pint of the same Fluid, that has but 32 degrees of Heat, then this Mixture will have 90 degrees, which is half 180, the difference betwixt 212, and 32. Hence it appears, that this distribution of the Fire is in proportion to the bulk; and that, therefore, when Bodies of the same nature are mixed together, the one hot, and the other cold, the Fire immediately disengages itself from its contact with the Elements of the former, and unites itself with those of the latter, till this becomes as hot as the other. This, then, being constantly the case, we see that the common degree of Heat is destroyed, and the difference is then equally distributed through them both. But, now, if this Experiment is made with Mercury, and Water, exactly of the same measure, but different degrees of Heat, and these are in the same manner swiftly

Why do dense Fluids destroy Heat soonest.

The effect of mixing a hot and cold Fluid.

And the
difference
observed
here.

swiftly mixed together; then the Heat that is produced by this Mixture, will be very different from what was observed in that just now mentioned.

For if the bulk of the Water, and Mercury to be mixed, is exactly equal, but the Water is hotter than the Mercury; then, the Heat of the Mixture will be always greater than half the difference of their separate Heats. And, on the other hand, if the Mercury is hotter than the Water; then, the degree of Heat in the Mixture will be constantly less than half this difference. And this diversity is always found to be the same, as if, in the first case, you had mixed three parts of hot Water with two of cold; and in the second, you had mixed three parts of cold Water with two of hot. But, now, if the bulk of the Mercury is to that of the Water, as three is to two; then, it don't signify at all, whether you heat the Mercury, or the Water: For the mixture will always have a degree of Heat equal to half the difference of their separate Heats, as we found to be the case when we mixed the Water together in equal quantities.

Fire is di-
stributed
through
Bodies in
proportion to
their Bulk.

In this Experiment, then, we plainly discover the law by which nature distributes Fire through Bodies; which is not in proportion to their densities, but in the same manner as it is diffused through space. For though the specific gravity of Mercury is to that of Water pretty nearly as 14 to 1; yet its power of producing Heat when measured by its effect, appears to be only the same, as if Water had been mixed with an equal quantity of Water. But the same thing is abundantly confirmed by every kind of Experiment as I took notice before, when I told you, that I had been convinced by Experiment, that all sorts of Bodies, if they are long enough exposed to the same common temperature, acquire exactly the very same Heat, or Fire, without any difference at all except what arises from the different spaces they take up: That, hence, it did not appear from Observation, that any Bodies whatever have a power of attracting Fire, though their greater density makes them capable of retaining it longer when once it is united with them. The Experiments, I have just mentioned, were performed for me by the famous *Fabrenheit*. What then is the reason, that Fire will leave the Body it possesses, to enter into a heavy Body, so much sooner than into the most light, and subtil space, into which one would imagine it should penetrate with a great deal more ease?

COROL. 12.

The greatest
Bodies retain
Heat long-
est.

Hence, again, we understand that the bigger any particular Body is, the longer it will *cæteris paribus* keep the Heat it has once conceived: For the density of the outward surface always prevents the quick egress of the Fire which endeavours from the inward parts to make its way out. The next orb then restrains the third, this the fourth, and so on to the end. And for this reason if a Body is heated perfectly through, its inmost parts are always longest a cooling. Hence, therefore, since the magnitude of any Body is capable of farther increase, it may at last become so large, that the Heat communicated to it, shall continue in it a prodigious long time.

COROL. 13.

It is demonstrated by the Geometricians, that if Bodies remain the same in
all

all other circumstances, the bigger they are, the less surface they will always have in proportion to their solidity. Hence, again, if we consider, it will presently appear that very large Bodies, if they are once heated, must on this account retain their Heat a very considerable time. From this law, then, it follows that every Body will preserve its Heat so much the longer, as it has more solidity contained under a less surface; that is, in comparison of others.

As well as Bodies of the least Surface.

But again, the Mathematicians have proved, that if the corporeal mass continues the same, a Body can never be reduced under a less surface than when it is formed into a Sphere. This Figure, then, is the most tenacious of Heat; both on account of the smallness of its surface in respect of its solidity; and the equal distribution of all the parts quite to the center, and the equal recess from the surface. Hence, a very large spherical Body, if it is once heated, will retain its Heat a vast while. And this possibly may be one reason of the globular figure of the Sun, and the fixt Stars.

Hence spherical ones.

COROL. 14.

When a Body is divided into parts, without any other alteration, then its surface will be always increased, though its quantity of matter continues the same; and then it will, of consequence, constantly grow cold so much the sooner. A Cube by being divided into two equal parallelipeds, has $\frac{1}{2}$ more surface than it had before. A Sphere by being split into two Hemispheres, has its surface enlarged by the Area of two great circles, which is equal to $\frac{2}{3}$ of the surface of the Sphere: And, hence, if they were heated, and afterwards thus divided, they would lose their Heat so much the sooner. The dividing, therefore, of a hot Body into smaller parts, and the reducing it from a spherical surface to a plain one, are two causes, by which the cooling it will be chiefly promoted; for its contact with colder Bodies will, by this means, be wonderfully increased. A pint of boiling Water reduced to a spherical figure, will retain its Heat for a long time; but if it is poured upon a large cold plate of Iron it grows cold in an instant.

When they are divided they cool sooner.

COROL. 15.

Now the right consideration of these things, will help us to discover the reason of the continuance of Heat in other cases likewise. It is an old Observation, that those Bodies, that are dense, hard, strong, are used to exercise, and are filled with compact heavy Fluids, are always found to be hotter, and to be longer growing cold than others, for the solution of which, a great many very different causes have been assigned: But from what has been said, it plainly appears that such Bodies must, by the strong application of their solids to their Fluids, condense them by this compression, and of consequence, collect more Fire within them, and retain it very tenaciously when it is united with them. In the same manner it is observed, that in dead Bodies, that want this vital Warmth, the internal parts cool very leisurely. the external very quickly. The reason of this is evident from what has been laid down; nor is there any need to suppose a vestal Fire in the internal *Viscera* to account for this *Phænomenon*. On the other hand now, your lax, soft, unactive, weak Bodies can never communicate so much Heat to their watery humours; for they always suffer less attrition, are less condensed, and are relaxed into larger

The different Heat of Human Bodies.

larger surfaces ; and for this reason too, are not disposed so much as to retain the Heat when once it is generated. Hence, then, we see, what ill consequences are to be feared from both these extremes ; and what kind of Medicine, in particular, should be made use of, if we expect a happy success in the curing them. And thus the usefulness of this doctrine becomes very extensive.

COROL. 16.

Where is the
greatest
Heat in the
Human
Body?

What is the
Heat of the
Air we in-
spire?

Now I am upon this subject, I can't help making use of this doctrine of the refrigeration of Bodies to give a solution of that question, which has so much exercised the skill of the Chemists, Physicians, and Philosophers ; viz. whether the human Blood has the greatest degree of Heat in the Heart ? And if this is the case, what is the reason of it ? What dissertations do we find amongst Authors upon this subject ! and what very different opinions about it ! This affair, therefore, I will endeavour to explain in the simple manner following. In the veins the blood is coldest. This is universally agreed on, and therefore needs no demonstration : It returns from those parts that are farthest from the Heart ; and from the external parts which are coldest ; it is mixed with the new juices that are received into the Body, which are rather colder than itself ; it circulates in a weak, large, lax, unactive vessel ; and is thus discharged into the right ventricle of the Heart. For these reasons, therefore, the venal Blood of itself would be colder in no part of the Body than in this right ventricle. But as such a degree of Cold in the Heart would be prejudicial to the Human Body, and even endanger life itself ; hence, the Blood in its return through the Veins to the Heart, is rendered something warmer, by the Heat supplied by Arteries, which is communicated to the Body, and applied to the Veins. Notwithstanding this, however, the venal Blood is coldest of all in the right ventricle if compared with the arterial. But this cool Blood, now, being pressed, and driven into the narrow, elastic, strong branches of the pulmonary Artery, by the force of the right ventricle, and the vast action of respiration, must necessarily pass through the Lungs alone, in as great a quantity as it does through the whole Body, and all its parts, in the same time. Hence, therefore, the Blood would in no part of the Body, suffer so great an attrition, and of consequence acquire so much Heat as in the Lungs alone. But this degree of Heat, again, would be intolerable, and more than we could be able to support ourselves under. This, therefore, nature has secured us against by the Air we draw into the Lungs in inspiration, which is always a great deal colder than the Blood. And it appears from the Observations of the ingenious *Malpighi*, that the Blood is here distributed through a vast number of exceeding fine Arteries, which are applied all around the thin vesicles of the Lungs, and by this means is exposed to the Air under a prodigious large Surface ; but the Air is every moment renewed, and therefore always cold ; and, hence, the Blood, of itself, is cooled in no part of the Body more, in this respect, than it is in the Lungs. Is not this, now, very surprising, that in the very same part of the Body, where for some necessary uses the Blood must have the greatest degree of Heat, there again, for reasons as necessary as the former, it should require the greatest cooling ? The Blood, and recent Chyle, could not be propelled through all the vital pipes of the whole machine without endangering the animal life, if it was not first vastly divided, and reduced into its most subtil Elements by the forcible attrition of the Lungs ;

Lungs; but this could not be effected without a great production of Heat: Should this Heat, however, thus communicated to the Blood remain in it, and there should be other causes to cool it at the very same time; certainly the Blood, in a very little while, would intirely putrify, and we should die of a most pestilential disease. By accident, I observed some time ago, in that part of the Sugar houses where the Sugar loaves are dried, that the Air was so exceeding dry, and hot, that I could not stay in it a moment without danger of present suffocation. I thought, therefore, I had got a very good opportunity of examining the degrees of Heat in the Air that Animals could breath in; but though I was vastly intent upon it, the multitude of my affairs, that could not be dispensed with, necessarily called me another way. I desired, therefore, that industrious Gentleman Mr. *Fabrenheit*, whom I have so often mentioned with respect, and my very good friend and kinsman *Jodocus Provost*, to make some Experiments for me in the manner I should direct, and to let me know exactly the success. This they were so good as to comply with, and gave me the following account, upon hearing which, I am apt to think you will be of opinion with me, that there is scarce any Experiment to be met with that will help us better to understand the effects of this heat of Air upon the Bodies, Humours, and parts of Animals. Nor, perhaps, is there any other, that is of greater service in the Art of Chemistry.

The Baker, then, in one of these Sugar houses was heated till an accurate mercurial Thermometer, after it had remained in it a sufficient time, rose to 146 degrees. A Sparrow was then set down in it in a cage, at six a clock in the evening. When it had been there about a minute, it began to open its mouth, and pant with a great deal of trouble, and uneasiness, the number of respirations increasing every moment, so that in a very short time the repetition of them was vastly quick, and with such a diminution of strength, that he could sit no longer upon his perch, but leaving it went to the bottom of the cage, where, with violent struggling, and panting, he died within seven minutes. At the same time a Dog was confined in the same hot room; who, after he had been there seven minutes, by opening his mouth, lolling out his tongue, and breathing very quick gave evident proofs that this great Heat was not a little troublesome. He remained, however, at that time quiet in the wooden cage in which he was inclosed. When a quarter of an hour was near passed, he began to breath very strong, and with a great deal of noise, and made such efforts to get out of his confinement, as were quite surprizing. A little afterwards his strength failed him, his respiration began to grow slower, and slower, till at last each inspiration, and respiration continued a long time, though they were still performed with a great deal of force. These, however, grew afterwards more and more languid, so that a little before his death they could not be heard at all. During all this time, a great quantity of *Saliva* ran out of his mouth, which was perfectly reddish, and stank so intolerably, that no body present was able to bear it: And this terrible smell, thus suddenly produced in the Animal, was of so hurtful a nature, that one of the persons that was making the Experiments, upon coming near him, was in an instant fainting away, so that it was necessary to refresh him with some Spirit of Wine, and Myrrh; by which means it happened, that he could not put the Thermometer into the mouth of the Dog the very moment he died. A little

The wonderful effects
of hot Air.

afterwards, however, being recovered by the abovementioned liquor, he thrust it in, and the Mercury stood at the degree 110. In this very great Heat now, and with all these vast struggles, there did not appear upon the dog the least sign of sweat. This Dog weighed ten pounds. At the same time these Experiments were made upon the Sparrow, and Dog, a Cat, too, was shut up in a wooden cage, and placed in the same stove. When she had been there a minute, she began to lay upon the ground, and pant; and in a quarter of an hour made a hissing noise as she breathed; she then struggled prodigious hard to get out, and after she had suffered exactly in the same manner as the former, underwent at last the same fate: But she was all over as wet with sweat as if she had been taken out of a River.

We learn evidently, then, by these Experiments, that the Air when it is † 48 degrees hotter than the Blood in the mouth of a healthy child, is capable of producing the most acute disease in an instant, and soon after destroying the Animal with the most terrible symptoms. But how surprizingly must all the humours of the Body here be changed, as they gave such evident signs of a most fetid putrefaction? Certainly there is not in nature a more abominable stench than this terrible rancid one, more loathsome than that of a dead carcase, which was so soon produced, and exhaled from this Animal which was perfectly well but just before? For this, we see, purely by its contagious quality, brought a strong man, and one used to labour into imminent danger of present death. And what greater proof can we have that all the Juices were resolved, and changed from their natural disposition, then, that even the *Saliva* in so short a time was become red. But the Fire of the room did not alone effect all this; for the flesh of the dead Animal, being hung up in the same Heat, was only dried thereby, and did not dissolve into such a noisome *sanies*. But the vital motion in these creatures, whilst by its attrition it generated Heat and a Tendency to putrefaction, must of necessity have produced a prodigious degree of Heat in the Lungs; and these having nothing to help to cool them, the Heat must have grown much greater there than even in the stove itself. And, hence, the Oils, Salts, and Spirits of these Animals were reduced to putrefaction within, perhaps, 28 minutes; whilst the Bird was affected within one. And here we may observe, when these rooms are heated to such a degree, the servants, who are obliged to attend there, stay in but a very little while at a time, and then go out for some refreshment. In the same manner, in the Melting-houses, where they cut the melted iron into large plates, the Workmen can bear the excessive Heat but for a moment, and then are forced to retire into some cooler Air, where they lie down, and recover themselves, or otherwise they would instantly fall into a *Deliquium*. And whenever the Air is heated but to such a degree, as is the standard of a man in health; if a person is then placed in it, he soon perceives the excess of the Heat, which grows so troublesome, that he can't remain in it any considerable time, but strives with all his might to get into some cooler place, or otherwise would faint away. Hence, therefore, we see, that hot Air enervates the strength; cold restores it: And, indeed, except the Heat was tempered by an alternate interposition of Cold, there would soon be an end, both of Plants, and Animals.

† This must be understood in the very greatest latitude in which it is ever observed; the Heat of a child in health very rarely rising higher than the 96th degree in *Fahrenheit's* Thermometer.

From what has been said, then, we at last make this conclusion; that the Heat of the Blood in the Veins, Arteries, Heart, Lungs, and other parts of the Body, is pretty equable. In the Lungs, however, it is, in reality, both hottest, and coldest; and hence, tho' it undergoes those effects in the Lungs, which are absolutely necessary, yet by this means it is still kept of a proper temperature.

COROL. 17.

The larger any Body is, the denser the matter is of which it consists, and the more exactly spherical its figure is, the more disposed will it be to retain the Fire which it has received into it; which is every where confirmed by Experiment. If such a Body as this, therefore, should be placed in an exceeding rare Fluid, or in a perfect *Vacuum*; then, all the physical causes that are at present known to promote this preservation of Heat, would be united together.

What Bodies do contain their Heat longest.

COROL. 18.

Nevertheless, all the solid, large, spherical Bodies, that we are conversant with, tho' they are brought to the very point of fusion, if they are placed in the common Air, soon return to the temperature of the ambient Atmosphere.

Even these grow cold.

COROL. 19.

Can we then look upon the vibration of the constituent Elements of Bodies, as the whole, and only cause, that Fire continues in a Body that is heated? As was the opinion of the illustrious *Newton*. It is true, indeed, if a large Bell is struck but in one place with an elastic metal Clapper, it will continue its sonorous undulations for some seconds, and its tremulous concussions a good while after we are able to hear them, as appears by sprinkling a little Sand on it: But in other cases, this vibratory motion of elastic Bodies is commonly pretty soon over.

What does vibration do towards Heat?

EXPERIMENT XXI.

The denser Bodies are, whether fluid, or solid, the longer time they require to grow equally hot, if they are exposed to the same Fire.

Dense Bodies are longer heating.

For making this Experiment, take a brass hollow Parallelepiped, open at top, and filled with Water; upon this, let there be placed some cylindrical glass Vessels of the same size, and filled to the same height with Fluids of different specific Gravities: Then, if you make a Fire underneath, so that the Water being constantly in motion, may acquire a very equable degree of Heat, you may with the naked eye perceive the lightest, and consequently, the rarest Fluid to be expanded very soon, but the densest a great deal slower; and the same is confirmed by the application of the Thermometer. Air grows hot very quickly, then Alcohol, next very liquid *Petroleum*, then Oil of Turpentine, and then in order, pure Water, salt Water, very strong *Lixiviums*, Metals, Mercury, Gold.

COROL. I.

The matter, therefore, of Bodies, both admits, and parts with Fire, with some

some difficulty ; and hence, Body, as Body, does, in this respect, retain its temperature, nor suffers it to be changed without some resistance.

EXPERIMENT XXII.

The larger Bodies are, the longer they are, *cæteris paribus*, in growing hot with the same Fire; and the contrary. The truth of this is so well known from the most common Experiments, that it may be almost made use of as a physical Axiom.

EXPERIMENT XXIII.

What Bodies are heated with the most difficulty ?

The denser and larger Bodies are at the same time, and the more exactly spherical their figure is, the more Fire they require, and the longer they are, before they arrive at their greatest Heat. For if one pound of Iron is hammered into a thin parallelipidal Plate, and another is form'd into a Sphere, and both these are immersed into boiling Water; then, the Plate will soon receive the Heat of the Water, but the Sphere slowly: So far therefore, the Surface seems to determine the time, which a Body takes up, in admitting, and parting with Heat, and Cold.

EXPERIMENT XXIV.

No Body of itself hotter than every other.

Among all the Bodies of the universe, that have hitherto been discovered and examined, there never was yet found any one, that had spontaneously, and from its own nature, a greater degree of Heat than any other. This surprising paradox has already appeared to be true by an induction of particulars: For, as I informed you before from Experiment, all those Bodies which are esteemed the hottest, will be reduced exactly to the same degree of Heat, or Cold, if they continue a good while in Air of the same temperature. Certainly, Phosphorus itself made of Urine, is as cold as the ambient Water, whilst it is immersed in it; tho' it soon grows exceeding active, and hot, when it is exposed to the Air. In like manner the Phosphorus that is prepared from calcin'd pinguious substances, and Alum, so long as it is secur'd in its glass Vial, has no more Heat than the Glass, nor has the least effect upon it; tho' upon the admission of the Air, indeed, it takes Fire, and burns immediately. Linseed Oil, which is never harden'd into a solid Mass, but remains always fluid in the greatest natural Cold, is even at that time as cold as the coldest Ice. Nor is the choicest Alcohol then at all warmer than the purest Mercury. That wonderful Spirit of Nitre, called the fiery Spirit, which is a curious preparation of *Glauber's*, and that distilled Oil, which the Chemists draw from *Saffras*, whilst they remain quiet in close Vessels, are as cold before the mixture, as the coldest Ice; tho' when they are mixt together, they produce a most terrible Fire. The coldest Steel and Flint, by a momentaneous percussion, excite in the sharpest frosty Air, the most intense Fire that we are at present acquainted with. And this is so universally true, that of all the natural Bodies that have hitherto been examined, there has not been found one, that of itself inclines more towards Heat, than Cold, not one, that is naturally hotter than the rest. I know people are generally strongly prejudiced in favour of the contrary opinion, and think it evident, that the Bodies of Animals, at least, have a greater degree of Heat in them, than others. And this, I confess, is true, if you consider them whilst they are alive; for so long there is a perpetual

collection of Fire, and communication of Heat, by that attrition of the parts, which is necessary to the support of the animal life : But, now, if you examine a drowned Body, that was just before strong, and in perfect health, and remains still in all respects exactly the same, except wanting this vital attrition ; you will then find it exactly as cold as the Water. But you'll be apt to say, sure the contrary of this appears to be true ; for we often see, that Bodies have a great degree of Heat after they're dead. And this, Gentlemen, I acknowledge to be frequently the case. Hence, you'll probably insist, that there **are** in reality, therefore, Bodies of Animals, that are disposed to keep up, and cherish Heat in them. Nor do I deny it : But then please to consider, that when this is the case, then putrefaction is actually begun, by which there is excited a constant, and pretty violent motion too, which by its attrition, and friction, is capable of communicating new Fire to the Body, which did not naturally belong to it. Take for instance, a quantity of cold Hay, press it hard down in a large heap, and then moisten it quite through with Water, and it will by this means grow very hot, and sometimes burst out into Flames. Fermentation, putrefaction, effervescence, and the mixture of Bodies together, will certainly very often produce the greatest degrees of Heat, as I shall hereafter expressly demonstrate, nor ever deny'd ; but then these motions are never observ'd to happen in one single simple Body alone, and therefore are never spontaneous, or belong properly to any Body in particular. Any other objection of this kind that may be raised against what we have asserted, you yourselves will easily be able to answer.

COROL. 1.

Does therefore a dense Body receive more of the substance of Fire into it, as it grows by degrees hotter and hotter ? Is this greater comparative quantity of Fire, owing to the greater degree of Fire that the Body is exposed to ? And is the continued application of this Fire likewise another reason, that a Body thus heated has a greater quantity of Fire communicated to it ?

COROL. 2.

Is Fire itself, that is so long insinuating itself into a Body, and enters into it in so great a quantity, the true physical cause of the long retention of the Fire in the Body when it is once heated ?

COROL. 3.

Or rather, is not this effected, by the heated corporeal Mass, and the Fire communicated to it, both their powers conspiring, and being united together ?

SCHOLIUM.

Thus far, Gentlemen, I have endeavoured by a few simple Experiments, to lay before you those evident truths that I have been able to discover, concerning the nature of that Fire, which Philosophers call elementary Fire. And this we have considered : First, as it is a created Being, existing separately, and without every other Body whatever ; then, as it resides in Bodies, and remains there pure and simple, nor receives any *Pabulum* from them, being determined in parallel or converging Rays ; and lastly, as the same is collected

Conclusion
of the doc-
trine of ele-
mentary
Fire.

in

in Bodies, purely by motion and attrition. And I have taken a great deal of pains to give you a right notion of this Fire, before I proceed to examine into that, which is supported by combustible matter, which is supposed to be of quite another nature from the former, and differs very much from it in its effects: For the not carefully distinguishing betwixt these two kind of Beings, which by universal consent are called Fire, has given rise to a great many errors in the chemical Art. Let us now, therefore, set about the examination of common Fire, which by many people is looked upon as the only real Fire. Give me leave, however, before I proceed, to give you a short account of some observations that may be understood from the doctrine that has been already laid down, and which properly belong to the History of Fire; that so both this History may be as compleat as possible, and every person may have the honour of his proper discoveries.

The Discoveries of other Authors.

An iron Rod a foot long, made red hot, gained $\frac{1}{60}$ of its length. A glass Cylinder, a span long, made red hot, gained $\frac{1}{36}$. *Sturm. Coll.* part II. p. 101. A metal Ring made red hot, had its diameter increased by $\frac{1}{100}$. *Sagg. di Nat. Sper.* p. 182. A glass Globe was distended in its capacity $\frac{1}{1000}$, purely by the Heat of the hand. *Des Amontons, Mem. de l'Ac. Roy.* 1704. p. 12. 1705. p. 4. If a Thermometer is immerg'd into a warmer liquor than itself, it first descends, and afterwards ascends; if into a colder, it first ascends, then descends: *Sagg. di Nat. Sper.* p. 178. *ad* 181. And this is proved by a great many arguments to depend in the first case upon the expansion, and in the second upon the contraction of the Glass, before the included fluid can be equally affected, *ibid.* In warming of Liquors, the Heat is supposed not to expand them equably, but by alternate impulses. *Halley. Phil. Transf. Abr. T. II.* p. 34. Mercury being put in a glass Vial, and then immerg'd in cold Water, which was afterwards heated by degrees, till it began to boil, ascended very equably; but when the Water boiled, tho' the Fire was increased, it could not be dilated any farther, but remain'd at the same point. Hence, therefore, Thermometers made with Mercury, will be most accurate. *Id. ibid.* And these following observations I choose here to subjoin, as matters that deserve consideration: Since one very often corrects another. If two metal Rods are of the same weight when they are cold; then, if you make one of them hot, and hang it to a balance, it will be lighter than the cold one; but if you place a live Coal under the cold one, the *equilibrium* will be again restored. If two metal Rods are exactly in *equilibrio*, then by holding a hot Coal over either of them it will grow lighter, and on the contrary will preponderate if you hold it underneath. *Sagg. di Nat. Sper.* p. 256.

Of the Pabulum of Fire.

Fire in Bodies in a twofold manner.

Since, then, it appears almost certain, that the very same Fire does always exist, in the same quantity; and without alteration; and farther, that when it is collected in some sort of Bodies, such for instance, as Gold or Silver, it will continue in them a considerable time, without any perceptible destruction of them; we come now in the next place to examine those Bodies to which Fire may be likewise communicated, and in which it may be preserved too a pretty while, but then, under this circumstance, that at the same time that the Fire is thus detained in them, nay, and sometimes increased, the very Bodies themselves

selves are so far consumed in this action, that they almost disappear from our senses. For when Fire is once collected in Bodies in this manner, it generally remains in them, and persists in its activity, till it has dissipated those parts of them, by which it was continually supported: But as soon as ever these parts are dispersed by the power of it, then the Fire likewise disappears too, exerting itself but very little longer upon those that are left behind.

Since therefore the Fire itself, and the Body in which it was collected vanish from our senses both together, hence people have universally called those Bodies, or those particular parts of them, the Aliment, or *Pabulum* of Fire: And thus far it may be allow'd, without any inconvenience. But when they pretend to call them so in too strict a sense, because they look upon them as the nutriment of real Fire, and imagine them to be changed by the Fire into the very substance of elementary Fire, and thus to have their own proper nature destroy'd, and to put on that of Fire; then, they propose something vastly different, which ought very well to be considered before it's admitted for true; for tho' the assertion of it is very easy, yet the demonstration of it is exceeding difficult: And certainly, whoever overhastily runs into this opinion, must necessarily suppose, that those Bodies which nourish, and support Fire, in the manner we have mentioned, are by this means constantly diminishing: And hence the quantity of all other Bodies in the universe must be continually lessened, whilst that of elementary Fire must be in proportion increased. Of consequence, therefore, Fire being thus perpetually augmented, and at the same time diminishing every thing else, would necessarily have destroyed all other Bodies long enough ago, and remained superiour, and alone in the Universe. In the mean time, however, if we examine the observations that have been made from the most ancient times, quite down to our own, we shan't find the least indication of any such increase. But on the contrary, the power, and consequently, the quantity of Fire is observed to continue the same, nor seems by any means to suffer any considerable augmentation or diminution. An Example, or rather Proof of this, are those very accurate Meteorological Tables, so nicely contrived, and so carefully perfected many years ago for public service, by that excellent Geometrician *Nicolaus Cruquius*, in which you may see what an extraordinary *equilibrium* of Heat is maintained. Nor is it a little to our purpose, that after burning of Woods, which has been continued sometimes for whole months together, there has never appeared the least sign of any increase of Heat remaining after it was over. Can you believe, Gentlemen, that after almost six thousand years, as in this time all the combustible matter of the whole inhabited Earth, where Fires are in use, must necessarily have been so many times consumed; I say, can you believe, that after all this long and constant augmentation of Fire, the Heat should not yet be grown intolerable to tender Plants, and Animals? In every part of the world at least, the Heat has always continued the same: For the very same warmth of the Air is always requisite, that the tender *Embryo's* of Plants, whilst they lie inclosed in their Seeds, and are nourish'd, fill'd, and distended with a kindly moisture, may expand their very fine, and feeble *Stamina*; for if the Heat increases beyond the bounds they are able to bear, it soon burns up the almost fluid Machine in its original state; nor does it less certainly perish if the Heat grows too languid: Why should I make mention of Animals? The animalcles of the

Why some Bodies are called the *Pabulum* of Fire.

Does this *Pabulum* become Fire itself?

This scarcely
credible.

Male Seed, when they have insinuated themselves into the Eggs of the Female, require such an exact temperature, that the 100th degree of Heat in *Fahrenheit's* Thermometer will burn them to death, and in the 70th, by reason of the Cold, they will hardly ever be brought to maturity: Nay, the very impregnated Eggs of Insects, that are able to bear the sharpest winter Frosts, are most certainly destroyed, if they are exposed to a degree of Heat that's a little too intense. In short, therefore, examine Nature in her whole extent, and you'll evidently find, that the quantity of Fire in the Universe, always continues the same: For it's certain, after so many terrible conflagrations occasion'd by Meteors; after such prodigious eruptions of burning Mountains; after such infinite numbers of culinary, furnace, and workhouse Fires; and, after all, the devastations that have happened since the invention of Fire-Arms: I say, after all these extraordinary methods of producing Fire, there does not appear to be the least quantity more at present, than there was in former ages. And I'll almost venture to promise, that our following examination of the *Pabulum* of Fire, will make it appear beyond contradiction, that the case is here very different from what people generally imagine. Let us therefore set about this very useful, and agreeable inquiry; and in the first place let us consider combustible matter as we find it, in the Vegetable, Animal, and Fossil Kingdoms. Now here we shall come at its Nature more readily, if we first examine it in the class of Vegetables; for 'tis by these that Animals are nourished and supported; and these may more easily be examined, and understood, than Fossils.

The *Pabu-*
lum of Fire
in Vegeta-
bles.

All Vegetables that we are hitherto acquainted with may be burnt with Fire, and will feed the Fire whilst they are burning; the Larch-tree itself not excepted. But as these now may be exposed to Fire, either crude, whilst they are yet perfectly alive and full of green juices, or when they are dead, and dry; hence they ought to be considered in both these circumstances: And as a right knowledge of the green ones, will help us more easily to conceive of the dry ones, for this reason, a proper regard to method leads us to examine what it is, that is properly combustible in Vegetables whilst they are alive.

An exami-
nation into
that part
of those that
feed Fire.

All crude Vegetables, therefore, of what kind soever, contain in them, Water; Spirits, as they are called, or invisible exhaling Corpuscles, which are generally odorous, and for the most part reside in this Water, and are dispersed into the Air as soon as ever separated from it; an acid volatile Salt, which almost always appears in a liquid form; a volatile alkaline Salt; a light volatile Oil, which has generally the peculiar scent of the Plant; a more fixed, heavy Oil; a black Coal, which tho' it is forced with a strong, and long continued Fire, in a close vessel, yet continues fix'd, and black; white Ashes, which are the remains of this black Coal, when it has been burnt in an open Fire; a fix'd alkaline Salt, which is contained in these Ashes, and may be procured from them, by making a *Lixivium* with them; and lastly, another part of these Ashes which remains after this Salt, is separated, and is called pure Earth. This, Gentlemen, is an exact account of those parts that have been discovered in combustible Vegetables. In these, therefore, as they are changed by the various actions of the Fire, we must examine what part it is, that is in reality inflammable, or combustible.

If crude Vegetables then, containing all the parts abovementioned, are com-
mitted

mitted to a brisk Fire, whilst their Moisture is yet in them, the first thing they yield is a Smoke, or vapour, which ascends in the appearance of a Cloud, and may be collected in form of Water, either acid, or alkaline, according to the nature of the Plant, the proper scent of which, in some measure, it almost always carries along with it. This Vapour is light, thin, and almost pellucid.

A particular account of what happens; First, in a green Plant.

After Vegetables have been deprived of this first part by the Fire, and, hence, begin to grow dry, then another kind of Smoke begins to arise, which is generally black, thicker, acrid, opaque, dense, and fetid; which every moment grows thicker, and denser, till at length it becomes of a pitchy blackness, and is rolled up, and whirled pretty strongly about the Vegetable.

Not long after this there bursts out a brisk, lucid, crackling Flame, and succeeds this thick Smoke; for this ceases when the Flame appears, and there always remains so much the less of it, as the Flame burns more clearly: But if you extinguish this Flame, then this dense black Smoke soon appears again. If this liquid, volatile Smoke now, is caught upon any Body, and by that means condensed; then wherever it fixes, it will form a very black, pinguious, and tenacious Pigment, which is bitter, and fetid, and goes by the name of Soot.

Vegetables being in this manner consumed by Fire, into Smoke, Flame, and Soot, there remains another part at the bottom, which may be made red hot indeed, in the same manner as Metals, but is absolutely unfit to feed, and support Fire; and this is called, Ashes. These now are found to be different according to the different nature of the Vegetables that were burnt: For if the Smoke they emit when they are exposed to the Fire, is of a very volatile, acrid, saline, and alkaline nature, then the Ashes that are left are for the generality insipid; as appears, in Garlic, Onions, Scurvy-grass, Rocketts, Hedge-mustard, Cresses, Leeks, Water-mint, Mustard, Mithridate-mustard, and the like acrid antiscorbutic Plants, which when they are burnt yield scarcely any fixt Salt. On the other hand if the Plants are succulent, and acid, and their fumes are so likewise, there then remains a great deal of Salt in their Ashes; as we find in the green branches of almost all Trees, which if they are large when they are laid on the Fire, there distils from their ends, an acid Water in great quantity. And lastly, if the Vegetables are of the austere-acid, or the aromatic-bitter kind, then the Ashes of these too yields a Salt in great abundance.

If Vegetables are moderately dry, and their Water is exhaled when they are exposed to the Fire, but yet are not too old; in this case the very same things happen as in the former, and in the same order, but there will be a much smaller quantity of the first watery Vapour.

In a dry one.

If the Vegetables are worm-eaten, fungous, light, very dry, and very old; then if they are laid on the Fire, they will hardly burn with such an open Flame but will grow red hot, shine, continue lucid some time, and then moulder into Ashes, in which there will be hardly any Salt at all; nor will they scarcely yield any Smoke, or Soot.

In a very dry one.

Since, therefore, these things that we have mentioned hold true in every kind of Vegetable that is burnt, we may hence upon inquiry be able to discover, which of all these parts it is that is in reality properly combustible.

First then, let us examine the Water which constitutes a considerable part of every kind of Vegetable. And this we find is capable of admitting, and

retaining

An examination of the particulars here. First, of the Water,

retaining for some time any quantity of Fire, not exceeding 212 degrees or a little more, but then, the Elements of the Water have received such a disposition from the Fire, that no more can be disposed, and confined in it. Hence, therefore, it is not possible by any known Art whatever so to impregnate Water with Fire, as to make it put on the brightness of a red hot Body, and thus to become perfectly lucid. Nay if Water, whether hot, or cold, is thrown in large quantity upon a burning flame, or any kind of matter that is on Fire, it will immediately reduce that violent Fire to 212 degrees, and by this means stops every kind of Fire, takes away the redness from Bodies that are heated, and extinguishes flame. Nay, if by the action of Fire, Water is resolved into Vapours, that are very active, and expand themselves every way with a great deal of force, yet even then, when it is reduced into this form, it has the very same effects with respect to Fire. This is evident; for if you hold a live-coal, or lighted Torch in the densest steam of boiling Water, it will be perfectly extinguished as if you threw Water upon it. And our chemical distillations likewise demonstrate, that Water, exert what force of Fire you will upon it, will always retain every character of pure Water. In the mean time, however, I cannot deny but that there are a great many effects produced by the Water in the burning of Vegetables, that would not otherwise happen: For if you fling Water upon Oil, whilst it is boiling hot upon the Fire, there will arise a new action betwixt the Fire, Water, and Oil, very different from what would have happened had not this been done. Suppose a pound of Oil, for instance, actually boiling, and on flame in a copper vessel, the Fire then in this Oil will have 600 degrees of Heat; but it will keep within bounds so long as it is moved equably through the Oil, and disposes it into a bright flame: Let now an ounce of Water be thrown at once into this Oil, whilst it is thus boiling, and flaming, and there will be immediately produced a rumbling, crakling noise, the mixture will fly about in a surprizing manner, and the motion of the whole will grow perfectly unequal: For the Water as it falls by its own weight through the Pores of the boiling Oil, meets every where with a degree of Heat three times greater than that of the hottest Water, whence the Elements of the Water being expanded with a prodigious force, and agitated with an exceeding swiftness, they put the more tenacious particles of the Oil into motion, dissipate them, and carry them with them into the Air. If whilst Bodies are burning, therefore, any Oil, and Water happen to meet in them, the Fire that is excited will be very different from what it would be otherwise: And this your Smiths are well acquainted with, who when they have a mind to blow up a very brisk Fire generally sprinkle a little Water upon their Coals. But there is another circumstance too in this affair that ought to be taken notice of, and that is, that Water is capable of receiving a greater quantity of Fire when it is compressed by a greater weight of the Atmosphere: And indeed this augmentation is so considerable, that for every increase of this weight there is a sensible addition of a degree of Heat. Hence, therefore, should it ever be so confined within Bodies on fire, as to be compressed with a double Atmosphere, what a terrible explosive force would it hereby acquire? And from this consideration I have often thought, and not without astonishment, how vastly the quantity of Fire that may be communicated to Water, would be increased, should the

Water

Water be placed in the Center of the Earth. For Air at the depth of 409640 fathoms from the surface of the Earth would be as heavy as Gold, according to *Mariotte's* Calculation, if the law he supposes always holds good: With what force then must Water be compressed in the same place? And of consequence how much more Fire would it be there capable of receiving? Would not Water, if it was made to boil strongly there, shine as much as Metals that are made ever so hot? Certainly this appears more than probable. Compare *Hist. de l'Acad. Roy. des Sc.* 1703. 6. and *Mem.* p. 101. But again, there is yet another power of Water, when in the Fire, that is very particular and surprizing. If you melt, for instance, a fixed alkaline Salt with a strong Fire in a Crucible till it runs like Water, and then instantly pour it out into an iron or copper mortar, if there is ever so little Water at the bottom of the vessel, it will be so agitated in a moment by this excessive Heat, as to be able to make the Salt fly about with an incredible *impetus*; as the Chemists have often experienced to their great loss, and danger. But the effect of Water with respect to Fire is never more violent, or terrible, than when it happens to meet with melted Brass: For if whilst this Metal is in fusion in the large melting Furnaces, a little Water unfortunately falls among it, there arises immediately a terrible noise with so violent an explosion, that the strongest Furnaces are instantly tore to pieces. If a few grains of melted Brass are thrown into Water, the force thus produced likewise is so prodigious, that it will burst the strongest vessel asunder, and reduce it to powder in an instant. *Hist. de l'Acad. Roy. des Sc.* 1699, p. 110. Hence, therefore, it appears, what are the effects of that Water which naturally resides in combustible Vegetables, with regard to the Fire that is burning them, if you consider it separately as Water; and how much it is capable of increasing the force of Fire, if it happens to meet with Oils, Salts, or Metals: So that the same Body, that is looked upon as peculiarly proper to extinguish Fire, we see, may under some particular circumstances, be the greatest instrument of rendering its power more intense.

The Spirits, then, as they are called, of Vegetables, come next under consideration, and that, as they naturally swim in this Water, and float about with it, before the Vegetables have undergone any degree of fermentation. And these, though you take ever so much pains to separate them from the Water, and collect them pure together, are never found to contain any thing in them that will feed, and support flame, or Fire. On the contrary, let them be depurated ever so nicely if you throw them upon the Fire, they will soon put it out, in case they have no mixture of Oil in them. The very fragrant Water that exhales from green Rosemary when it is chemically managed, has nothing in it inflammable. Nay, if with a very gentle Fire you separate the most fragrant part of this again in a close vessel, neither was this ever found to yield a proper *Pabulum* for Fire, but on the contrary it extinguishes it when it is burning.

Secondly, of
the native
Spirits.

The third sort of Bodies, that enter into the composition of Vegetables, are what the Chemists call acid Salts, which exhale too with the scented Water, and Spirits abovementioned. These volatile Salts, now, have long ago been discovered to be very often exceedingly acid, as the smoke that arises from acid Wood when it is burnt demonstrates, as well as the acid Soot that is sometimes

Thirdly, of
the acid vo-
latile Salts.

sometimes produced by it. Nay, the Spirits that arise in the distillation of the very heavy Woods, such as Box, Juniper, *Guaiaicum*, Oak, and the like, are found to be as acid as Vinegar itself. Thus if you take shavings of *Guaiaicum*, and distill them with a moderate Fire in a very clean vessel, you will have a liquor, that by every characteristic discovers itself to be very acid. If you then carefully separate it from all the Oil that is mixed with it, which may be easily done, by filtration, and gentle distillation, you will by this means have your Acid perfectly pure, limpid as Water, and even then considerably volatile: And yet, when it is by this management rendered as pure as possible, if you throw it upon flame, or Fire, it is so far from supplying them with fuel, that it will soon extinguish them. Nay, and that pure acid, vegetable Spirit, that is procured by Fire from the native Balsams of Vegetables, is perfectly of the same nature. If with an exact Fire you distill some pounds of fine Turpentine, in a very clean vessel, you may draw from this oily, pinguious Balsam, a liquor of a perfect acid taste, that may be intimately mixt with Water, and is perhaps the noblest diuretic we are acquainted with; and yet this, which possibly you would not imagine, will extinguish Fire in the same manner as common Water does. We evidently see, therefore, from these Experiments, that the volatile, acid Salt that rises from Vegetables when they are burnt, is not a proper fuel for flame, or Fire, but on the contrary put them out. But here, perhaps, you will be ready to say, don't we see plainly, however, that Sulphur will burn? Certainly it will. But, you'll go on, Sulphur is compounded of a fossil Acid of Vitriol, Alum, or the Pyrites, united with a vegetable, or fossil Oil. And this is generally true. Hence, then, you'll be apt to infer, that the latent Acid of the Sulphur is a proper *Pabulum* for Fire. But, Gentlemen, if we will but look into this affair with proper care we shall find that it is the Oil only that in this case feeds, and supports the Fire; for the Acid does not remain in the flame, but is dissipated in fumes, which being afterwards collected, compose that liquor which goes by the name of the *Oleum*, or *Spiritus Sulphuris per Campanam*, and is the true original Acid of the Sulphur without any alteration.

Fourthly,
of the volatile Alkali.

But again, if we examine the volatile, alkaline Salts, that exhale from most kind of Vegetables whilst they are burning, and are found to be contained in their Soot; or that are procured from some of them purely by distillation, as we see in Garlic, Onions, Scurvey-Grass, Rockets, Cresses, Leeks, Horseradish, Mustard, Mithridate-mustard, and others: I say these Salts, if they are carefully separated from the Water, Spirits, and acid Salt beforementioned, are never observed to burn, or flame in the Fire, but either fly off immediately, or diminish its power. And lastly, even that volatile alkaline Salt, that is artificially produced from putrified Vegetables, which is in larger quantity, and more acrid than the former, appears by no effect whatever to be a proper *Pabulum* of Fire. Give me leave, however, here to give you this caution, that what I assert of these Salts, must be understood of them, when they are reduced to their greatest purity, so that there is not the least Oil adhering to them. For in the distillation of Vegetables, as well as in the burning of them, when the saline, alkaline, volatile part rises, it carries up with it a considerable quantity of a fetid, volatile Oil, which it pretty intimately unites with itself, so that a person may easily be deceived if he makes this Experiment with

with the Salt, whilst this Oil remains mixed with it; for then if it's exposed to the Fire it will really burn. But as soon as ever this Salt is perfectly freed from its Oil by the methods which we shall hereafter explain, and is by this means rendered quite pure, then its inflammable power is intirely taken away.

The fifth part that enters into the composition of Vegetables, is the Oil that's procured from them by distilling them with boiling Water in a close Alembic; and this is called their essential Oil, and is the most volatile of all the Oils that are drawn from them, as well as the most pure, not having so great a mixture of heterogeneous parts with it, as the rest have. If this Oil, when it is well separated from all the other parts, is set upon the Fire, in a clean vessel, and suffered there to grow hot, and boil, and then a Flame is apply'd to it, it will take fire, flame, burn away, emit a little Smoke, consume and leave behind it a few *Fæces*, that are of the nature of Coal, black, spongy, brittle, and earthy. If this very Oil now, which is generally reckoned so pure, undergoes a second distillation in boiling Water, it then becomes a great deal purer, thinner, and lighter than it was before, and leaves behind it a good deal of new *Fæces*, that will not rise in this second operation: And if you then take this Oil thus rectify'd, as the Artists call it, and expose it to the Fire in the very same manner as you did the former, it will take fire, yield less smoke whilst it is burning, and the quantity of the *Fæces* that are left behind, will be a great deal less than before. And as for those that remain in the Water after this second distillation, they are nothing near so combustible as this rectify'd Oil. Hence, therefore, it appears, that the inflammable matter is by this means diminished, but at the same time, that part of it which remains, becomes much more disposed to feed and support Fire. If the purification now of this Oil by distilling it in boiling Water, is frequently repeated, then at last, a large quantity of this Oil, that was at first look'd upon as inflammable, will appear to be of an earthy Nature, that will not so easily burn in the Fire: In the mean time, however, the Oil that rises in distillation, and is separated from the new *Fæces*, grows every time lighter, finer, and more limpid, burns away with a clear Flame, generates less Smoke, and leaves behind it less *Fæces*, than it did in any preceding operation. And this may be prosecuted so long, till this Oil becomes so vastly subtil, that it will at last almost consume without any Smoke or *Fæces* at all. But again, if you take this distill'd Oil after it has by this means been rendered totally inflammable, and put it fresh into a clean glass Retort, and with a gentle Fire gradually increased, carefully distill it again, and repeat this frequently as before; then, as the famous Boyle has taught us, the greatest part of this Oil will be changed into earthy *Fæces*, that are left at the bottom, and are not very combustible; but the Oil that still remains, becomes every distillation, purer, and more inflammable, so that it burns away in form of Flame, without any considerable Smoke or *Fæces*. If then all the *Fæces* that are left behind after every distillation are collected together, and torrify'd, and made red in an open pure vessel, they'll emit Sparks, and Smoke, and sometimes Flame, and at last will moulder away into Ashes that are absolutely incombustible. These Experiments now, Gentlemen, I beg you will consider very carefully: For hence we may already discover, how small a portion of this Oil, when purest of all, truly burns away in Flame, without

Fifthly, of
the Oil.

Smoke

Smoke or *Fæces*, that is, is totally and perfectly combustible. And this will be of singular service in helping us to an accurate knowledge of the nature of Fire, considered as it acts upon this its *Pabulum*, and as it is likewise affected by it. This then being rightly understood, please to give your attention to an Experiment of another kind. Observe this live Coal, which as you see, is very full of Fire: I'll put this now into this copper Vessel, and pour upon it this cold ætherial Oil of Turpentine, which of all Oils is esteem'd the most inflammable; and you see, contrary 'tis probable to your expectation, that this red Coal is as soon extinguished with a Smoke and Hiss, as if it had been immersed in Water. So that hence it appears, that Oil is not so soon lighted by a live Fire as people generally imagine; but in order to this, there are some particular circumstances requisite in the application of them to one another. It is very likely you may imagine, that Flame is necessary to set it on Fire. To try then, whether this is the case or no, I have disposed a Candle as you see in this vessel, in such a manner, that the extremity of the Flame is below the brim; and hence, if the vessel is fill'd with Oil, the Flame will be below the surface; I'll pour in now the same pure distill'd Oil of Turpentine till the Flame is cover'd, and you see it is perfectly extinguish'd, nor does the Oil take Fire. But again, I have heated some of the same Oil in another vessel, till it smokes and is ready to boil, into which you shall see me throw this little glowing Coal: Don't you all now certainly expect that I shall set it on fire? Nothing less; but it sinks as you perceive with a noise, and goes out. And lastly, I'll invert this burning Candle, and thrust it into the same almost boiling Oil; and here again you see that it is perfectly extinguish'd without lighting the Oil, or being lighted by it, contrary to what one would imagine. But those vegetable Oils remain still to be examined that are drawn from them by distillation, without the addition of Water, which have a fetid empyreumatical scent, are opaque, and of a thicker consistence. These now, if they are managed in the same manner as the distill'd Oils abovementioned, exhibit exactly the very same *Phænomena*. At first they are inflammable, burn away, emit a great quantity of black Smoke, and leave behind them a great deal of *Fæces*; but afterwards, by repeated distillations, they become purer, lighter, more limpid, more inflammable, yield less Smoke, and leave fewer *Fæces*, and every operation are depurated more and more, and grow more combustible. And when by this means they are rendered like the essential Oils, they are perfectly affected by Fire in the same manner. Since then all these things are constantly observ'd to hold true in every vegetable Oil, existing in what condition soever; whether it is naturally concreted in some parts, or naturally secreted in others, as Gums, Balsams, Resin, and Pitch; or procured by distilling the Vegetables; or lastly, by burning them: I say, since what we have said holds good of them all, we may hence form a true notion of the matter that is chiefly combustible, and hence be able to draw a great many inferences that are absolutely necessary to a just History of Fire; and which indeed, if we are not first well acquainted with, we shall certainly run into a great many errors, if we pretend to explain either the nature of Fire, or combustible Matter. If we rightly understand now, what has been laid down concerning that part of Vegetables, which alone, is really burnt when they are set on fire, *viz.* their Oil, or as it is call'd, their Sulphur, we shall then be able hereafter to proceed more

more readily in the rest: This therefore I recommend to your careful consideration, as it will be of service to us in our future inquiries.

If any kind of Vegetables are burnt in the Fire to such a degree, as to be glowing red quite through, but are not yet reduced to Ashes, then, if they are on a sudden suffocated in close Air, extinguished with Water, or buried deep under Ashes, or any other Bodies that exactly cover them, they lose their Fire, and are changed into a Body that is perfectly black, after you have shook off the Ashes that may possibly lie upon their outward Surface; and the Body thus prepared is called a Coal. Again, if you take any sort of Vegetable whatever, put it into a metal, earthen, or glass Receiver, and with a violent and long continued Fire, urge it so long till scarce any thing more will come over into the Receiver; then, if the vessels were so perfectly closed that not the least Air could find admittance, there will remain at the bottom of the Retort, a Vegetable substance intirely black, which is likewise a true Coal, exactly of the same nature with the former. Now either of these, if it is laid upon the Fire when it is thoroughly dry, very readily takes fire, retains it strongly when it's once kindled, burns as long as any blackness remains in it, and thus almost totally consumes without any Smoke: during all this time, however, it emits an exhalation, which if received into a close place, quickly, and insensibly, proves fatal to every kind of Animal; nor does it at all signify, whether the Coal is prepared from Plants, Woods, or bituminous Turfs. When every thing then, that was black in the Coal is thus consumed by the Fire, what remains is a whitish Powder, which goes by the name of Ashes, and which it is impossible to excite into a Flame by the application of any degree of Fire whatsoever: The most you can do with them, is uniting Fire with them in the same manner, as you may with Metals, Stones, and the like, which we gave an account of before in our History of Bodies, that are capable of retaining Fire without being consumed. In this affair now, it is particularly remarkable, that the Coal then only grows unfit to feed the Fire, when it changes its black Colour for this cineritious one, it constantly affording a *Pabulum*, so long as the former remains. This we see evidently in that common, yet elegant Experiment made with that exceeding fine vegetable Coal, Paper, when burnt to a blackness: For if a Spark falls upon such a black Paper, it soon begins to run up and down in form of a fiery Spark, and leaving those places that are whitish, and will no longer burn, it perpetually shifts about to those that are black, which it in like manner consumes, and then quits for the next black Spot, till at last by this means, all the blackness being perfectly destroyed, there remains the form of a very thin Paper, consisting purely of white Ashes, which in some measure still cohere together. A vegetable Coal, therefore, is that part of Vegetables, from which the Fire has expell'd the Water, Spirits, volatile Salts, and some of the lighter Oil that is not so closely united with the other parts; and in which there still remains an Earth, and fix'd Salt, whose increased Surfaces the Fire has covered over with a rarified attenuated Oil, which by burning has acquired a black Colour: For all that appears black in the Coal is purely Oil, which being put into a rapid motion, and greatly expanded by the action of the Fire, was in some measure extricated from those parts that were not inflammable, tho' not perfectly freed from them, and hence being nearest to the Flame, and attracted towards the Surface, upon this sudden extinction, it remained apply'd

to the exterior *Superfices* of those little cells, in which the Water, Spirits, and volatile Salts resided before the Coal was thus prepared. From what has been observed then, we may at last conclude, that the combustibility of Coal, consists intirely in the Oil that remains united with it, the other parts being by no means capable of flaming or burning so as to be consumed by the Fire that is received into them, as those Bodies are, which are a proper fuel for Fire.

Seventhly,
of the Ashes.

But not to omit any thing this is requisite to make this History fair and compleat, let us yet farther examine these very Ashes that remain, after Vegetables are thoroughly burnt. These now, if they are produced from pure Vegetables, will be almost always of a pretty white colour, and a salt taste, a few as I hinted before excepted: If you boil these Ashes in Water in a clean vessel, the *Lixivium* will have an acrid, alkaline, fiery, urinous taste. If you, then, pour off the Water that is thus impregnated, and add more fresh Water to the remaining Ashes, boil this again as before, then pour off this, and put on more, and repeat this operation, till at last the Water that is thus boiled with the Ashes comes off as insipid as it was poured on; then, if you mix all these *Lixiviums* together, and evaporate them to a dryness, you will always have at the bottom of the vessel an acrid, alkaline, fiery, fix'd Salt: This now will grow perfectly red hot in a strong Fire, and retain a lucid Fire in it for some time, but will never support Fire, excite Flame, or be itself consumed by them as a proper *Pabulum*. Fix'd alkaline Salts therefore are incombustible; as Stones, &c.

The Salt of
which is not
a proper *Pa-*
bulum of
Fire;

Nor their
Earth.

Eighthly,
of the
Smoke.

But let us now look back to that part of the Ashes, which after the separation of all the Salt, remains at the bottom of the Water; and this, if it is carefully dry'd, and kept perfectly by itself, is found to be a light white Earth, vastly simple, and exceedingly immutable by the action of the Fire: This evidently appears in the Cupels, which are made of these Ashes, with the addition only of Water; for these, when they are exposed for a long time, to a very intense Heat, grow red hot as other incombustible Solids do, but the Earth itself will never burn, flame, or supply the Fire with a proper *Pabulum*.

Thus, then, we begin by degrees to discover what parts of Vegetables it really is, that properly feeds, and supports Flame, and Fire, and which must necessarily remain in the Fire so long as it continues to flame, or burn. But farther, whilst Vegetables are thus on fire, there constantly rises from them a dense Smoke, which at first is watery and thin, grows thicker and thicker every moment, at last grows very black and dense, and then is blackest and densest of all, when the Flame is just appearing, which generally soon breaks forth with a crackling noise; and as soon as ever the Flame appears, the Smoke immediately diminishes, and so much the more, as the Flame is more vivid; so that when it is brightest of all, the Smoke seems quite to cease rising, tho' even then, indeed, we are sure that there is actually Smoke. Hence, therefore, it seems probable, that Smoke is a confused mixture of different parts of the vegetable *Pabulum* of Fire, which are put into a violent motion by the action of the Fire, are carried upwards, and agitated among one another, but not thoroughly set on fire: If this action, however, is continued, and increased, and these Particles are urg'd with a stronger Fire, they then grow red hot in the Air, the Smoke is converted into Flame, and the Particles of the Smoke being now grown bright, and at the same time vastly attenuated, appear purely igneous.

And

And hence, likewise, it is evident, why a vivid Flame, when it encompasses the whole burning matter, seems to consume all the inferior Particles that are agitated by the Fire, in the form of Flame, without any Smoke; for it is certain, that except the watery part, Smoke may be totally changed into Flame. This, indeed, has long ago appeared to be true, by that elegant Experiment of the *Focus Acipnos*; in which, one may evidently see, that the black Smoke which rises from burning Vegetables, is in reality a Coal, which is combustible in a strong Fire, or great Flame: For when it is exposed to either, it is reduced to mere Ashes, or its matter is so far attenuated, that it escapes our senses, and is dissipated into the Air.

The Inventor of this Instrument was that ingenious Artist *Dalesmius*, who contrived it in the Year 1686 at *Paris*, as we have an account in the 116th Page of the *Journal des Scavans*, published that year. The famous *Justeleus* afterwards first published a Cut of it in the *Philos. Transf.* almost at the same time, which is as follows. ABCD is a hollow Cylinder made of Plates of Iron, open at both ends, within whose inferior Base BD, there is fitted the Grate BD. This Cylinder, which is the Fire-place of the Instrument, is joined to the cylindric Tube EFG, in such a manner, that there is a communication between their Cavities. And this Tube EFG, which is of the same capacity with ABCD, made of the same Metal, and in the same manner, is open at G, and close at E. If then the Tube EFG is made very hot, and some live Coals are laid on the Grate BD, and over them some combustible matter, then the Flame that is produced, will descend into the Tube EF, and pass through FG, and all the Heat will go out at G; and the Smoke likewise that is generated following the same course through the Tube EFG, will be forced to pass through the Flame that fills the whole Tube; and hence, being acted upon by the Fire in all this passage, it will lose the thickness and disposition of Smoke, will be converted into Flame, and in this form passing out of the Aperture G, will disappear, without any visible Smoke, or Soot. The famous *De la Hire* has added some Notes upon this Machine in the place in the Journal above cited. In order now to give you an ocular demonstration of the same thing, I have provided this Instrument which is made of Plates of malleable Iron. ABCDEF, is a hollow vessel consisting of five equal iron Plates well soldered together, and open only at the top ABCD. At the height EI within this vessel there is a Grate IKLM. In the side DF, there is an elliptic Hole NO, of the breadth MK, and height EI, to which is joined the Tube OGH, open at ON, and H, and every where of the same capacity. Please now to observe the effects of this Machine. On the Grate IK, I lay some live Coals, that the vessel may grow hot; and that the Air in the cavity of the Tube NOGP, may at the same time be heated likewise, I put some more on the part of the Tube NP. As soon as ever now the Air below the Grate, and in the Tube NOGP grows hot, the Heat that was produced by the Coals above the Grate in the vessel CK is diminished; and the Heat in LF below the Grate, and in the Tube NOPG, is in proportion increased; so that now you observe the force of the Fire, with its little Flames, tend downwards, by which means a new degree of Cold is generated above the Coals that are laid on the Grate. The Machine then being thus prepared, when I lay this Straw upon the Coals, you see with what rapidity the Flame drives downwards through the Grate, and

Which is a
volatile Coal.

A Fire-place
and Chim-
ney without
Smoke, the
Smoke being
burnt.
Pl. IV.
Fig. 1.

Fig. 2.

through all the Tube OGH, so that it breaks out at the top H, without Smoke, and there produces a very great degree of Heat; whilst at the same time the space CK continues cold. But farther, whilst I add Wood, Turf, Sulphur, and Oils, it proceeds exactly in the same manner, and the force of the Fire is so great within the Tube, that the Tube you see is now red hot, and the Fire burns with so much fury and rapidity, that one may hear the noise that is produced by the agitation of the Flame. You take notice too, at the same time, that these Bodies, which commonly, when they are burnt, diffuse an intolerable fetid, or a very agreeable scent, now they are laid on this Fire, don't discover any smell at all, but perfectly consume without the least sign of it, leaving nothing behind them but pure Ashes at the bottom of the vessel under the Grate. All the other parts are driven by the force of the Air pressing upon the Aperture of the Fire-place, into the Tube which is higher, and narrower than the Vessel that contains the Fire; so that all the Flame, and the power of the Fire, exerts itself within the space LFOGH; and hence, the combustible parts that are reduced into a very dense Smoke by the action of Fire, are now carried through this pure Flame, and not into the open Air; by which means, being thus strongly agitated by the violence of the Fire, even within the Fire itself, they are so attenuated in their passage, that every part of them that was combustible, or could be so divided by the motion of the Fire as to become perfectly imperceptible, is dissipated into the Air, without discovering the least sign of any particular quality. Smoke therefore is combustible matter, exceedingly agitated, but not yet shining, or red hot; Flame is the very same matter, only thoroughly red with heat, and divided into very minute Particles. But it appears likewise by other Experiments that Smoke is inflammable. If you take, for instance, shavings of *Guaiaicum*, and with a strong Fire force it out of a Retort in a dense Smoke, then, in the end of the operation when nothing rises by the action of the Fire but a very attenuated and rarefy'd Oil, if this Smoke insinuates itself through the cracks of the Lute, and a Candle is apply'd to it, it immediately takes fire, and flames, and that not without a great deal of danger. And the same thing is true of all parts of Animals, if they are treated in the same manner. Hence, therefore, Smoke comes nearest to Flame, and the blacker it is, it comes so much the nearer; for then it becomes a true Coal, exceedingly thin and attenuated, perfectly volatile, and easily combustible; as any one may easily understand from the History of Coal, that has been already delivered. And hence, therefore, lastly, there is nothing in Smoke that supplies Fire with any *Pabulum*, except the Oil; but this will appear more evident hereafter.

Lastly, of
the Soot.

In the last place, in the burning of combustible vegetable Matter, the Smoke which is carried upwards applying itself to the sides of the Chimney, instills into them a penetrating black pinguious moisture, changes them of a very black colour, and fastens to their outside in form of black, loose flocks, that easily drop off; and the matter thus collected is called Soot. This now is in reality a true volatile Coal, but exceeding fat, and hence if it is dry, it is very easily inflammable. It is excessive bitter like Oil that is burnt; very pinguious from the quantity of Oil it contains; and from this Oil's being burnt, is very black, as all other Coals are. This matter now, tho' it appears thus simple, if it is nicely resolved into its parts by a chemical distillation, in the first place yields a

Water, in pretty great plenty, which being carefully separated and collected, extinguishes both Flame and Fire. And the very watery Vapour that thus exhales in this first distillation puts out Fire intirely; so that you can scarcely properly call it a Spirit. If you then increase your Fire, there comes over from this Soot, a large quantity of yellow, inflammable Oil, which yields a plentiful *pabulum* to Fire and feeds and supports Flame. That part likewise of this Oil which is exceeding subtil, and goes by the name of a Spirit, is in the same manner inflammable. But it farther yields, too, a very volatile Salt, one less volatile, and then one that is drier; from all which if you perfectly separate the Oil and Spirits, just mentioned, you will find nothing at all in them that is any ways inflammable, but only a Salt that is incombustible. And last of all, this *analysis* will give you a Coal, which we have sufficiently considered already, under our sixth and eighth Observation. Hence therefore it appears, what Soot is, and what part of it is really combustible. If this Soot now is taken dry from the Chimney, and thus laid on the Fire, it burns fiercely, and breaks out into Flame, in the same manner as any other combustible matter does; which persons experience, sometimes, to their great danger, when they let their Chimneys go too long without sweeping; for the Soot being, by this means, collected in large quantities, frequently takes fire, and flames out of the top of the Chimney.

From all these Observations, then, that I have fairly related to you, we plainly perceive, what part of crude Vegetable it is that is properly inflammable, and may be esteemed a true *Pabulum* of Fire, *viz.* the Oil alone, and that, in what form soever it exists, whether in a thick one, or a thin one, like that of Spirits.

Conclusion
concerning
the crude
Pabulum of
Fire.

Since every thing, however, must be considered and examined that will give us any light into the nature of Fire, and that it may be perfectly evident, what it is in Vegetables that properly and solely yields a matter proper for the nourishment of Fire, let us now suppose, that we certainly knew, from what has been premised, that there is nothing contained in crude Vegetables that will feed and support Fire, and is, at the same time, capable of being dissolved in Water. But if we will turn our speculations farther, to the vegetable Substances, that, by a true chemical fermentation, are produced from those Vegetables that are thus disposed to ferment, we shall then find, that by this method a liquor may be produced from them, which goes by the name of Wine; this, now, when it is fined according to Art, and hence rendered pure, if it is thrown upon a large Fire, will soon intirely extinguish it; nor is it any way fit to support Flame. Nay, and after you have examined it in this manner, if you put it into a clean glass vessel, and, with a very gentle Heat, evaporate the most volatile part of it, and reduce it to a Fume; even this, if you apply a Flame to it, will scarcely burn, but on the contrary, for the most part, rather puts it out.

Wine don't
take fire,

But if this Vapour, when it is afterwards grown cold, is collected in form of a liquid, and this is treated in the same manner as the former, then this will yield a liquor that may be mixed with Water, and at the same time will perfectly take fire, will afford a plentiful *Pabulum* to Flame, and be itself consumed in it. That part of the Vegetable, now, that is separated from the Wine, whether in form of Lees, or the *Residuum* in the distillation just mentioned, if it is examined by the fire, will yield almost the same parts, which

But its Spirit
does.

are

are found to be procured from crude Vegetables, under the same management. By this instance therefore it appears, that by Fermentation there is generated from Vegetables, a liquor that will mix with Water, and feed Flame, which did not really exist in them, when they were crude.

Putrefaction
of Vegetables
produces
Fire.

But it will be worth our while to examine Vegetables whilst they are managed in another manner, different from the former. If Vegetables then are thrown into large heaps, when they are just cut down, and full of their natural juices, or are disposed under the same circumstances, in great wooden vessels, close and hard pressed down, they will there grow warm, then very hot, and emit a watery Fume, a disagreeable Smell, a black Smoke, Flame, and Sparks. On the other hand, if they are exposed to air after they are mow'd, till they are grown sufficiently dry, then, though you heap them together in the same manner, they will continue dry, and will not undergo the same alterations: But however, even in this case, if you pour Water upon them, till they are thoroughly moistened, they will conceive Heat, and take fire in the same manner as the green ones just mentioned. After Vegetables, now, have by these means acquired this spontaneous Heat, and retained it for some time, if they grow cold again, without taking fire, they then are found to be quite putrified, and converted into a fetid, pappy Matter. If then you distill this putrified Pulp, the first part that comes over will be a watery Vapour, which will extinguish Fire and Flame: And when this first watery liquor is drawn off, if you expose the remaining dry parts to an open Fire, they will yield almost all the same principles as crude, or fermented Vegetables do in the same circumstances.

But lastly, if you take Vegetables that are perfectly putrified, and distill them in a Glass retort with a moderate Heat, till they are become nearly dry, you will then have first a fetid subpinguious or cloudy Water, in which there is found to be contained a volatile, alkaline Salt, tho' then intirely dissolved; and indeed it is rather from the admixture of this Salt, than from any true Oil that the Liquor appears thus pinguious. Whether now this Water thus impregnated with Oil, is thrown upon the Fire; or whether you first resolve the compound Liquor into a purer Water, and its Salt, and then throw both these separately upon Fire, the Event in both Cases will be exactly the same; for in both the Fire will be extinguished.

And some
inflammable
parts.

But again, when this first Liquor is separated, and the putrified Matter remains now almost dry in the Retort, if you urge the *Residuum* still further with a stronger Fire, there will come over a fluid, oily, thin Liquor, which swims upon Water, is fetid, and yields a *Pabulum* to flame, like Oil, or Spirit of Wine. After this Spirit, or fine Oil, is drawn off, if you still increase your Fire, then a volatile, alkaline Salt, and an Oil thicker than the former will rise together in a considerable quantity. And here again, as the Oil is found to be inflammable, so the Salt appears perfectly otherwise. But farther, if when you have separated all these, you still urge the *Residuum* with a strong Fire, and continue it a good while, you will have another Oil, still thicker, and more tenacious, almost like pitch, which is exceedingly combustible: And at the same time there will come over a dense Vapour, which, upon the Application of a lighted Candle, will instantly take Fire in the open Air. This being done, if the Fire is still constantly kept up to its greatest Degree, you will at last

last force out a *Phosphorus*, which, though it is not of so solid a Form as that which is procured from animal Substances, yet it comes very near it in a great many of its Properties. Last of all, when this fluid Matter is intirely gone off, there is then left in the Retort, a very black Coal, such as we described before, in which there remains indeed a black inflammable Oil, but not the least appearance of any fixed Salt.

If we thoroughly understand then what has been laid down, we may boldly and safely determine, concerning all the parts of Vegetables, naturally contained in them, that are endued with such properties, that if Fire is applied to them, they may be consumed into Flame, and will so long feed and continue Fire in that place; as likewise of those which may by certain methods be procured from them, or produced in them, so as to dispose them to have the same effect. It is evident then, that amongst these Parts, the Water, the native Spirits, as they are called, all the kinds of Salts, and the Earth of Vegetables, are capable of being heated by Fire, and hence of admitting Fire into them, and of retaining and preserving it there for a considerable time, but this only under the limitations above mentioned. The Fire likewise, when it is thus united with them, may, by the help of them, be at pleasure communicated to other Bodies: And the fixed Salts may, by a strong Fire, be heated thoroughly red hot, and will retain this shining Heat a considerable while. In the mean time however, neither of these four Parts can, by any contrivance whatever, be raised into Flame, or, by the application of Fire, be consumed in it, in the same manner as those Bodies are which are generally called the *Pabulum* of Fire. But farther, the Oils of Plants of what kind soever, their Balsams, the Gums that are generated in them, the Resins likewise, and the Substances compounded of these two last together, hence called Gummy-resins; these five other sorts of Parts, I say, that are found in Vegetables, are disposed likewise to grow hot with Fire, to retain it a great while, to apply it to other Bodies, and that without taking Fire, or flaming themselves; though if you urge them with a stronger Fire, they will melt, boil, and yield a true *Pabulum* to Flame or Fire. But yet even in this case, their Inflammability is only confined to those particular parts of them that are of an oily nature; for all the rest are chiefly of an earthy disposition, and are only acted upon in the same manner as the former which we just described.

But the vegetable Spirits now that are generated by Fermentation; the other Oils that are drawn from fermented Vegetables; and lastly, the Spirits and Oil that are procured from Vegetables by putrefaction; all these, I say, considered as they are perfectly pure Spirits, or Oil, are constantly observed to be absolutely inflammable. It evidently appears therefore, from every kind of experiment, that the Oils of Vegetables, in what Form soever they exist, are the only Matter contained in Vegetables, that without the addition of the other Parts is capable of being so agitated by Fire, as by its assistance to produce true Flame, and then to support and continue it so long as any of these oily particles still remain: That in the mean time this very Matter is by degrees consumed by the Flame, and disappears; and that then too the Flame immediately goes out. And though this Oil is found in Vegetables to have very different appearances, and undergoes considerable alterations from various causes; nevertheless, in the sense above explained, so long as it re-

Conclusion
concerning
all that is
combustible
in Vegeta-
bles.

mains Oil, it will always continue to be inflammable. And yet farther, when by Fermentation or Putrefaction this Oil is so attenuated as to be reduced to very subtil Spirits, that will bear to be diluted with Water; even these Spirits likewise are intirely inflammable, and as a *Pabulum* of Fire have the very same effect which we just now observed of real Oil. But whenever now you have perfectly extracted every thing that is of an oily nature, either from the whole Vegetable, or from any of its parts, then the remainder, treat it in whatsoever method you will, can never be made susceptible of Flame, or capable of supplying it with any nourishment. In the mean while, however, the watery, spirituous, saline, and earthy parts, as they contain and confine these Oils within them, must necessarily, when the Oil is set on fire, be agitated, put in motion, vibrate, and very much increase the force of the Fire; for whilst this is supported by the Oil, this violent agitation of all their particles will of consequence excite a prodigious attrition in the very Flame itself; and hence, being thus agitated, they will apply the Fire more forcibly to any other Bodies. And lastly, they serve for a time to defend the Oil itself from being too soon consumed by the Flame, that thus the *Pabulum* of the Fire might not be so quickly destroyed and dissipated as it would be otherwise.

Whoever, therefore, duly considers all these effects, will easily see that the force of a Fire raised by Vegetables, does not depend only upon elementary Fire, and the Oil set on Fire by it, but principally, and most of all, on the other parts that are incombustible, but which at the same time are agitated by the Fire with a vast *impetus* within the sphere of its activity. And for this reason, when elementary Fire acts upon the purest Alcohol, which is the simplest of all combustible matter, it then neither produces such violent effects, nor so much Heat as it does by a ponderous fossil Coal, a great part of which is not inflammable. Nay, even a Torch made of the rich, pinguious wood of the Pine, gives a stronger Fire than its Oil, let it be ever so pure, or be separated ever so carefully from all those parts that are not combustible. And thus we understand the reason of this paradox, that pure Fire, applied to inflammable matter alone, very often produces a less degree of Fire than if the inflammable matter was mixed with something else that was not so. Hence, the wise Author of Nature has no where created any inflammable substance by itself, but always disposed it in the bosom of some other Bodies that are not combustible, that by this means it may be capable of producing greater effects. As the right notion of this now is of very great consequence in our present inquiry, give me leave to explain it to you in the following manner: When a pinguious piece of Wood is laid upon a Fire, the Oil that is contained in it, in conjunction with the Fire, is capable of exciting, and really does excite a Flame. This then being thus produced, plays upon the surface of the Wood, attracts, fires, consumes and converts into new Flame all the Oil that lies open and exposed to its action; and hence the first Flame is supported, and constantly increased, so long as this Oil comes within the sphere of its activity. The Salt in the mean while, and Earth, that are intimately united with this burning Oil, will at the same time be attenuated, and reduced to very minute particles, by the rapidity of the Oil, and will hence be agitated with more violence within the Flame, than even the Oil itself, and

and suffer as vehement an attrition as any we are acquainted with. This violent attrition then of these particles, that are exceeding hard, and are very forcibly compressed together by the weight of the atmosphere, will of course collect more fire in this place, and thus make it both larger and stronger; and of consequence will still put this Oil in a more rapid motion; which will very easily account for the vivid appearance of the burning Fire. Whilst these things then proceed in this manner, the solid body of the Wood grows hot to its very innermost parts, dissolves, rarifies, expels the elastic parts contained in it with a very great *impetus*, pours out its melted Oils, and by these successive actions continues and maintains the Fire so much the longer. On the other hand now, if exceeding pure Oil only is kindled by the application of Fire, then the tenacious, oily particles alone will be rapidly agitated by the elements of Fire, which being of a softer nature than the Salts, Earth, &c. must necessarily produce less attrition, and a weaker Fire. They will, it is true, burn away faster; but then their *impetus* will be of short continuance, nor will they collect Fire so powerfully, as when they are mixed with something that is not inflammable. And thus I think I have sufficiently explained what is the true *pabulum* that Fire receives from Vegetables.

It will be our business then in the next place, to examine with the utmost attention, what it is that nature is really effecting, whilst this matter which we have described in the Vegetable Kingdom, is so apply'd to Fire, as to feed and support it. And upon this head, certainly, I have not taken a little pains to come at the truth. After considering the affair then in every light, I have discover'd, first, that all those parts of Vegetables, that in conjunction with Fire are capable of exciting a true Flame, are of that nature, that they will bear to be mixed with one another; especially, if there is no heterogeneous mixture with the pure, simple, inflammable Particles. For to come to the matter more closely, Alcohol is the only Body that we are acquainted with, that is absolutely inflammable; but this, let it be prepared from what you will, if it is perfectly pure, may be intimately united with any other sort of simple Alcohol whatever, so that there won't appear the least sign of difference after the mixture. All kinds of Oils, in the same manner, if they are thoroughly depurated, and separated from every thing else, may be intirely mixed together; as appears by every kind of Experiment. I confess, indeed, in some Oils procured from a semi-fossil Matter, as Amber, and the like, as you increase your Fire successively, the Oils that ascend, will lie upon one another in distinct *Strata*, without being mixed together: But you know very well, that these ponderous Oils, that are at last forced out by the strongest degree of Heat, have almost the very melted substance of the Bodies themselves united with them; and besides, I am here treating only of Vegetables. All vegetable Oils, then, are of that nature, that they'll easily bear to be compounded into one liquid concrete, which will scarcely afterwards be found to have any dissimilarity. But again, all kind of Oils, if they are carefully depurated, may be intimately mix'd with pure Alcohol, so that the Fluid that arises from this Mixture will be absolutely homogeneous, all the parts of it appearing perfectly uniform to the nicest Microscopes. But here, I take for granted, that there is not the least drop of Water, either in the Alcohol, or Oil, for otherwise such union could not possibly be expected. But farther, Camphire, which is a solid vegetable

Of the manner in which Fire is fed by this *Pabulum*.

Substance, and totally takes fire, will intirely dissolve, not only in Alcohol, but in every kind of pure Oil likewise. And the other parts of Vegetables that are perfectly inflammable, may in the same manner be mixed with Oils and Alcohol, and always the more intimately, the more they are purely inflammable. In Refins, Balsams, and Gumma-Refins, this is every where found to be the case. And when they are capable of being mixed in this manner, they are observed to be either naturally fluid, or disposed to be rendered so by a small degree of Heat. How easily does Camphire run by a slight action of the Fire? And what a gentle Heat is sufficient to melt Balsams, Colophonies, and Refins? Nay, many of these inflammable substances, are able to withstand the greatest degree of natural Cold that ever was observed, without being frozen, as is evident in Linseed Oil, and a great many others. It is particularly remarkable now, that all these Bodies that are purely inflammable, whether separate, or compounded together, by their tenacity constantly discover a viscid cohesion of their Particles, which does not a little resist their separation. Observe, for instance, this Alcohol, which of all known Liquids is the most subtil: Don't you perceive, that even the Particles of this run down in spiral *striae*, which cohere and hang together? If you pour Alcohol into clear Water, you observe that the Particles of the Alcohol affecting this cohesion run about in the Water in form, as it were, of little Eels, and by their convolutions sufficiently evince their tenacity: Nay, and even if you dilute Oil with Alcohol, you may discover the same kind of streaks. But it is farther observed, that all Oils that are inflammable, burn so much the easier, the more perfectly, with the less Smoke, and leave the less Ashes behind them, the thinner they are, and the nearer, by their exceeding fineness, they approach to the subtlety of Alcohol; which is every where confirmed by Experiment: But at the same time, the thinner the Oils are, their Flame is always so much the weaker. Thus, Gentlemen, I have laid before you a collection of Observations concerning the nature of the *Pabulum* of Fire, which are constantly found to hold good, and which will help to give us some light into the manner in which Fire acts upon its *Pabulum*, and that again upon Fire. And to this purpose, let us again make use of the following *Series* of Experiments.

EXPERIMENT I.

The extinction of Fire and Flame by Alcohol.

In this clean, brass, cylindrical Vessel, is contained some very pure cold Alcohol, which of all the Fluids that we know of, is the most totally inflammable; into this, you observe, I dip this Match whilst it is burning; upon which no doubt you imagine the Alcohol will be set on fire: Nothing less; for you see it is perfectly extinguished, all one as if it was immerg'd in pure Water. But again, which is more surprizing, I'll immerge this burning sparkling live Coal just taken from the Fire, in the same Alcohol; and what is the consequence? Why it is extinguished in the same manner as if it had been thrown into cold Water. But now, if I dip the end of this lighted Match, so cautiously into the Alcohol, that some of the burning part, which is of a considerable length, shall be above the surface of the Alcohol, then the attracted Alcohol will begin to take fire, and the Flame will in a little time be dispersed over all its surface.

COROL.

COROL. I.

Hence, therefore, it evidently appears, that burning Fire will not set fire to the most inflammable matter that we are acquainted with, except in its upper part only that is contiguous with the Air, but will be perfectly extinguished itself, when it is so disposed within the inflammable Body, that no part of it remains in the Air above its Surface. And yet this very remarkable *Phænomenon* is scarcely taken notice of.

COROL. 2.

It is not true, therefore, that active Fire will so easily kindle even those Bodies that are vastly inflammable.

EXPERIMENT II.

I have fill'd the same clean Vessel with very pure Alcohol, which I have heated you see till it emits a Vapour; if I bring now this lighted Match towards this Fume that exhales from the hot Alcohol, as soon as ever the Flame of the Match touches the Vapour, it immediately takes fire, flames, and burns, and the Flame extends itself intirely over the whole surface of the heated Alcohol. And this Flame remains spread accurately over all the surface as a firm *Basis*, nor can by any Art whatever be made to convert into Flame that part of the Alcohol that lies cover'd under its Surface: For all this you perceive it intire, pellucid, not on fire, but remains under the flaming Surface without being consumed, except so much of the Spirits as are separated from it by the Heat, and thus raised and brought to the Surface that is contiguous with the Air; for then these, and no other, immediately take fire and flame; nor is it possible to set on fire more at a time, than those which are now so disposed that they can float in the Air: This I have observed most evidently; for if the Alcohol is cold, and you light it leisurely on its Surface, by dipping a burning Match in it, as I mentioned before, so that some part of the Flame shall still remain above the Surface of the Alcohol; then the Flame that is in this manner excited, will be gentle, weak, and very small. On the other hand, if this Alcohol is first heated, and by this means emits a large quantity of Spirits from its Surface, then the Flame will be greater, and burn with more strength and violence; for then more Particles coming to the Air may be set on fire by the Flame. In this Vessel therefore, the Alcohol will always yield more Flame, the more it is heated through its whole Bulk; and of consequence, if it is made so hot as to boil, then will its Flame be strongest of all. But again, if the agil Vapours that exhale from a Vessel of boiling Alcohol, and float about in the Air, are confined by any means within a narrow compass, then if you bring a burning Candle within this space, thus full of Vapours, the whole place will be instantly filled with a flashing Flame, which shines for a moment with a faint light, and then tends towards the Surface of the Vessel, and fixing there, so covers the exhaling Surface of the Alcohol, that no more Spirits can any longer be dispersed into the former space, or be set on fire there; for now it is all forced to pass through the incumbent Flame, where it is so changed, that during its stay there, it creates Flame itself, but then, is afterwards converted into a Fluid, that is no longer Alcohol.

The prefer-
vation of
Flame and
Fire by Al-
cohol.

That this is the case, I have abundantly learned from Observation. And farther, this Flame continues to burn so long as there is the least drop of Alcohol left in the Vessel, and then it goes out. All the Alcohol, therefore, can't possibly be consumed by this Flame at once, but only that part of it which forms the Surface contiguous with the Air. The broader therefore the Surface is, the sooner will it be burnt up; and consequently this waste may be increased or lessened at pleasure. Thus then we have two methods of accelerating the Flame, and of consequence the consumption of Alcohol, *viz.* making it boil, and disposing it under a large Surface. This Alcohol now, when it is intirely burnt away, leaves no *Fæces* behind it; nay, if it is perfectly pure, there does not remain the least spot or sign of it: Nor in the Surface of the Flame, is there the least Smoke that the Eye is capable of discerning. Nay, if you hold a very white clean Paper over the burning Flame, it will be no ways soiled with any Soot; but it will receive only a pure Moisture. The olfactory Nerves, however, will perceive a fragrant smell like that of Alcohol. The Flame now of this Alcohol, when it burns in a very quiet Air, is of a conical figure; for the Fire being strongest about the center, elevates the incumbent Atmosphere in that place more powerfully than that does which is towards the circumference of the *Base*, which is less confined and compress'd, and consequently weaker. If you look slightly upon this Flame, you'll take it to be blue; but if you look upon it very intently, the *Base* of it is always blue, but its *Apex* appears double, the inner of which is constantly yellow, but the outer is blue likewise. But there's nothing, it's possible, will seem so surprizing in this Experiment, as what I am going now to shew you. You perceive the Alcohol in this little Vessel burns very fiercely; I'll now throw into it this live Coal which is perfectly red quite through; and you see in sinking it is extinguished immediately, nor is able to retain its Fire when it is cover'd with the Alcohol. What now is the cause of this wonderful effect? Why the live Coal requires a great deal more Fire to keep it burning, than is contained in Alcohol, whilst it is boiling; and Alcohol when it once boils, cannot afterwards acquire a greater degree of Heat. The hotter Coal therefore being flung into this colder Fluid, must of necessity lose that greater Heat, which was requisite to keep it on fire; and therefore it will be extinguish'd or reduc'd to 180 degrees of Heat, which are sufficient to make Alcohol boil, but can never set on fire any sort of combustible matter, that is, can never, by the assistance of the Oil of any such matter, produce a lucid Fire. But farther, as the Coal is totally immersed in the Alcohol; hence it is intirely kept from any communication with the external Air, and for this reason the Coal is not able to set fire to the Alcohol, but only with its first *Impetus* puts the Alcohol into a greater motion, makes it throw out more of its Spirits, and by this means, as we explained before, just for that instant, increases its Flame. If this glowing Coal now had been so laid on the flaming Alcohol, that one part of it had been above the Surface of it contiguous to the Air, then it would have continued burning with the Alcohol, and that pretty fiercely.

EXPERIMENT III.

An examination of the purest Flame.

I took a good deal of pains formerly to find out some Experiment that should be sufficiently evident to the senses, by which I might come at the knowledge of

of the action that Fire exerts upon its *Pabulum*; and at last, I brought the affair to the issue that I am now going to explain to you. To this purpose then, I again set fire to this pure Alcohol contained in this clean cylindrical Brass Vessel; and thus burning, as you see, I place it upon this Table, and put over it this large glass Cucurbit, which is one of the biggest that the Glass-makers can blow for chemical uses, and whose bottom I have carefully cut out in a circular figure, so that it is now a true Bell, whose diameter at bottom is ten inches, and whose top has an orifice that will admit one's little Finger. This clear glass Bell then thus every way surrounding the burning Alcohol, you'll evidently perceive all the *Phænomena* that I related to you, and shew'd you under the former Experiment. Fig. 3.

The first thing, then, remarkable here is this, that the whole surface of the Bell appears, as you see, opaque, from the action of the Flame burning within, so long as the Bell itself remains cold: But now, as it grows warm by the Fire that's under it, you perceive that it begins again to look clear. By the same action continued, it is at present actually hot; and it is now become perfectly pellucid. If you look ever so attentively, now, you will not perceive the least kind of Fume in the whole cavity of the bell, but the Air throughout the whole space appears perfectly clear. And as the vessel in which the Alcohol is contained is cylindrical, hence the Flame, as far as the eye can discern, continues exceedingly equable, from the beginning to the end. At the bottom, however, of the inside of the Bell, you perceive something running down in streaks, like those that are formed in the distillation of Spirits. This yields an exceeding limpid thin Vapour.

This liquor now is by no means the true spirit of the Alcohol, for it has a perfect watery taste. But that you may perceive this evidently yourselves, observe the fine Vapour that exhales through the upper Orifice: This, if it was really the Alcohol, raised by the Heat, would immediately take fire upon the application of this lighted match, as we saw in the preceding Experiment; but, on the contrary, when I move it into this exhalation, you observe the Flame of the Sulphur is extinguished by the Vapour, exactly as if it was held in the steam of hot Water. But again, I'll put this burning Match under the Bell, and thus hold it in the very place where the Alcohol is burning, and diffusing its Vapour; and you see, now, that it remains a'light, and burning, till it is quite consumed, but not in the least sets fire to the fumes that rise from the flaming Alcohol, and fill the whole Bell; which, had they retained their former nature of Alcohol, after they had passed through the Flame, must necessarily have taken fire upon the application of the burning Match. Hence, therefore, it seems to appear, that this matter, which, of all that we know of, is the most inflammable, whilst it is thus converted into Flame, and by this means, likewise feeds the Fire, is really changed into another substance, which, after this alteration, is no ways capable of supporting it any longer, but as far as we are able to judge, acquires the nature of Water. Did, then, this Water actually reside originally in the Alcohol, and so as not to be separated from it by any other method than this? Or did the Fire, by burning the Alcohol, convert it into Water, by a true transmutation? Or, lastly, was not this Water, in reality, supplied by the Air, during the time that the Alcohol was burning? These things, farther Experiments, And indeed an aqueous one.
made.

made by men of judgment, may hereafter determine. But here give me leave to caution you, that it's necessary, that the Alcohol used for this purpose should, by a gentle distillation, in a tall vessel, be drawn off of the driest Alkaline, fixed Salt of Tartar, that, by that means, the true Spirit of Wine may be freed from all the Water that it is possible, by any Art, to separate from it; and with this sort it is, that I make these Experiments before you, very well knowing, how closely the Water coheres with the pure Spirits, even with such an union, that is not easy to be dissolved. After I had examin'd Alcohol in this manner, I found, that the famous *Geofry*, the younger, a Gentleman of great application, and a particular genius for these Inquiries, had, in the *Mem. de l'Ac. roy.* Ann. 1718, published some very accurate and ingenious Observations, which, though made with another view, yet elegantly confirmed what I had before discovered by the method I have just mention'd. For my part, I was vastly solicitous to know what physical alteration it really is that inflammable matter undergoes, when it is so exposed to fire, as to produce Flame, which is the purest of all Fires; and what at the same time, happens to fire, whilst this combustible matter, in conjunction with it, rises into Flame: For I imagined, if I could once come to a certain knowledge of this, it would be a good step towards getting a better insight into the nature of Fire itself. For this purpose, therefore, I prepared a matter, which being burned in a cylindrical vessel, and thus being forced to pass through the Flame, that intirely covers the whole surface, would totally feed the Flame, and be itself totally converted into Flame, without Smoke, Soot, or *Faces*. When this, then, was exposed to the pure Air alone, (without the admission of which all Flame goes out) and so set on fire, I found it was intirely consumed into Flame, that this Flame produced a very fine Vapour, and that this Vapour might be condensed into Water, or, at least, wou'd generate it: And thus far I was then able to proceed, and no farther. But had I now as much leisure as I have inclination for these inquiries, I wou'd endeavour, by the help of more of these glass Bells, to collect some quantity of the Water thus produced; for I observed, as you yourselves likewise did just now. that far the greatest part of the Vapour passed through the upper Orifice, and was by this means dissipated. Over this Bell, therefore, there should be hung another of the same kind, that this Vapour, likewise, might be there received, condensed, and rendered fit for examination. And a third, again, might be suspended over this, so that by this means at last the Vapour might be totally collected. The properest time, now, for making this inquiry is, when the weather is exceeding cold, that the Vapour may be very quickly condensed by the Cold, and frozen in the upper Glasses. And these Experiments should be likewise made in a place that is very dry, and not incommoded with wind: Nor do I at all doubt, but that the thing will some time or other be discovered, the knowledge of which is as valuable as any thing in natural Philosophy, and will be of infinite service in the chemical Art. I know, indeed, that the worthy *Geofry* has inferred from his Experiment, that he could procure from pure Alcohol, by converting it into Flame, more than half its quantity of Water; and it is certain, that he did exhibit so much. But this excellent Chemist is well apprized what a great quantity of Water is diffused about through the Air; how imperceptibly this Water quits the Air, and insinuates itself into saline, dry, spirituous

spirituous Bodies, and, by subtilly mixing itself with them, often overturns our Observations: The blue Flame of the dryest burning Sulphur exhales into the Air, to a great compass, and, if it is collected under a Bell, produces a very sharp, acid Liquor; which, if the weather is dry, is in a small quantity, and always so much the stronger; but if the Air is moist and cloudy, it is in a greater, but then it is more watery. From this we can, by a gentle Fire, separate a large quantity of insipid Water, and from the remainder prepare a small portion of a thicker liquid, that is exceedingly acid: If you expose this last now to the Air, in a broad vessel, when thus simple, and freed from its Water, the Water in the Air will immediately unite itself with the pure Acid, increase both its weight and its bulk, and at the same time dilute, weaken, and render it less efficacious. Perhaps, now, the very same thing may happen to the Spirits, whilst they are burning. These things, however, bring again to my mind the expressions of the ancient Alchemists, who called them, the moving, or governing Spirit, the Child of the Sun, the Offspring of Fire, and the internal Fire of Bodies.

And another part that does not fall under the cognizance of our senses.

Is it not possible, then, that this pure Spirit, which, in conjunction with Fire, produces Flame, and is absolutely, and totally inflammable, may be but an exceeding small part of the Body in which it is contained, but dispersed thro' a large quantity of Water, and intimately united with it? Certainly, though we endeavour ever so artfully to confine this principal, we always find it so infinitely subtil as to escape our nicest Observations. Tired in these inquiries, I confess, for my own part, that I have for a long time past desired nothing more earnestly, than rightly to understand the proper nature of that Matter in the Alcohol, which is truly inflammable; for I knew that I here was in possession of something which is perfectly inflammable. And I have for a good while been satisfied by Experiments, that all other inflammable Bodies are only so, as they contain Alcohol in them, or at least something, that on account of its fineness, is exceedingly like it, the grosser parts of them that are left behind, after the separation of this subtil one, being no longer combustible. I had the pleasure, therefore, of believing, that if I could but once discover this in Alcohol, I then could very easily comprehend how Fire is supported in all other combustible Bodies. But how was I disappointed when I found that Alcohol, by passing through Flame, would burn away into a Vapour, in which I could not discover any Alcohol; so that if this was really the remains of the Alcohol, it left nothing behind it but an exceeding pure Water. These therefore I acknowledge the boundaries of my knowledge upon this subject: The *Pabulum* of Fire, when consumed by Fire, leaves a Water behind it, but becomes itself so vastly fine, that it is dissipated into the Chaos of the Atmosphere, and gets beyond the reach of our senses.

EXPERIMENT IV.

But by this new Experiment, the Opinion which I just now laid down, will appear more evident. For this purpose I have provided a live Coal, in this earthen Pan, which is so perfectly red quite through, that, as you see, there is not the least appearance of Smoke; the Pan too is perfectly clean, and very dry. Upon the Coal I place this pure brass porringer, which is about an inch deep, round at bottom, and four inches in diameter. Into this I now

A instantaneous production of the purest Flame.

pour.

pour some choice Alcohol of Wine, to the height of half an inch ; and then cover the whole, as before, with the glass Bell. You may perceive, now, that the Alcohol, by means of the Coal in the Pan underneath it, boils pretty strongly in the brass vessel, but does not take fire, or diffuse any Fume that is visible within the cavity of the Bell ; nay though the exhaling surface of the boiling Alcohol is so broad, yet there does not appear the least Vapour coming out of the upper Orifice. In the mean time, however, you begin to perceive some streaks of the Spirits running down the sides of the Bell, especially about the lower parts of it. As you see, now, a considerable part of the Alcohol is, by boiling, exhaled out of the brass porringer, it's time for us to try what will be the effect of applying a lighted Match to the upper Orifice of the Bell. This then I'll do ; and you observe, that whilst I thus hold it over the mouth, the Flame of the Match does not set fire to the Alcohol, that is floating about within the Bell, but is rather itself extinguished. Hence, therefore, as the Alcohol, that is now dispersed in the Bell, does not, by this means, take fire, you will be apt to imagine, that it does not appear, by the former Experiment, that the Alcohol, which was burnt by passing through the Flame, did really lose its inflammability, or else, that this has lost it likewise, purely by exhaling without burning at all : But please to attend, with a little patience, and you will soon be of another opinion. Observe then this lighted Match, which I now hold in a pair of Tongs, that I may be at a convenient distance from the effect of this dangerous Experiment. In this manner, then, I cautiously carry it along above the Table, in a horizontal direction, towards the glass Bell, 'till the Flame of it comes underneath the lower rim of it ; and you see as soon as ever the Flame reaches within its cavity, the whole space within the Bell, that is now filled with the Vapour of the boiling Alcohol, like Lightning, instantly flashes out, and that with a great noise, and such a violence, that the moment it takes fire the Flame rushes out at the bottom, between the Bell and the Table. This happens, now, because the whole cavity, being filled with the very minute particles of the Alcohol, and at once set on fire, is not able to contain all the Flame, which, therefore, will diffuse itself through those parts where there is least resistance, *viz.* in this case at the bottom ; at which place, could it not have found a vent, it would have either blown off the Bell, or burst it in pieces, not without a great deal of danger to the persons about it. If ever, therefore, you make this Experiment, take this caution, never to come too near the Bell when you apply the lighted Match, nor ever to hold the Match in your hand, without a pair of Tongs ; for otherwise, that Flame which bursts out at the bottom may very easily burn your hands and face. This, then, may suffice for the first part of this Experiment ; let us now turn to the other.

Which sets
on fire boil-
ing Alcohol.

The very moment, then, that the Flame was excited in the Bell, you observed the whole surface of the Alcohol that was boiling in the brass Porringer to be likewise perfectly covered with a bright Flame ; which you saw did not in the least take fire before, tho' the Fire underneath it made it boil pretty strongly. Hence, therefore, it is very evident, that Alcohol will not easily be set on fire without the application of Flame to it. But the Flame of the Alcohol, now it is once lighted, continues burning under the Bell, till the Alcohol is quite consumed, nor goes out before the Dish is become perfectly

dry. In this beautiful Experiment, now, nothing formerly gave me more pleasure, than what you have all seen at this time, viz. that

The Flame that was raised by the match, at some distance from the vessel in which the Alcohol was boiling, diffusing itself through the whole cavity of the Bell, set on fire the Alcohol that was contained in that vessel: But the very moment that this began to flame and burn, the Flame in all the other parts of the Bell instantly disappeared, and this only upon the surface of the burning Alcohol remained quite to the end, till all the matter of the Alcohol was perfectly burned away; nor was there, from the first moment of accension, during the whole time, any other flame excited throughout the whole capacity of the Bell, than what just hovered over the Alcohol in the Porringer. Does it not, therefore, evidently appear, that pure Alcohol, though it is agitated with a pretty strong Fire, provided it is not lighted, may be diffused through large spaces, without undergoing any alteration, and that it will still possess its inflammability in the same degree that it did before, so that if you apply a Flame to it, it will in a moment take fire, and burn with a great deal of violence? Nor is it hence less certain, that the very same Alcohol, when it is forced to pass out of its vessel through the Flame that covers its substance, and is by this means forced to feed the Flame itself; I say, when it has thus exhaled through the Flame, into the cavity of the Bell, it is not less certain, that it has so perfectly lost its aptitude to Flame, in an instant, that though the parts of the Alcohol are now attenuated by so much stronger a Fire, yet they can never afterwards be set on fire by the Flame that continues burning under the Bell. This extraordinary and surprizing *Phænomenon*, now, deserves, certainly, the maturest consideration; for it does not at all seem probable, that the Fire can perfectly expell all the Alcohol, out of the large space of the Bell, the very moment it has burnt it: And yet if the particles of the Alcohol, when they have passed through the Flame, float about in the cavity of the Bell, which seems very likely, then, if they remained still inflammable, they must necessarily be set on fire by that very Flame. What shall we say, then, Gentlemen, in this case? If the only pure inflammable matter that we know of in nature, when it once takes fire, totally loses its inflammability, must not there, of consequence, so much of the true *Pabulum* of Fire be every day destroyed, as is thus consumed by Flame? And for this reason, therefore, must not this at last be quite spent, if it could not, by some means or other, be recruited? Is this, therefore, continually supply'd by the operations of nature, in the bowels of the earth? And by which of them? By those, certainly, by which it generates Oil and Spirits. And, hence, in particular, by vegetation, fermentation, putrefaction, and distillation. But all these operations, whether artificial, or natural, are performed by the efficacy of Fire alone. Fire, therefore, which destroys combustible matter, is that cause in the universe, by whose energy it is again renewed. Or does the other opinion seem more agreeable, which we proposed before, when we made this Query, whether the matter that is intirely inflammable, does not, in reality, consist of a large quantity of Water, intimately united with a small portion of some other principle, that is vastly subtil, and very much resembles, nay is, perhaps, Fire itself? Whence this Fire being separated from the Water, by the

And is, at the same instant, extinguished itself.

action of burning, would again be freed from its confinement, and become true elementary Fire. If you suppose this to be the case, then ultimate, inflammable matter would be Fire itself; and, hence, when it is set at liberty from every other Body, would, of consequence, be dissipated into the Air.

EXPERIMENT V.

The extinction of Flame by Oil.

I dip this flaming Match into this pure, cold, distill'd Oil of Turpentine, and you see it is put out in the same manner as if it was immersed in cold Water, exactly as it happened before in the Alcohol. And again; I throw this live Coal into the same Oil of Turpentine, and by this means it is perfectly extinguished, without producing the least appearance of Flame. Hence, therefore, almost all those things that we before asserted of Alcohol, will hold true likewise of this Oil; and for this reason, as they may be consulted there upon occasion, it is needless to repeat them here.

EXPERIMENT VI.

The increase of Flame by the same.

I have again put some of the same pure distill'd Oil of Turpentine into this brass cylindrical Vessel, and set it upon the Fire 'till you see it begins to boil. To the Vapour now that exhales from this boiling Oil, I'll apply this lighted Match; and you perceive that when I do this, it is much longer before it takes fire than the boiling Alcohol was, tho' at last it does light and burn. You observe farther, that a black Smoke arises gradually from it, and as this appears, the Oil burns with more violence, till at last you see the Flame grows very fierce and vehement: And now it is burnt out, there are no *Fæces* left at the bottom, but it is all intirely consumed. The purer now, and more limpid this Oil is, so much the less black Smoke it always emits, and burns away more quietly. This therefore is the case, when it has been purify'd by repeated Distillation, for in every Operation it gets rid of some of its *Fæces*, but at the same time approaches so much the nearer to Alcohol, in lightness, limpidity, purity, and disposition to burn. But tho' by this means it constantly comes nearer to the nature of Alcohol, yet still it does not in reality ever become Alcohol, as it is never capable of being mixed with Water.

EXPERIMENT VII.

Examination of the Flame of burning Oil.

The same Oil of Turpentine being exposed to the Fire in this brass Vessel till it boils, and being then set on fire, I'll place it now, whilst it is burning, upon this earthen Plate, and cover it with the glass Bell. It burns now you see as in the sixth Experiment, but then with this difference, that it sends forth a black, thick Smoke, that fills the whole cavity of the Bell, rises through its upper orifice, sullies its sides with Soot, and fixes at the same time a kind of watery Vapour all round it: So that one would believe, that Water was here likewise produced from the burning Oil, or else by the concurrence of the Air. Hence, therefore, it appears, that Oils, which come nearest to Alcohol, tho' they are acted upon by Flame, and compelled to pass through it, yet will still retain some inflammable parts, that are not perfectly burnt away, but are only converted into a Coal; and that these being expell'd by the Fire out of the Flame in form of a sooty Smoke, are dissipated to a great distance, and afterwards being deprived of their first motion fix to the sides of Chimnies.

And

And this the fetid smell of burning Oil, which may be perceived a great way off, sufficiently demonstrates. These parts therefore, seem of too thick and tenacious a nature to be so soon reduced by the quick action of the Flame, to the subtlety of the finest Alcohol. When these Oils now are made use of for common Lamps, and have a Wick in them that is every way surrounded by the Air, they then burn with a smaller flame, and much more leisurely; and at the same time they produce a great deal more Soot, as the Blackness that soon settles upon a clean Paper held over them plainly evinces. But when they are thus set on fire in a cylindrical Vessel, the whole Surface of the burning Oil being perfectly covered with the incumbent Flame, all the Particles of the Oil as they consume, must necessarily pass through the Flame itself, and consequently will be more forcibly attenuated, and changed by the action of the Fire, than they are in the Lamps abovementioned; for there the oily Particles being put in agitation, have a free passage into the ambient Air, from every point of the Surface of the Flame, and hence fly off, without being totally altered by the force of its Fire. From all that has been observed then, it seems exceeding probable, that if by any Art Oils could but be reduced to the subtlety of Alcohol, then the Flame that is excited by them, would be free from Smoke, and the Fire from Soot.

EXPERIMENT VIII.

I have in this clean brass cylindrical Vessel, mixed some very pure Water, with an equal quantity of the choicest Alcohol, so that now after shaking them together, they appear you see a homogeneous Liquor. This Mixture then being heated, and set on fire, I'll place again under the glass Bell. You observe now, that the Flame that rises hence, is much weaker than that which we saw in the first Experiment upon this Subject; nor does the colour of the Flame by any means come up in brightness to that of the pure Alcohol. And you perceive too likewise, that this Flame, before it goes out, hovers a long while over the Surface of the Liquor, and then disappears, leaving the Water behind it in the bottom of the Vessel, in which there remains but a very small portion of the Alcohol, as the taste of it evidently demonstrates. Hence then we understand, that tho' Alcohol is mix'd with Water, yet it will be extracted thence by the power of Fire, and consumed by it; and that at the same time the Water is repell'd both by the Alcohol, and the Fire.

Examination of Alcohol and Water burning together.

EXPERIMENT IX.

In this very pure Alcohol, I have dissolved some fine Camphire. This Mixture now, I'll set on fire, and place burning under the Bell, as in the former Experiments: And the event is pretty remarkable. For first you see it takes fire exactly in the same manner as if it was simple Alcohol, and all the *Phænomena* appear perfectly the same; and that the pure Alcohol is thus first consumed, and the Camphire without burning is depress'd to the bottom of the Vessel, where it is collected in a Body by itself. But the Alcohol now being all dissipated by the Fire, you observe another Flame arising perfectly different from what appeared before, whilst the Alcohol was burning; for this you see is stronger, whiter, more lucid, and its Vibrations are greater than the former. At the same time too, this Flame produces a black Smoke; and then

Of Alcohol and Camphire.

both the smell and taste of the Camphire ascend from the Flame, and disperse themselves not only through the cavity of the Bell, but also through this whole apartment. This Flame now you perceive lasts as long as there is any Camphire remaining, and when it goes out, leaves no *Fæces* behind it in the bottom of the Vessel. Hence, therefore, we may learn, that if inflammable substances of different natures are united together in one compound, they will not burn away at the same time; but the most subtil part will be first of all consumed by the Fire; and the remaining grosser part will continue defended as it were under the burning Flame, and will then only begin to take fire when the former is dissipated. In combustible Substances, is that always first, and most easily set on fire, that is the lightest of them all? This certainly seems to be the case universally. Is the Flame that is excited in burning Alcohol too weak to set Oil on fire? This too seems exceeding probable: And hence, as soon as ever the Oil, or the Camphire dissolved by the Fire begins to burn, the Flame immediately you see becomes fiercer. Does then Fire by burning combustible Bodies, as well as by distilling them, separate their differently inflammable Principles, according to their various degrees of subtilty, or spissitude, the Spirits, for instance, first, then a thin Oil, next an Oil that is a little thicker, and lastly, a thick, pitchy, tenacious Oil? This plainly appears in this Experiment. Is this then the reason, that Charcoal, and the like Substances prepared by Fire, and consisting of an Earth and Salt covered over with this last very thick Oil, yield a stronger Fire than can ever be procured from Wood before it is thus burnt? This certainly is found to be universally true, that the Fire that is excited by burning Oil, is always so much the more violent, as the Oil has a greater spissitude, and is more ponderous. That this was the case just now in burning Alcohol, and Camphire, you yourselves are witnesses. And all these things are confirmed by the most common Experiments: As every body knows, that a Fire then gives most Heat when the ultimate combustible matter comes to be burnt. The burning therefore of combustible Bodies must not be looked upon as an action, that at once mixes, blends, and consumes all the different kind of inflammable Elements together; for it appears on the contrary, that this is effected distinctly, and successively.

EXPERIMENT X.

Of Oil and
Alcohol.

Let us now make the same trial upon Alcohol of Wine, so intimately mixed with fine distill'd Oil of Turpentine, that the Mixture appears perfectly homogeneous. This therefore I'll set on fire under the Bell in the same cylindrical Vessel, that we may see what will be the event. In the first place then, we observe rising from this burning Mixture, a beautiful, strong, very bright Flame, which is exceedingly equable, and appears divided at top into two parts. This now, as far as we can discern, does not exhibit the least appearance of Smoke, or generate or deposit any visible Soot; but yet it has so discoloured this white Paper that I held over the upper Aperture of the Bell, that you perceive it is grown quite black; whence it evidently appears, that there immediately upon the mixture arises something in this pure simple Liquor, which is able to disengage itself from the Flame, before it is perfectly consumed. At the same time, however, there is not the least disagreeable

agreeable smell in the Vapours of this Flame; and it wastes away so quietly, that there is not the least noise produced by it whilst it is burning. But in the second place, the Flame having now consumed all the Alcohol that was contained in this Mixture, the appearance you see is intirely altered: for the Oil of Turpentine is now left burning at the bottom of this Vessel, and the Flame of it leaps, sparkles, and makes a noise, sends up a great deal of Smoke, and leaves at the same time some resinous *Fæces*, which are not combustible by this Fire.

EXPERIMENT XI.

I have again mixed some perfectly pure Alcohol, and a very strong alkaline Spirit of *Sal Ammoniac* in equal quantities, and by this means have procured this surprizing *Coagulum*, which was long ago known to *Lully*, and was so much celebrated by *Van-Helmont*. And I think it worth while to expose to your view what I have myself observed in burning this in the same manner as we did the former. What now do you judge will be the consequence? The unforeseen events that so often deceive our expectation in trials of this nature, make you cautious no doubt how you determine. Let us therefore make the Experiment. You'll now answer then, that the Alcohol will be first set on fire; that this being consumed, and dissipated, the Flame goes out; and that then there remains at the bottom the alkaline Spirit of the *Sal-Ammoniac*, almost intire. And this is certainly the case; for you observed, that when this pure *Offa-Helmontiana*, was heated, set on fire, and placed under the Bell, it first of all exhibited a very weak, equable Flame, scarcely visible, without Smoke, or Soot; tho' the inferiour part of the Bell however, was render'd pretty opaque by the exhaling Vapour. You then took notice in the second place, that the Flame grew stronger, more lucid, sparkled, made a hissing noise, grew unequal, and hover'd about, and soon after went out. At last there was diffused a smell of a volatile, alkaline, spirituous Salt; tho' the Vapour collected into a Liquor on the sides of the Bell was almost insipid; and as I shew'd you, there remained at the bottom an exceeding sharp, strong, Spirit of Urine, very volatile, and strong scented. In this Experiment now there's one very singular *Phænomenon* that well deserves our observation, which you'll conceive in the following manner. The Salt contained in the alkaline Spirit of the *Sal Ammoniac*, is much more volatile than even the Alcohol itself; as appears in the sublimation of this *Offa* of *Van-Helmont*, with a very gentle Heat; for in that Operation, a dry Salt always rises first; and yet whilst it is burnt in this manner, the Alcohol in this Mixture is first of all attracted upwards into the Flame, and so consumed; and altho' this Mixture is heated in the brass Vessel, and is at top very forcibly agitated by the Fire, nevertheless, this very volatile Salt is forced downwards with its Water, and is so confined under the incumbent Flame, that it is not capable of disengaging itself, or breaking through it. And this, Gentlemen, I beg you will consider in a particular manner, as it will help us to a knowledge of the nature of Flame, and combustible matter, which has not hitherto been much taken notice of. But since now Camphire is looked upon by many famous Chemists, as a solid *Sal volatile Oleosum*, concentered like *Van-Helmont's Offa*, from two principles, the one a saline, the other an oily one; it will be worth while to try what will be the consequence of burning

Of the *Offa*
of *Helmont*.

burning this under the Bell likewise. We find, then, that upon the application of a Flame to it, it very readily takes fire, and then flames in such a particular manner, that one cannot look upon it without admiration. This Flame, as you see, is white, equable, and long; and terminates in a smokey cone, which is of a great length, and very small. But what a copious, dense, black Smoke does it likewise disperse through all the Bell! and at the same time, as you perceive, there are abundance of little black sooty particles, thrown out on all sides by the Flame, which are so heavy, that they fall to the bottom, and in which there remains the smell and taste of the Camphire, though the colour of them is black. In the bottom, now, there are left hardly any *Fæces*, the Camphire having quite done burning. Hence then we may make some judgment of this wonderful Body; and you'll believe with me, that it is a very perfect simple Resin, or an Oil existing in a solid form.

EXPERIMENT XII.

Of Alcohol
and Earth.

I have here a very pure Earth, *viz.* *English* Chalk, reduced to powder; with which I'll mix some of the same Alcohol of Wine, as intimately as possible, and set it on fire under the Bell, as in the former Experiment. The Alcohol, then, you perceive, burns away intirely, as in the third Experiment; but the Earth, you see, remains at the bottom, perfectly dry, pure, intire, and without any Alteration.

EXPERIMENT XIII.

Of Alcohol,
Oil, Cam-
phire, the
Offa Helmon-
tiana, and
Earth, all
mixed toge-
ther.

But none of these Experiments are more entertaining than that which I am going now to shew you. For this purpose I mixed Alcohol, Camphire, and Oil of Turpentine together, in such a manner, that they were most accurately dissolved one amongst another; and to these I then added the *Offa* of *Van Helmont*, which will bear conveniently enough too, to be united with the former; and I afterwards worked all these, thus mixed together, with some of that fine earth, *English* Chalk, so as to form them into a mass, with which I then mixed some shavings of wood. This, now, I'll set on fire before you, under the same circumstance as in the former Experiments, and beg that you will observe the issue. The Alcohol then you see burns away, in the first place, almost in the same manner as if it had been set on fire by itself. This being consumed, the Oil of Turpentine next takes fire, and sufficiently distinguishes itself by its particular *Phænomena*. In the third place, you see the evident signs of the burning Camphire. And, at last, the alkaline spirit of the Sal-Ammoniac, the shavings of the wood, and the pure Earth, are left at the bottom. You observed here how strong, unequal, and red, the Flame was, and how it crackled and made a noise, whilst it was burning: And what a small quantity of Smoke rose in the beginning; which afterwards increased, by degrees, till it at last became exceeding black, and very thick. Then too there was produced a very black and dense Soot. And towards the end you perceived flakes of Soot flying about within the cavity of the Bell. As for the Wood, you see the Flame has not affected it. From all these things, then, carefully considered, you have, I think, a fair opportunity of discovering the method which nature makes use of in consuming combustible matter by Fire; which certainly is very different from what people generally imagine;

imagine; at the same too you have learned, that there is hardly any thing in all natural philosophy that is more difficult to understand, than what corporeal substance that really is, which is solely inflammable, in combustible Bodies. It is a very easy matter, indeed, to talk of Oils, Sulphurs, and nitrous substances too, which some people have very injudiciously added, and to assert, that these are the bodies that constitute inflammable matter: But to disengage that which is purely inflammable from every thing else, and thus to examine it, and discover its nature, is a very difficult task; nor could I ever meet with any one who could give any tolerable account of it; much less of the alteration that Fire actually induces in it whilst it consumes it. But of this enough.

SCHOLIUM I.

1 In the first place, then, there is discovered in nature, and that produced from Vegetables, by fermentation and distillation, a certain Liquor, of all that we are hitherto acquainted with, the simplest, the most limpid, the lightest, exceedingly immutable, and capable of being mixed with Water and Oils, which is of such a nature, that if it is heated, and has a Flame applied to it, it will easily take Fire, will then totally burn, and feed and support a pure Flame in every point of its surface that is contiguous with the Air, and by this means will have its whole substance gradually consumed into Flame, as its particles, by degrees, come to be contained in this surface: And this will succeed in such a manner, that so long as there is the least drop of this liquid remaining, the Flame will continue to burn, and the very moment it is intirely burnt away, will totally disappear, without leaving the least indication of Flame behind it. We are therefore in reality masters of such a Fluid that properly deserves the name of Aliment or *Pabulum* of Fire; since as far as our senses are capable of discerning, it may, by burning with an open pure Flame, be totally and absolutely converted into the purest Fire. For if you please, Gentlemen, to consider this affair attentively, what does become of all this Alcohol, when it is thus consumed? Is it not changed into the purest Flame? But is not all the Flame that is excited and sustained by this means, exactly the same in every effect as that Fire which we have already described by its proper physical characters? Certainly there is not any one thing taken notice of in our whole history of true Fire, that does not equally hold good of the Flame that is fed by this Alcohol.

Alcohol the
one pure in-
flammable
Body.

2. But we observe here in the second place, that the Fire thus collected about the Alcohol, persisted to be Fire there, so long as any of the Alcohol remained, without adding any other Fire to it, or bringing any to it by any means whatever; so that when once the Alcohol was set on fire, it was constantly present there, nor needed any other Body, or any other *Pabulum* to continue it, when it was thus excited in the open Air.

Which,
without any
assistance,
supports
Flame, when
once excited.

3. Thirdly, there is this farther remarkable, that as soon as ever the Alcohol was consumed, there was not the least remains left of the Fire or Flame; so that it did not continue one moment after that was burnt away. This *Pabulum*, therefore, is the true cause that procured at least the presence of

Which goes
out as soon
as this is con-
sumed.

of all that Fire, in that particular place; for this never remains when that is dissipated.

Nor does it
produce any
Smoke.

4. Fourthly, there is this particularly singular in this Aliment of Fire, and the Flame produced by it, that from the first moment it began to burn, to the moment of its extinction, it never emitted the least Smoke, which every other kind of fuel is observed to do, either at the beginning or the end.

But a Water.

We found, indeed, that a moist Vapour did evaporate from the Flame of the Alcohol; but this being a very limpid aqueous fluid, formed only a perfectly pellucid exhalation, which being afterwards collected, produced a pure simple Water, in which there was not discoverable, the least colour, thickness, or oiliness. This, now, is particularly surprizing, as we don't know of any other liquid, or solid Body, in the whole compass of nature, that will feed and sustain fire, absolutely without any Smoke at all.

Nor yields
any Ashes.

5. We learn again from these Experiments, in the fifth place, that Alcohol does not contain any matter that is fixed and incombustible; for if it is perfectly pure, as it must always be for this Experiment, when it goes out, it won't leave the least spot behind it; nay, it will be totally converted into more Flame, without producing the very smallest quantity of *Fæces*. This again we observe no where else but in Alcohol; for all other inflammable substances leave some *Fæces* behind them, which are not combustible; though indeed, those that are very pure leave but few. *Naptha*, *Petroleum*, and *Camphire*, yield a bright, strong Flame, but they deposite something in the bottom of the vessel where they are burnt, that is not so combustible: Alcohol is the only one that leaves nothing.

Nor causes
any disagree-
able Smell.

6. Sixthly, Alcohol, when it was thus set on fire, did not diffuse any disagreeable Smell, of a different nature from what naturally belongs to it. But this again is not the case with any other combustible matter; for every thing else sends forth a rancid, footy Smell, or an empyreumatical one, when it is reduced to Flames in the Fire. One would thence, perhaps, be ready to imagine, that all the parts of Alcohol are perfectly homogeneous in their natural state, and that they remain so during their burning, and after they are burnt; unless those observations, of Water's rising from the Flame of Alcohol were against it, and taught us, that even in Alcohol there resides something that is not combustible.

It has no so-
lid Substance
formed from
it.

7. In the seventh place, we hence learn farther, that in this Body which alone when exposed to Fire, discovers the properties above mentioned, there is not the least appearance of any solid substance; not even to the sharpest eyes, assisted by the most perfect Microscopes: Hence, therefore, a solid form is no ways necessary to render Bodies a proper *Pabulum* for Fire; but on the contrary, the most liquid one that human observation has ever yet discovered.

But is tena-
cious of Wa-
ter.

8. But we perceive yet again, in the eighth place, that this Alcohol is of such a nature, as to attract, take in, and unite to itself the purest, elementary Water; but that at the same time the Flame excited in the Alcohol, will again attract the pure simple Spirits of Alcohol out of the Water and Alcohol thus blended together, and having drawn them to the surface of the mixture, will then imbibe them, consume them, turn them into Flame, and by that means separate all the pure Alcohol from the Water that is mixed with it; and at the same time refusing to be united with the Water, will repel this, and deposite it in the bottom of the vessel.

9. It's

9. It's surprizing now, in the ninth place, that the very same Alcohol, perfectly the same in every respect, may, by fermentation, and a gentle distillation, be procured from every kind of known Vegetable, that is naturally disposed to ferment: Whereas, excluding the vegetable Kingdom, and the assistance of fermentation, examine all the Bodies you are acquainted with in the universe, and you will not find one that is possessed of the properties above described.

And is a true Offspring of Vegetables.

10. But farther, in the tenth place, from what has been observed in these Experiments, we are of opinion, that though Alcohol be ever so pure, yet there is in reality some difference in its constituent parts, though not discoverable by any other Art than setting the Alcohol on fire; for by this means it is separated into a Water, which when alone extinguishes Fire, and into an inflammable part, which is truly consumed in the Flame, and reduced to such a subtilty, that it afterwards becomes quite invisible. *Van Helmet*, indeed, has told us, that by the application of Salt of Tartar to the purest Spirit of Wine, he could instantly convert it half into Water, the other part being retained and held fast by the Alkali; but I always doubted, whether he should not be understood to speak there only of rectified Spirit of Wine, of which it is strictly true, and not of pure Alcohol, skilfully prepared, of which I believe no body has hitherto ever made it appear. If these things, now, are really true, as they certainly seem to be, then Alcohol would very much resemble Sulphur, as both of them would be totally consumed in the Fire; both of them would yield a blue Flame; be resolved into one invisible part, that is inflammable; and whilst they are burning, yield another part that extinguishes Flame; which in Alcohol is a mere inactive Water; in Sulphur, an exceeding acid Salt of Vitriol diluted with a portion of Water, whose Vapour is hence perfectly suffocating.

But compounded.

Other substances changed in the Fire like Alcohol.

11. In the eleventh and last place, we hence farther infer, that solid compound Vegetables, whilst they are burnt, are changed and agitated in the same manner; inasmuch as their inflammable part alone is consumed by the Fire, the rest being dispersed into a matter, which if it is again collected, becomes visible, nay and sometimes combustible too; or else, being converted into a fixed one, which we then call Ashes, or *Fæces*.

SCHOLIUM II.

1. In the first place, then, Alcohol seems to have something of the nature of Fire. This appears evident from many of its effects. Both of them coagulate Blood, *Serum* of Blood, and bile, and parch up, as it were, the flesh, nerves, and *viscera* of Animals, whites of Eggs, and Bread. Is Alcohol, then, a magnet to Fire? It is certain, it has a power of attracting the light that approaches it. Does the mixing Alcohol and Fire together cause an effervescence, and by this effervescence produce Flame?

Alcohol agrees with Fire.

2. Secondly, all other inflammable Liquids, let them be ever so subtil, if they are burnt in the manner proposed, yield a visible black Smoke and Soot, and leave some *Fæces* behind them, which are not perfectly combustible. This incombustible matter in the purest Oil is at first a mere Earth, to which there still adheres some portion of Oil, in which respect, as it retains the nature of a Coal, there is yet something inflammable remaining in it. But when these Oils are often depurated by an artful distillation, they always deposite an Earth,

Other Pabula produce Fæces.

grow constantly thinner, become more inflammable, produce less Smoke, Soot, and Ashes; and thus continually come nearer to the nature of Alcohol: Repeat this operation, in the mean time, ever so often, yet you'll never reduce them to such a subtlety that they'll bear being diluted with Water.

What would
be the effect
of Alcohol
upon Fire if
it had no
Water mixed
with it?

3. Thirdly, that Body, that we have discovered to be absolutely inflammable, so that it will totally feed and support Flame, yields not the least Smoke in this Fire, produces no Soot, nor leaves any *Fæces* behind, but as far as our senses are able to penetrate, has its whole substance converted into Fire; or at least when it is set on fire affords us nothing but a pure Water. If it were possible then by any Art to separate that part of the Alcohol, which is perfectly combustible, and hitherto unknown, from the Water that appears to be collected during its burning, and this afterwards should be applied singly to pure Fire or Flame, what would be the consequence? Would it then burn successively, as it does now it has a mixture of Water with it? Or would it like lightning be consumed in a moment? A close meditation, certainly, suggests a good many things upon this head; but this pure speculative knowledge, must not be too much indulged, but must give place to that more solid one founded upon Experiments.

The true
Pabulum of
Fire vanishes
in it intirely.

4. From what has been demonstrated, we may venture to assert, in the fourth place, that that part of inflammable Vegetables, Alcohol, or Oils, which in reality is not combustible, is either an intimately united Water, a Salt, or an Earth. These, then, if they could be perfectly separated from Oil, or Alcohol, the remainder would be that simple pure matter, which is totally convertible into the purest Flame, without *Fæces*, Smoke, or Soot. In *Alcohol*, certainly, that very subtil limpid Vapour, which is collected in the Bell, whilst the Alcohol is burning, is produced only from that watery part of the Alcohol that is not inflammable. All Ashes, Smoke and Soot, therefore, that are mix'd with inflammable substances, consist solely of Water, Salt, or Earth, nor of any thing else in nature, that we are acquainted with.

Whence
arise Smoke
and Ashes?

5. In the fifth place, we learn farther, that the quantity of Smoke, Soot, and visible Vapours in burning Vegetables, will be always so much the greater, as they contain more Water, Salt and Earth, in proportion to their Oil and Alcohol; for this is found to be the case universally, as well as in the Experiments we have been making. That is to say, such Bodies, when they are on fire, yield some parts, which though they are attracted into the Flame, and agitated there with a violent rotation, yet will not be converted into that subtil evanescent matter, but will either be expelled upwards out of the Flame, or else will fall to the bottom. If you compare a piece of very green wood laid on the Fire, with another in the same circumstances, that is so moderately dried as to retain its Oil, you will easily see a demonstration of the truth of what I asserted.

What are
the less com-
bustible
parts?

6. Sixthly, we find it is possible, that the parts of a combustible Vegetable that are not inflammable, *viz.* the Water, Salt, and Earth, may so far exceed those that are, that the Alcohol, or purest Oil, will not be able to flame in the Fire, but only send forth a mere Smoke. Alcohol, if it is mixed with an hundred times its quantity of Water, will not take fire, tho' it is heated hotter than Alcohol is when it boils; and if it is thrown upon the Fire it will extinguish it. A piece of Wood that is very oily, but at the same time very green, and full of Water, yields a large quantity of Smoke, but no Flame.

In

In fat clayey Potter's Earth, there is an Oil, which will take fire when alone, though when it is united with the Earth in such a manner, that there is but a very small quantity of Oil to a very great one of Earth, it refuses to burn. And in every instance you examine, you'll constantly find this assertion hold true.

7. But, in the seventh place, I think there is nothing more remarkable in this affair than this, which has been already proved in the former Experiments, *viz.* that if Fire is applied to a combustible Vegetable, composed of combustible and incombustible parts, and so far exerts its power upon it, as to set the combustible part on fire, and at the same time, and by the same action, to minutely divide and agitate the incombustible one; then the Flame that is thus excited from the combustible and incombustible matter agitated together, will be much stronger than would have been produced by the combustible one, if it had been separated, and set on fire by itself. For we always find Flame to be so much the weaker, as the matter is purer of which it consists. The Flame likewise generated from such a mixture, will always be more unequal than that which rises from a simple inflammable Substance: and hence, such a fire always makes more noise whilst it is burning, so as sometimes by its crackling and flying about to be very troublesome. At the same time too it produces more Smoke, and a greater quantity of *Fæces*. The more incombustible matter now there is in any Body, the more violent will all these *Phænomena* appear, if you can but set it on fire, and make it burn.

The greatest strength of Fire rises from the parts that are not combustible.

8. But again, eighthly, it is universally certain, that the denser, closer, or heavier the incombustible matter is, that is united with the Oil, the stronger will the Flame and Fire be that are produced by such a Body, if set on fire. So that not only the solidest part of any particular Vegetable yields the strongest Fire, if compared with the rest, (for who, that wants a strong Fire, ever prefers the Flowers or Leaves of Trees to their solid Wood) but also of different Woods compared with one another, we observe those afford the greatest Fire that are most ponderous; those the weakest, that are lightest. Thus, for Instance, compare Cedar with Sallow, or *Sideroxylom* with Poplar, and you'll find the strength of the Fires they excite will be in proportion to their weights.

And the *Pabulum* that is heaviest.

9. But, in the ninth place, we must here have regard to the doctrine we laid down before, that no Vegetables will burn, 'till they are heated to that degree, which is necessary to make Oil begin to boil. Light ones, indeed, will grow hot with the same Fire sooner than heavy ones; and therefore these will soon take fire, but those more leisurely: And for this reason you see that nobody makes Matches with solid Oak, but with spongy Reeds, or something of that nature. But the sooner they take fire, the weaker will be the Flame; and on the contrary, the longer they are before they light, the stronger and more durable will the Fire be that is raised by them: And hence, of consequence, the heavier the Wood is that is to be burnt, the more pre-existent Fire is always requisite to set it on fire; and without this it will not grow hot, ignite, and kindle.

No *Pabulum* of Fire burns of itself, but by means of Fire.

10. In the tenth place, these things being considered, it follows, that in the burning of Vegetables, all the combustible parts are not consumed at once, but gradually, by the successive action of the Fire. And here, during the time that the Fire is thus acting, that combustible matter, which is purely inflammable,

Burns successively, and in order.

flammable, and consequently the lightest, always takes fire, is separated and changed first; for this sort grows very soon hot, is first put in motion, and is more easily extricated than any of the other. This being consumed, that matter is next agitated, heated, set on fire, and separated, that possesses the next degree of inflammability to the former. This then being likewise burnt away, that last of all begins to burn, that of all is the least combustible. And it appears by an infinite number of Experiments, that this ultimate combustible matter in Vegetables is a small quantity of Oil, firmly united to a great deal of fixed Earth. Hence, then, we see the reason why this Oil cannot be separated from this Earth, in close vessels, where there is no admission of fresh Air. And hence, likewise, we know that this last combustible matter will never yield a violent Fire; for whilst it is burning away, a small portion of the combustible Oil is gradually distributed through a larger one of the incombustible Earth; and hence it may be made red hot, and lucid, but will very rarely produce Flame.

And most at
one certain
time.

11. From what has been said, therefore, we perceive, in the eleventh place, that Fire which is raised by compound combustible matter, will be most violent when it is in the middle of its burning, *viz.* when all the elements are flaming in the most vivid manner: Whereas towards the end, if you would keep Fire up brisk, it is necessary to rouse it with a pair of Bellows; for then the earthy, saline, fixed parts, which are interspersed throughout, in the form of Ashes, always begin to damp the force of the Fire, which is now supported by a smaller quantity of Oil.

Weak in
Alcohol.

12. In the twelfth place, we are farther certain, that the purest Flame of all, *viz.* that produced from mere combustible matter, without the mixture of any other particles with it, will never yield a very strong Fire; for it appears on the contrary, from former Experiments, that the purest *Pabulum* always produces the weakest.

What the in-
combustible
part does in
Fire.

13. Hence, therefore, contrary to the common opinion, we infer, in the thirteenth place, that the strength of Flame depends as much, nay, perhaps more, upon the incombustible elements in the burning matter, than upon those that are in reality truly combustible. And therefore the quantity of Fire in Flame raised from combustible Bodies, is more collected within the compass of this Flame, by the rotation of the immutable corpuscles that are mixed and whirled about with the rest, than by that fine volatile simple oily substance, that is agitated likewise by the Fire, in the same space.

Hence a
two-fold
matter of
Flame.

14. In the fourteenth place, then, why may we not suppose, that there are two causes exerting their united forces in material Fire; the first, elementary Fire, and its proper simple *Pabulum*, *viz.* perfectly pure Alcohol; the second, other kind of particles dispersed through the Fire thus produced, and which one would call pure Fire, which, though they are not able to sustain elementary fire of themselves, yet being agitated in the former pure Flame, excite a violent action by means of their vibratory motions, which is very often much greater than could ever be brought about by this agitating cause alone. That you may thoroughly take my sense, Gentlemen, please to reflect upon half an ounce of Gunpowder set on fire in the open Air; in this case, you know, a Flame will burst forth on all sides, and be over in a moment: But, now, if you put the same into a narrow cylindrical Tube, with some Bullets over it, and so fire it,

it will then, by its own proper motion, force these hard thick Bodies out of the Tube, with an incredible *impetus*, hardly any of which was observed before in the Particles of Gunpowder, tho' they were, by being set on fire, reduced to their most subtil Elements. In the same manner, therefore, you conceive, that the hard incombustible Particles of Vegetables being swiftly whirled about, and vibrated in the rapid Flame, must of consequence add a vast deal of force to it.

15. In the fifteenth place then it appears, that the greatest strength of this Fire, may be rendered more intense by Water, Salt, and Earth, if they are intimately mixed with the combustible Matter, and with one another in this pure burning Fire; provided the force of this Fire is great enough to put these Bodies into a violent motion.

Whence
Fire is in-
creased.

16. We observe again in the sixteenth place, that some cause is absolutely necessary, and that there really is some cause which continues this Flame, or keeps in this Fire, when it is once kindled. And one effect of this cause, must be the keeping the *Pabulum* of the Fire whilst it is burning, closely apply'd to the Fire itself, so that they shan't be separated from one another, which otherwise would instantly happen from the proper power of the Fire. But again, the hard incombustible Particles too, that are agitated by the action of the former combustible ones, must be likewise confin'd by the same cause within the compass of the burning Fire; that these likewise may not fly off too soon, but be compell'd to remain in the place where they are mov'd in such a manner, as by this very motion to be continually expelled out of it: For unless this was effected likewise, all this matter must of consequence be immediately dispersed by the agitation of the Fire, and thus all the vibratory force of these Corpuscles within the sphere of the Fire, would be lost in a moment. Hence, therefore, it appears, that all Fire would be momentaneous, was it not for this uniting, applying, and compressing power. It is probable, however, that this cause which compresses these Bodies together, must not act with so much force, as to unite them into one immoveable Mass; for by this means the lighted Fire would instantly be put out: But such a pressure only seems requisite, that the grosser Particles, whether combustible, or incombustible, as they are agitated in the Fire, may successively disengage themselves in proportion, as others begin to be put into the same agitation. Now for this purpose such a cause appears vastly best suited, that acts with a reciprocal, oscillatory compression, and relaxation, itself all the while remaining perfectly fluid, and incapable of being consolidated. Such a one now is our Atmosphere, which perfectly surrounds us, and always compresses us. Before we proceed any farther, therefore, it is necessary to have a just notion what assistance the Atmosphere really gives towards the support of Fire; which I shall endeavour to explain as evidently as possible in the following manner.

The cause of
uniting Fire
with its
Pabulum.

Let us suppose a Fire kindled upon an iron Plate with the choicest Wood, and burning perfectly quite through, upon a Base a Rhineland foot square. Upon this Base then there presses such a weight of the Atmosphere, as is contained in a prism of Air, whose Base is of the same magnitude. The weight, however, of this Prism, appears by the Barometer, to be different at different times; tho' the excess of its greatest weight above its least, is scarcely ever more than one tenth part of the whole. Let us imagine then the Atmosphere at this

The Phys-
ical manner
explained in
a common
Fire.

time to be heaviest, that is, the Mercury to stand at the height of 30 inches in the Barometer. Hence, if we suppose the specific gravity of Mercury, to be to that of Water, as 14 to 1; and a cubic foot of Water at the same serene time, to weigh 64 pounds *Troy*: Of consequence, the pressure of the incumbent Atmosphere upon this square Base, will be equal to the weight of 2240 pounds *Troy*. This Fire-place, therefore, is pressed upon by this vast weight at this time. But in this very place, by supposition, there is burning a flaming Fire, which repels from it on every side, and elevates with an incredible force all this bulk of the Atmosphere that is in its way, and at the same time expells from the space in which it is burning, all the heavy matter of the Atmosphere; and hence, of consequence, must increase its weight. It appears then, from the doctrine of Hydrostatics, that the resisting Fluid of the repell'd Atmosphere will press upon every point of the burning Surface; which therefore will be as strongly compressed by this weight, as if it was confined in a Furnace so strong that it would not break with the weight of 2240. All the inflammable Particles, therefore, that are agitated in this Fire-place, by the force of the elementary Fire collected there, and all those Corpuscles likewise that are incombustible, but are put in motion by the action of both the former, as they endeavour to disengage themselves from the Fire, are repelled towards its center by this vast weight, and that constantly, and exactly, so much the more as the Fire exerts itself within more violently. Hence, therefore, you perceive, that the Elements of the Fire itself, and the Particles of the combustible Matter, must be applied to one another, and compressed together with this prodigious force, and at the same time must undergo a very rapid concussion, and circumvibration among themselves from the incredible expansion, and active power of the Fire. Must there not therefore be excited a prodigious attrition in this Fire among these solid Particles? And will not the compression of these to one another, whilst they are thus agitated, increase in proportion to the greater attrition generated by the Fire? But the Fire is continually acting upon the Atmosphere by unequal concussions, which always makes an equal resistance: And hence this collection of Fire is beat upon by the continual return of the Atmosphere, with as much force, as if it was every moment struck upon with a Hammer of 2240 pounds. But we are farther certain, that the Air boils very violently over Fire, as one may perceive by exposing a live Coal to the Solar Rays, and then looking upon it towards the Sun, and hence the *subsultus's* of this very elastic Fluid, boiling thus strongly, must be still so much the more violent and frequent upon this Fire. If now, in any part of this burning space, the Fire yields less resistance than in the rest, then, the Air being driven thither by the weight of the Atmosphere, must rush in with a prodigious violence, and being instantly rarefy'd, and repelled again, will produce a continual strong oscillatory motion round the whole compass of the Fire. So long therefore as there remains Fire enough in this Fire-place to excite a Flame with its proper *Pabulum*; so long as the other incombustible Particles can be forcibly agitated by the action of the Flame; and so long as they continue to be pressed together by the weight of the Atmosphere, that they are not able to extricate themselves: So long the attrition excited in this space, will be so great, as to collect such a Fire here, as is sufficient to continue the like Flame. But on the other hand, as soon as ever the active elementary Fire, the true inflammable

Pabulum, or the other grosser hard immutable Particles that should be agitated among the other, are wanting, then the Fire presently grows weaker, and goes out: If the pressure of the aerial arch too is by any means lessened, or made less ponderous, the Fire immediately likewise loses its strength; and if it happens to be diminished to a very great degree, then the Fire, *Pabulum*, and other Particles, instantly fly asunder, and are dissipated. Hence in *Boyle's Vacuum*, all Flame, and then sparkling Fire, soon goes out; as there is nothing there to keep the Particles apply'd to one another. And from the same principles we see the reason why a moderate Wind very much increases the force of Flame; for it is then affected in the same manner, as if it was compressed by a heavier Atmosphere. If the Wind, indeed, blows so strong upon the Fire, as to destroy this arch of Air that surrounds it, the Flame will, then, be extinguished in an instant; tho' perhaps the next moment it will be raised again by the same blast that blew it out. Hence, therefore, if you blow a Fire with a pair of Bellows, so as not to put it out, by breaking this arch with the too great force of the Wind, the application of the Particles to one another, will by this action be stronger, and consequently the Flame more violent. But if two large pair of Bellows are placed in an opposite direction, and blown strongly upon the same Fire, then the Flame, excited by this means in the middle of them, will be prodigious intense, fit for fusing of Metals, and other Operations that require a violent Heat. This you may see at any time among your Workers in Gold, and other Metals. And from these Principles we see, lastly, why Fires burn more fiercely than usual, when the Air is contracted by a very sharp Frost; for then, the aerial Arch surrounds the Fire proportionably closer, and confines it more powerfully, and by this means prevents the Corpuscles, that are flying about and torried in it, from extricating themselves, till by the long continued action of the Fire, they are reduced to such a subtlety, as to be able to pass through the Air itself, and so to make their escape. But at the same time, likewise, the Fire exerts itself with the greatest force in its upper parts, and less about the circumference of its Base; and hence the Air finding there the least resistance, presses both the Flame and Fire upwards; and since the Fire is most condensed, and consequently strongest in the middle, hence the Flame will rise higher in the middle than on the sides where the force of the Fire grows gradually weaker; and of consequence will dispose itself into a pyramidal figure. But as soon as ever now the Surface of Fire is surrounded with such a Body as cuts off the communication with the Air, then the Fire of the *Pabulum*, and the agitated Particles, soon lose their motion, the Flame goes out, and the Fire itself is soon extinguished, except you remove the cover, and let in a free Air; then indeed, it will presently burst out into Flame, or at least may be raised to a bright, burning Fire.

17. But in the seventeenth and last place, if we carefully consider every thing that has hitherto been demonstrated, or delivered, it does not appear, that there is any Body in Nature, which being committed to elementary Fire, will in reality be converted or transmuted into Fire: For my own part, I have examined every argument that offers itself, and have not been able to find one that proves it. Hence, therefore, I dare not by any means assert, that either Alcohol, Oil, or any other Matter, becomes pure Fire by being burnt. I confess, indeed, that perfectly combustible Bodies are so changed in Flame, as to get

The *Pabulum* of Fire does not become Fire.

get beyond the reach of our present perception ; but if we would have a proper regard to truth, we must not hence absolutely assert, that they are therefore converted into Fire itself.

Of the Pabulum of Fire in the Animal Kingdom.

Combustible Matter from Animals.

Having thus then carefully treated of the combustible Matter discovered in the Vegetable Kingdom, we come now in the next place to examine that which is contained in the Animal one. But here, as every one knows, that the Bodies of Animals consist of Vegetables reduced by their concoctive powers to proper nourishment, hence this head likewise is almost intirely exhausted in our History of Vegetables. And indeed, if we will credit Historians, the humours of the animal Body have sometimes been advanced to that prodigious subtil oily nature, as to take fire like Alcohol, and yield a weak pure Flame. We have accounts too of Flames kindling about the exhalations of Men's Bodies ; and *Helmont* takes notice, that the Wind of the Bowels being discharged upon a Candle, actually burned, and was converted into Flame. These things, however, if they are true, certainly happen very seldom. As for the other Oils of Animals, they differ hardly any thing in respect of their inflammability from those of Vegetables, and therefore the repetition of the Observations already laid before you, will here be needless. In these likewise we discover Water, Spirits, Salts, Oils, and Earth : And the nature, preparation, depuration, and effects of them in the Fire, are perfectly the same in Animals, as they are in Vegetables. If you'll please therefore to recollect what we have before delivered of the latter, and apply them to the former, the doctrine of these too I think will be sufficiently evident. You may possibly, indeed, surmise, that the *Phosphorus* procured from Animals, is an instance of some other inflammable Matter in Animals, than what is observed in Vegetables : But this may likewise, by the chemical Art, be extracted from the pinguious Coals of burnt Vegetables ; especially if they are of that kind, whose Juices very nearly resemble the Humours of Animals, as has long ago appeared in the Mustard. Any farther inquiry therefore upon this head, I think, is absolutely unnecessary.

Of the Pabulum of Fire in the Fossil Kingdom.

It is particularly remarkable now, that the very same law of combustibility, which we took notice of in the two former, holds true likewise, even in the class of Fossils. For here it is observed in the same manner, that the Oils alone are inflammable, the other parts not at all ; and that all these Oils likewise yield so much less Smoke, Soot, and Ashes, as they are more subtil and lighter ; and on the other hand so much more, as they are thicker, and more ponderous. Possibly in these too, there may be something that almost arrives to the subtlety of Alcohol ; tho' at present, I confess, I don't know that ever any body has discovered an Oil in them that would bear to be diluted with Water.

Naptha like Alcohol.

I have read, indeed, of Fluids sometimes distilling from rocks, that by the application of a lighted torch to them, would take fire, flame, and burn ; and have likewise met with accounts of Streams running from Fountains, that in the same manner might be raised into Flames : But whether the same Liquor that would thus take fire, would bear to be mixed with Water too, the persons

sons that mention these things take no notice. As for the *Naptha* of *Babylon*, Historians tell us, that that was so subtil, volatile, and easily inflammable, that rising, and being dispersed through the Streets, it would take fire from the Torches that were carried about in the night, so that it seemed as it were to burn spontaneously, covering all the Surface of the Ground with a blue Flame that was not very strong, and but little pernicious. This Liquor, therefore, on account of its exceeding subtilty, seems to come very near to the nature of Alcohol; for the same thing possibly might happen to our Alcohol, if it was distributed about in that hot country, in the same manner as we saw it take fire by the application of a lighted Match to its Vapour, when it exhaled into the cavity of the Bell. As it is hardly possible, however, to procure this sort of *Naptha* genuine, at any price, hence we can scarcely come at any certainty about it: As for that which is commonly sold about under that name, it has never any such degree of inflammability, but is always thicker, and more tenacious.

Petroleum is likewise very subtil, but no ways comparable, either to the *Naptha* of the Ancients, or the Alcohol of the Moderns. This, however, if it is depurated by proper distillations, grows gradually more subtil, and sooner inflammable, tho' it at last still remains an Oil, nor ever is reduced to Alcohol. And here again, as we observed in Vegetables, the finer, subtler, and lighter the oily combustible Matter of Fossils is, they always yield so much less Smoke, Soot, Stench, and *Fæces*; but at the same time the Flame is always in proportion the lighter, purer, and weaker.

As for the inflammable Fossils that have a mixture of a gross heavy incombustible Matter in them, they always take fire with more difficulty, and require a strong blast of Wind, or Bellows to make them burn strongly; but then the Flame and Fire that is raised from them, is so much the more violent, as we see evidently in the burning of the fossil Coal: Such Bodies likewise emit an exceeding black, thick Smoke, (which has somewhat of a disagreeable smell, and produces a good deal of Soot) and leave behind them a large quantity of Ashes, which generally have an insipid taste, but are very heavy.

Lastly, amongst the fossil Bodies, that afford a *Pabulum* for Fire, there are some which consist merely of a perfectly combustible Oil, united with an exceeding acrid, acid Salt. By these you'll easily perceive I mean Sulphur: Whilst the oily combustible part now of this burns away in the Fire, the other very acid saline one (which exceedingly resembles that Liquor which is forced from Vitriol by an intense Fire, and is called Oil of Vitriol) is incombustible in the Fire, and being collected by itself in form of a vaporous Fume, and then suffered to cool, goes by the name of Oil of Sulphur *per Campanam*. If this is then accurately freed from the Water that is mixed with it whilst the Sulphur is burning, and thus rendered pure in its kind, it appears to be the heaviest of all Fluids next to Mercury, and the most acrid we are acquainted with. And hence it happens, that Sulphur will not yield Flame, 'till it is first melted, and consequently, made very hot; but as soon as ever the Flame is excited by the inflammable part, the very ponderous, corrosive, saline, acrid one, being agitated, attenuated, boiling in the Flame, and being hence driven outwards, produces at first in the Flame, a very violent Fire, tho' afterwards, indeed, when by the continued action of the Fire it is so divided, as to be able to break

through the Arch surrounding the Flame, it floats about freely in the Air, and produces a Vapour that powerfully inflames all the parts of Animals it comes at, and hence, if it is apply'd to their Lungs, quickly suffocates them. And as for other Bodies that are exposed to the Fumes that rise from burning Sulphur, they are by this means surprizingly altered, and that, differently, according to their particular natures, and the relation they bear to the acid, which is the most so of any we know of in nature. These effects now produced by the Fire of burning Sulphur, are generally ascribed to the elementary Fire, tho' very wrongly: For these ought to be perfectly distinguished, and it should be constantly remember'd, that these effects are partly to be ascribed to the elementary Fire partly to the combustible portion of the Sulphur, and partly to the Acid that is by this means rendered volatile. I don't think it necessary now to explain particularly what *Phænomena*, *Bitumens*, *Asphaltus*, *Pissasphaltus*, and *Pix Judæicus*, produce in the Fire; or what they suffer there. I believe this will be so easily understood, from what we have delivered already, that we need not stay upon this head any longer. It is sufficient to take notice, that in all these there is a mixture of pinguious fossil Oils, generally acid Salts, Earth, and frequently something metalline or rocky; and that in them all, that only is truly inflammable, which is of an oily nature. As for the other parts of the composition, they afford a sort of *Spicula* which fly about in these fires, and by their vibrations, surprizingly increase their violence, or give them some singular physical power upon some particular sort of Bodies. These then being dispatched, I think we have sufficiently treated of the nature of the *Pabulum* of Fire, for our present purpose. And now, therefore, from this whole History of Fire, we may fairly deduce the following Corollaries, as truths which have been evidently demonstrated.

Fire rare-
fies all Bo-
dies.

1. Simple, pure, elementary Fire, insinuates itself into, and rarefies all Bodies in the universe that fall under the observation of our senses, whether they are solid, fluid, or compounded of both.

When alone
always equa-
ble.

2. This power is so proper to Fire alone, that it is not common to any other Body in nature, that human knowledge is yet acquainted with. The effervescences, fermentations, and particular rarefactions of Bodies, do not prove the contrary.

3. This Fire, as distinguished by this property, is always present in every place, as well in the solidest *Plenum*, as in the most perfect *Vacuum*.

4. And this Fire is every where distributed in the most equable manner, 'till there arises some cause that is able to collect it, thus dispersed, into one particular place.

Collected by
attrition.

5. The first of these collecting causes, and perhaps the principal one, is the attrition of some sort of Bodies with one another.

Expands it-
self.

6. Fire from its own nature is moved equally every way; or at least, is spontaneously expanded in this manner.

7. It's possible, however, that this motion, or expansion of Fire, may be so determined, that it may be directed in parallel, or converging lines; and this is a second very common method, by which Fire is likewise collected.

May be de-
termined by
the Sun.

8. The principal cause that compels Fire, of itself thus undetermined, into a parallelism, is the Sun; for this Body is found to be of vastly the most consequence for this purpose.

9. The

9. The cause then, that makes these Rays of Fire, converge, and unite in a small space called a *Focus*, is either reflection, or refraction.

10. And hence again we have a third manner of collecting Fire.

11. The rapid percussioſion of the coldeſt Steel, againſt the coldeſt Flint, in the coldeſt place, and weather, will in a moment produce the moſt intenſe Fire: This therefore furniſhes us with a fourth.

12. This Fire therefore does not any ways depend upon the Sun, with reſpect to its Matter.

13. It will continue, however, ſome while in Bodies, being united to them during that time.

14. And the time of its continuance, will be proportionable to the denſity of the Body with which it is united.

15. There is not, however, any Body yet known, that is able to retain Fire always, when it is once communicated to it.

16. This Fire now deſcribed in theſe 15 Particulars, is in reality that which every Body calls elementary Fire.

17. There is, beſides this, likewise, as people generally imagine, another Fire ſupport- fort of Fire, which conſumes combuſtible Bodies into ſomething inviſible, ed, which is ſuppoſed to be fed, and ſupported, and is falſly believed to convert combuſtible Matter into Fire itſelf: This is thought to be produced, when Fire firſt exiſting, is apply'd in the open Air, to a proper *Pabulum*. And by this means we have a fifth manner of collecting Fire; and that, the moſt common of all.

18. There is diſcovered, now, but one kind of matter in the Univerſe, By Alcohol. which will feed Fire in ſuch a manner, as to be ſo intirely conſumed by it, that nothing will be generated by it, but pure, ſimple Flame, and nothing at all will remain behind, when the *Pabulum* is burnt away, and the Flame goes out: And this is pure Alcohol alone.

19. Other Bodies, however, being mixed with the true *Pabulum* of Fire, And Oil, remains the ſame, whiſt they are agitated by and in the Fire, together with this *Pabulum*, are capable of conſiderably increaſing its power.

20. Upon the kindling a common Fire, therefore, there is no Fire created, or generated *de novo*; nor is there any deſtroy'd when it is extinguiſhed; nor does it undergo any alteration; nor perhaps has it any weight. The contrary, indeed, to this laſt aſſertion, ſeems to be grounded upon ſo many, and ſuch ſolid arguments, that after Mr. Boyle had publiſhed his Treatiſe, *Of the Ponderability of Flame*, it was thought there was hardly any room left to doubt of it; much leſs ſtill, ſince we have been favoured with thoſe Obſervations of Monſieur Homberg, concerning the great weight that is added to incombuſtible Bodies, by pure elementary Fire, where there is not the leaſt Mixture of any corporeal *Pabulum*; for by theſe, indeed, it ſeems plainly to appear, that elementary Fire may on a ſudden be ſo abſolutely concreted with Bodies, as to increaſe their weight very conſiderably. Theſe Experiments, therefore, both candour and love of truth, oblige me to lay before you. Firſt, then, Mercury, that was perfectly depurated by the help of Metals, and thus rendered more liquid than the native, being for a convenient time digeſted in a pure Veſſel by the Flame of a Lamp, was converted into a black, white, or red powder, and in the operation was ſomewhat increaſed in its weight. Secondly, the famous *Du Cloſius*, Nor becomes heavy.

demonstrated before the *Academy of Sciences*, that Antimony calcined in the *Focus* of a burning *Speculum*, weighed a sixteenth part more when it had been thus exposed to the Fire, than it did before, notwithstanding so much in the mean time was dissipated in form of Smoke. But the egregious *Homberg* prosecuting the inquiry still more accurately by the assistance of the *Focus* of *Tschernhausen's* Convex, directed into a hollow Vessel, seems to have made it much more certain, that true Fire may be united with Bodies; that by this union it will be concentered with them; that by this means it will produce with them a new Body perfectly different from the former, and add a very considerable increase to their weight. For this purpose, therefore, four ounces of powdered *Regulus Antimonii Martialis*, were exposed to the *Focus*, as it was called, of the great dioptrical Glass of the *Duke of Orleans*, at a foot and a half distance from the true *Focus*, and was there frequently stirred about with an iron Spoon, 'till it would not smoke any longer; for at the beginning, and for some time after, it emitted a large quantity of dense Fume. This Powder then, was found to weigh four ounces, three drachms, and some grains; so that it had gained about a tenth part of its whole weight. The same afterwards being exposed to the true *Focus* of the Glass, was instantly put in fusion, and by this means lost three additional drachms, and grains, together with an eighth part of the first weight of the *Regulus*. Hence, therefore, it should seem probable, that the *Regulus* lost half an ounce by the Fumes of the first calcination, and gained three drachms of Fire, and that this fusion afterwards took away those three drachms of Fire that were thus superadded. The Preparations of *Minium*, Quicklime, and other substances in the Fire, seem to evince the same thing. That this now was really the event of these, and some other Experiments of Mr. *Boyle*, I make no doubt; nor do I in the least call in question the capacity of these great Men for making these Experiments, or their integrity in relating them. This, however, in the mean time, is certain, that a Mass of Iron of eight pounds, being made perfectly red hot quite through, did not acquire any additional weight. The degree of Heat, now, or quantity of Fire in the *Focus*, mentioned in M. *Homberg's* Experiment, which was a foot and half distant from the true one, was by no means so great as that of this Iron; and yet I weighed this Iron when it was red hot, and left it in the Scale till it was quite cold, and there was no alteration in the weight. That calcination was performed in an iron Ladle, or an earthen Vessel, and the matter to be calcined was continually kept stirring with an iron Instrument: Hence, therefore, the quantity of Powder might be augmented. The true *Focus*, in an instant, is supposed to expell again the Fire that was thought to be united with the Antimony. But who can venture to assert, that this was actually Fire? All Bodies thus calcined in the same Fire, do not acquire the same increase of weight, but those only that abound with a corrosive Sulphur, as Antimony, Lead, Tin, Iron, and Orpiment. Hence, therefore, may be, this external, or additional part, is obtained by the Sulphur's corroding, and rubbing of the Particles of the other Bodies, and thus mixing them with the Matter to be calcined. And as for the increase of weight that Bodies are found to acquire, when exposed to the Fire in glass Vessels, supposed to arise from the insinuation of the Fire into them, this is so inconsiderable, that it may possibly be ascribed rather to what may be communicated to them from the Glass, than to the Fire itself. These

Experiments

Experiments certainly ought to be made on purpose, and with the utmost caution; as nothing is more easy here than being deceived. Lest, however, I should be suspected of being too obstinate, or partial, in my opinion, give me leave to refer you to *M. Du. Hamel*, a Gentleman particularly careful in relating Experiments, in the *Mem. de l'Ac. Roy.* p. 14, 15. where you will see how very prudently he himself raises some difficulties after he has recited his Experiments. And there too you will meet with some other Experiments of the famous *Bouledue*, which almost evince the contrary.

21. It has appeared farther, that this elementary Fire may be increas'd in a particular place, to a prodigious degree; so that by this means, certain physical effects, not easily understood in any other way, may be produced, observed, and reduced to a natural History. This we see evidently in Dioptrics and Catoptrics; but more remarkably still when both their powers conspire in the same action. And of the effect of this Fire we take the more particular notice, because as there is here neither any heterogeneous mixture, nor any material *Pabulum*, hence the purest elementary Fire exerts itself alone, and thus plainly teaches us what is the proper power of simple Fire, when bodies are expos'd to it. If we nicely examine, now, the effects of this Fire, we shall find they may be reduced to these two: First, both Liquids and Solids, that are volatile in the Fire, are dissipated by it in a moment; and secondly, almost all fixed Solids, that have hitherto been examined in it, run into Glass. The most intense elementary Fire, therefore, that has ever yet been discovered, either dissipates, or vitrifies. But, as I have often observed before, the utmost that we know of this Fire, is only what we are able to learn from the greatest degree of it, that we can excite, by the assistance of those Arts which we are at present masters of; and therefore, as in the nature of things it may by collection be increased, and rendered more intense through an infinite number of degrees, we must not imagine, that the possible action of Fire is as yet determined. On the contrary, certainly that force of Fire which is with us at present the greatest, is scarce, as one may say, a beginning of what may possibly be generated. Since, then, we see in that small increase of it, which is contained betwixt the greatest Cold and the Heat of that *Focus*, which is produced by the union of *Vilette's* and *Tschirnhausen's* together; I say, since we see, even in this small extent of augmented Fire, so many various, singular, and surprizing *Phænomena*, who can so forget himself as to think, that the Doctrine of the power of Fire upon Bodies is as yet exhausted?

22. It is certain farther, that if this elementary Fire is collected in a particular place, let the cause be what it will, it may there be supported, by the help of proper *Pabulum*; which is always either Alcohol, or Oil procured from the animal, vegetable, or fossil kingdom. But again, this Fire being thus collected in this place, and supported by this *Pabulum*, may there likewise be prodigiously increased, by a greater weight of the incumbent Atmosphere, acting freely upon it; by a large supply of oily *Pabulum*, very strongly and intimately united in a proper quantity, with other very heavy Bodies; and by the action of a great many very large Bellows, blown swiftly, and so disposed as to unite their force in the center of the Fire. Now the ultimate effect of the greatest Fire of this kind that we are hitherto acquainted with, is, in Animals, and Vegetables, the production of Phosphorus; in Vegetables, the making of

May be rendered vastly intense by collection.

In various manners.

† Is not the
fusion of Iron
greater? See
p. 25.

of Glafs; in Fossils, the fusion of † Gold, which remains in this Fire, without suffering any alteration.

23. Having thus, then, explained to you the physical methods I am acquainted with, by which Fire may be collected and supported in any place, it remains now that we say something of that other most common and efficacious one, by which the same thing is effected, *viz.* the mixing different Bodies with one another, which affords us abundance of very extraordinary *Phænomena*. Of these, however, as there is an infinite number, it is impossible to mention them all, though it is necessary to touch upon some of them.

Of the Heat arising from the mixture of vegetable Substances.

The Philosophers have long ago observed, that upon mixing certain different Bodies together, there often suddenly arises a very considerable degree of Heat or Cold, evidently depending upon this cause: And this Heat or Cold, they took notice, did not exist in the Bodies before this Mixture, nor continued any longer than till this was perfectly compleated, the Bodies then returning again to the very same temperature they were of before. The history of these the Lord *Verulam*, in particular, began, and *Boyle* and *Hook* carried to greater perfection: A few instances I shall here exhibit before you. Give me leave, however, first to explain to you the instruments that have been contrived on purpose for these Experiments, and which I shall make use of as I proceed. ABCD is a large Thermometer filled according to Art with ting'd Spirit of Wine, which is fixed in such a manner to the board it is let into, that the lower part of it MBA may be free of the Wood, and thus the Vessels, in which the Liquors to be examined are to be mixed, may receive it without any difficulty; and to render the numbers on the side sufficiently visible, the board is painted very black, and these white. The Vessel, then, with the Liquid is to be placed in such a manner under this Instrument, that the whole Thermometer AB may be within the Vessel, and in the Liquor; and then let the other Liquor be poured in, and let them be well stirred about with a glass Pipe, that they may be intimately mixed together; and by this means the Thermometer will immediately indicate the alteration that is produced, with regard to Heat or Cold, from this mixture. By this instrument now, and this method, you will be able to see perfectly the whole Affair at a distance; let us now therefore begin.

Pl. V. Fig. 1.

EXPERIMENT I.

In this vessel are two ounces of rain Water, rendered exceeding pure by distillation in a tall Glafs with a gentle Fire. In this other there is the same quantity of common Spirit of Wine. Both these Liquors, you shall see me examine with this small Thermometer; and you observe they have both 44 degrees of Heat. One of these, now, I put under the Thermometer just explained, which stands likewise at the same number 44. I'll now mix these together at once, and stir them about with this cold glass Tube; and you perceive evidently, that they have acquired such a degree of Heat from this mixture as to make the Thermometer rise to the degree 52. Hence then we learn, 1. That this pure Water, and the Spirit of Wine, were in the Air equally hot before the mixture. 2. That the Air, Spirit of Wine, and Water, had before this mixture the same degree of Heat. 3. That if Air and Water,

or

or Air and Spirit of Wine, are mixed together, there will be no alteration produced in their Heat. 4. That upon mixing Spirit of Wine and Water together, they grow hot immediately, but not from the Heat that was in them before, for they were both equally hot or cold. 5. But from some other physical cause, which was latent in them, and which, upon the mixture, produced this Heat. 6. That this Heat, that is thus generated from this mixture, lasts no longer than during the time in which it is performed, and then ceases, tho' you agitate them much more forcibly than you did in mixing them. 7. That the whole physical cause, therefore, of the production of this considerable Heat, is only the first application of the particles of the Spirit of Wine to those of the Water; and that Fire is instantly excited in the very contact, and disappears again presently after it. 8. That the Fire thus generated, or discovered by this mixture, is true elementary Fire; as its effect upon the Thermometer evidently demonstrates. 9. That a good deal of the Heat was destroyed, whilst the Thermometer was heating by the mixture to this degree.

EXPERIMENT II.

Observe, again, these two Vessels, one of which contains the same quantity of Water, as in the former Experiment, and heated to the same degree, viz. 44; the other the same quantity of pure Alcohol precisely as hot as the Water; the Thermometer likewise, as before, standing at the degree 44. These then being mixed in the same manner as in the preceding Experiment, the Thermometer rises to the degree 62. Hence, then, we infer, 1. Every thing that was taken notice of in the first Experiment. 2. That Water and Alcohol, by being mixed together, grow very hot, much hotter than Water and Spirit of Wine. 3. That the cause, therefore, of this greater Heat depends intirely upon the proportion of the Alcohol, to that of the Water with which it is mixed. 4. That Water, by being poured upon Alcohol, causes a greater quantity of Fire to enter into the Alcohol, than was in it before, though this so much resembles Fire; for Alcohol mixed with Alcohol produces no heat at all; Water mixed with Alcohol does. 5. That the less Alcohol, the Water, which is thus mixed with the Alcohol, has in it, that is, the purer the Water is, the more Heat it will generate in the Alcohol; and the reverse.

EXPERIMENT III.

I take now two ounces of alcalifated Alcohol; and the same quantity of pure Water. Before they are mixed they are equally cold, viz. 41 degrees; as is likewise the Thermometer: The mixture gives 54 degrees of Heat. Hence we see, 1. The truth of what has been asserted under the first and second Experiment. 2. That Water and alcalifated Alcohol grow hotter upon mixing, than Water and Spirit of Wine; but less so, than Water and pure Alcohol. 3. That the cause therefore of Heat in these mixtures is owing wholly to the Alcohol, and pure Water.

Compare with these the Observations of the famous Mr. *Geoffry*, in the *Mem. de l'Ac. Roy.* 1723. p. 53. These Experiments furnish us with some Bodies, and those pretty remarkable ones too, by which we may bring about this

this generation of Heat; and in these, besides what has been observed already, I think this deserves to be particularly taken notice of, that in them all the Heat is only generated in the very point of mixing, nor is any greater degree perceived afterwards. And hence, the quicker this is performed, the Heat that is excited by the same quantities will be always the greater; and on the contrary the less, the slower, and more successively. For as soon as ever the mixture is so compleated, that all the particles of the Water are united with all the particles of the Alcohol, in vain will you expect any farther increase of Heat. Nor will a violent agitation of the mixed Liquors be then of any consequence; for the degree of Heat will afterwards not only be no greater, but in those three Experiments, when the mixture is once perfectly finished, it begins immediately to remit, and a succeeding Cold increases every moment, till the Liquor is soon reduced to the common temperature of the Atmosphere: And in the same manner the Experiments I have tried have always succeeded. Hence, therefore, we infer, 1. That at the point of time, in which the Elements of the Water and Alcohol come into contact, there arises some physical cause which attracts the Fire thither. What this cause is, it is not easy to determine. This, however, we observe, that at the time particularly when the mixture is first made, the Liquors, which were before clear, lose their transparency; and that this opakeness continues so long as the Heat is generating, which being quite compleated, they perfectly regain their pellucidity. And again, precisely at the very same time, there is produced a vast number of very small bubbles, which move among the mixed elements of the Liquors, presently burst, disappear, and are again renewed; but when once the Heat is generated, are never observed after. Whether, now, these Bubbles do by their motion produce this Heat, or rather, whether they themselves are generated by the Heat's rarifying the aerial particles interspersed through the Liquors, is hitherto matter of doubt. 2. This, however, we learn certainly from those Experiments, that this Heat does not depend upon the united substance of both Liquors, but upon some other cause, which exerts itself only in the very first union of the elements together. On this Account, therefore, it seems very probable, that all the Heat thus generated exists there but the least instant of time; which certainly is very remarkable. Nor does Gunpowder, perhaps, burst sooner into Flame, by the application of a spark to it, than this Heat arises upon the mixing of these Liquors. 3. The more accurately, and intently, therefore, we examine this affair, are we not so much the more at a loss to find out what this in reality is, which thus collects this Fire? Is it the reciprocal attractive power of these elements, by which, when they approach one another, they rush into contact, and by this Collision excite little Fires? Or does an alternate attraction, and repulsion between these elements, produce a very swift attrition among them, and by this means generate Heat, the attrition ceasing again, when the particles are equally distributed among one another, are at rest? 4. Since this Heat arises in Water and Alcohol, upon their being mixed together, whether they had this or that particular degree of Heat, when they were separate, and the new degree is so much greater than that before the mixture; hence, therefore, Alcohol, by being mixed with the Water of our Blood, may, to a certain degree, and for a certain time, heat it

very suddenly, tho' afterwards, however, it will in this respect have no farther effect upon it. 5. For this reason, therefore, Bodies that are cold from a watery dampness upon them, may be warmed by being rubb'd with Alcohol; and on these principles the effects of Baths and Fomentations made with Alcohol may be understood.

EXPERIMENT IV.

If the purest Water, and the most generous Wine are perfectly united together in the same manner, they don't discover the least sensible increase or decrease of Heat; there is something of Warmth, indeed, but it is so exceeding small, that it can scarcely be perceived. Hence it appears, 1. That Water and Wine are equally warm in themselves, and that they still continue of the same Warmth after they are mixed together. 2. That the application of Wine, therefore, does not heat any thing considerably more than Water. 3. That the Heat, of Consequence, that is perceived in a human Body from drinking of Wine, does not arise from any Heat that pre-existed in the Wine, and is then communicated to the Fluids, but is owing to its *stimulus*, by which the velocity of the Blood being increased, and a greater attrition excited between the Vessels and the Fluids, Fire of course is attracted thither.

EXPERIMENT V.

From this quick mixture of Water with the distilled Vinegar of the strongest Wine, which were perfectly of the same warmth, you don't perceive the least degree of Heat produced, but they remain exactly as they were before. Hence, therefore, 1. The Heat of Water and Vinegar is the same, nor does there arise any alteration in it, by mixing them together. 2. The refrigerating power, therefore, of Vinegar in the human Body, so extolled by the Physicians, must depend intirely upon some other causes than a Cold that is natural to the Vinegar.

EXPERIMENT VI.

These two Vessels contain equal quantities of Oil of Tartar *per Deliquium*, and pure Water, which are both exactly as warm as the external Air; and you perceive evidently, now I have perfectly mixed them together, they retain precisely the same degree of Heat. Hence, 1. That Liquor, which of all Fluids appears to us the most fiery, is in reality no hotter in itself than pure Water; nor is Water any ways cooler than that very heating Liquor. This assertion, to a person unacquainted with this Experiment, would seem an extraordinary paradox; but the Truth of it, however, is undeniable. 2. This Liquor, which is esteemed so igneous, if it is mixed with Water, don't at all lessen its Coldness. 3. When a fixed fiery alkali is once dissolved in such a quantity of Water as is sufficient to dilute it, it will not afterwards generate Heat in any other Water. 4. Neither, therefore, can this liquid Alkali excite any Heat in this respect, by being mixed with the Water of our Blood.

EXPERIMENT VII.

I have here Water, and distilled Oil of Turpentine, which now they are separate, are just as warm as the Air at this time; and though I now mix them together as intimately as possible, yet they don't generate the least degree of Heat. Hence again, 1. Distilled essential Oil, which heats the human Body to such a degree, and defends it so happily against the ill effects of Cold, has in reality no more Heat in it than simple cold Water. 2. This Liquor, though in a great many of its properties it comes so near to Alcohol, yet communicates no Heat to the Water it is mixed with, though Alcohol, by being mixed with Water, excites a very considerable degree; which extraordinary *Phænomenon* makes probable the doctrine we before laid down, when we assigned the first contact of the elements of the Water and the Alcohol, as the principal cause of the Heat that is thus generated. 3. This Oil, therefore, again, cannot add any Heat to the Water of our Blood, by being mixed with it.

EXPERIMENT VIII.

The most certain mark, perhaps, of Alcohol's being perfectly pure, is its suffering itself to be intimately mixed with distilled Oils, by simple concussion; for if it contains but the smallest quantity of Water, such a perfect mixture will not be possible. Some such Alcohol I have here, which is equally warm with this very pure ætherial Oil of Turpentine, and the Air at this time. These, now, I'll mix together, and what do you imagine will be the consequence? You see they unite intimately with one another, just as Alcohol does with Alcohol; and that there is not the least variation from the Heat which both the Liquors had before the mixture. This, certainly, persons generally would not have expected: Nay, even those who were acquainted with the former Experiments would imagine, that some degree of Heat must arise from the intimate contact of the Oil and Alcohol. We here see, then, that the particles of Alcohol will bear to be as perfectly and equably dispersed through the Oil, as they will through Water; but that no Heat, however, is generated by this means. Alcohol, therefore, will not excite any Heat by being mixed with our Oils, though it will if it is mixed with the Water of our Blood. What new and unexpected discoveries do we make in natural Philosophy, when we designedly apply Bodies to one another! Let us, therefore, prosecute this method as much as possible.

EXPERIMENT IX.

Distilled Vinegar, and Oil of Turpentine, which now they are separate, are equally hot with the Air, and one another, viz. * 44 degrees, I thus gently and gradually mix together; and by a successive augmentation, they increase the heat to the degree 45. Here therefore, 1. The Vinegar and the Oil are of themselves equally hot. 2. Some Heat arises from their being mixed together. 3. Hence the power that Acids have of generating Heat with oily Bodies begins to discover itself, tho' they are so but in the smallest degree, for as *Monf. Homberg* has demonstrated the strongest Vinegar don't contain above one eightieth part of pure acid. *Mem. de l'Ac. Roy. des Sc. T. 1. p. 52.* 4. Vinegar,

* Should not
this be 42?
See the next
Experiment.

Vinegar, therefore, will generate some Heat with our Oils by being mixed with them. 5. And in this respect Vinegar differs from Water.

EXPERIMENT X.

The same Vinegar and Alcohol, which I made use of before, and which are qually hot with the Air, I now mix together; and you perceive what a remarkable Heat immediately arises: For from the degree 42, in which they were before the mixture, they now raise the Thermometer to 52. Hence, therefore, 1. Alcohol and Vinegar are separately equally hot. 2. A very considerable Heat is generated by their being mixed together. 3. Alcohol grows hot with Vinegar, so much more than it does with Oil.

EXPERIMENT XI.

Oil of Tartar *per Deliquim*, and Oil of Turpentine, separately equally hot, viz. 45 degrees, upon mixing, raise the Thermometer to the degree 48. Hence, 1. These Liquors of themselves have the same degree of Heat. 2. In mixing, they grow considerably hotter than they were before.

EXPERIMENT XII.

The same Vinegar and Oil of Tartar *per Deliquium*, which separate were equally hot, viz. 46 degrees, being expeditiously and accurately mixed together, continued exactly in the same degree of Heat: But in this Experiment I made use of 3 parts of Vinegar, and 1 of Oil. Hence, therefore, it appears, that Fire is not collected by the Union of opposite Salts.

EXPERIMENT XIII.

Alcohol, and Oil of Tartar *per Deliquium*, that were as hot as the common Air, by being intimately mixed together, increased their Heat from 64 degrees to 68.

EXPERIMENT XIV.

I have in this Phial some of the same Alcohol, equally hot with the Air at this present time, viz. 47 degrees. Into this, now, I pour some pure, dry, fixed alkaline Salt of Tartar; upon which the Liquor in the Thermometer rises to the degree 51.

EXPERIMENT XV.

With this pure Water, I mix one third part of the same Salt of Tartar; and the Thermometer rises from the degree 47 to 57.

EXPERIMENT XVI.

I now put one part of the same Salt of Tartar, to three of the Vinegar we made use of before; and the Thermometer rises from 43 to 49.

EXPERIMENT XVII.

With three parts of Oil of Turpentine, I mix one of the same Salt of Tartar; and the Thermometer rises from 43 to 48.

From what has been hitherto laid down, then, we learn, 1. That the simple Bodies, which are chemically extracted from Vegetables, have really the very same degree of Heat in them, *viz.* that of the common Air, at the time they are examined. 2. That some of these acquire a greater Heat by being mixed together; which generation of Heat, however, continues no longer than during the time of the mixture, which being perfectly completed, the new degree of Heat does not remain, but they gradually return again to the temperature of the common Air. 3. That this production of Heat, therefore, does not depend upon the Substance of the united Bodies, but only upon the union of them at that time. 4. That Alcohol and Water are the principal of the vegetable Fluids, which have that power of generating Heat, which has been described. 5. That Salt of Tartar and Water are the chief among the Solids and Fluids, which, by being mixed together, produce the greatest degree of Heat. 6. And that next to these, Alcohol and Salt of Tartar, are the most efficacious. These, then, being thus dispatched, let us, with the same care proceed to examine the parts of Animals.

Of the Heat arising from the Mixture of animal and vegetable Substances.

EXPERIMENT I.

Fresh Urine, well concocted in a healthy Body, being exposed to the Air, soon acquires the same temperature with that at that time; and if it then, as you see, is mixed with an equal quantity of Water, it makes no alteration at all in the Thermometer.

If it is mixed with Alcohol, the Heat increases from 38 degrees to 49.

With Oil of Turpentine it suffers no alteration.

With Salt of Tartar the Thermometer rises from the degree 38 to 39.

With the strongest Vinegar no alteration.

Nor with Spirit of Urine.

With Salt of Urine it descends two degrees.

With Spirit of Nitre it rises from 38 to 43.

With Spirit of Salt, from 39 to 43.

With Oil of Vitriol, from 39 to 54.

EXPERIMENT II. *After various manners.*

The Urine of a healthy man being kept a good while in a close Vessel, and by this means being very much putrified, will have the same temperature as the Air at that time; and if it is then mixed with Water in equal quantity, will cause a small descent in the Liquor of the Thermometer.

Being mixed with Alcohol in the same manner, the Heat increases from the degree 38 to 45.

With Oil of Turpentine, no alteration.

With Salt of Tartar, the Thermometer descends from 38 to 36.

With the strongest Vinegar, ascends from 37 to 38.

With Spirit of Urine, descends from 38 to 36.

With Salt of Urine, from 38 to 32.

With Spirit of Nitre, ascends from 38 to 40.

With

With Spirit of Sea Salt, from 38 to 41.

With Oil of Vitriol, from 38 to 45.

EXPERIMENT III. *After various manners.*

Salt of Urine procured from fresh Urine by distillation, without the addition of any thing but Sand, being mixed with Water in the manner often described, made the Thermometer descend from 40 to 38.

With Alcohol, it ascends from 40 to 41.

With Salt of Tartar, from 40 to 45.

With the strongest Vinegar, it descends from 43 to 41; but with the same inspissated to the consumption of one half, ascended from 42 to 44.

With Spirit of Nitre, from 43 to 60.

EXPERIMENT IV. *After various manners.*

With a pretty strong, volatile, alkaline Spirit, prepared from equal quantities of *Sal-Ammoniac*, and Salt of Tartar, I mixed an equal quantity of Spirit of the strongest Vinegar, when they were both equally hot with the Air; and the Liquor in the Thermometer rose from the degree 44 to 48.

With the strongest Vinegar, inspissated to one half, from 46 to 47 $\frac{1}{2}$.

With spirit of Salt distilled with Bole, and afterwards rectified, from 46 to 64.

With Spirit of Nitre, distilled with Bole, from 46 to 82.

Of the Heat generated by the mixture of fessil Substances.

EXPERIMENT I. *After various manners.*

I here take 3 ounces of clean Water, 47 degrees hot, and put to it 1 ounce of pure Nitre reduced to powder; and the Liquor in the Thermometer descends to the degree 36.

I mix 1 ounce of pure Borax with 3 ounces of Water, 48 degrees hot; and the Thermometer falls to 45 $\frac{1}{2}$.

With 3 ounces of Water, 46 degrees hot, I mix 1 ounce of Sea Salt; and it falls to the degree 43.

To 3 ounces of Water, 47 degrees hot, I put 1 ounce of *Sal-Ammoniac*; and it falls to the degree 28.

With 3 ounces of Water, 45 degrees hot, I mix 1 ounce of Oil of Vitriol not rectified; and it rises to the degree 60.

To 2 ounces of the purest Alcohol, 47 degrees hot, I add 1 ounce of Oil of Vitriol not rectified; and it rises to the degree 60.

With 3 ounces of distilled Vinegar, 46 degrees hot, I mix 1 ounce of Oil of Vitriol not rectified; and it rises to the degree 60.

Cerufs, by causing an ebullition with weak *Aqua Fortis*, makes it rise from the degree 44 to 57.

Tin, by causing an ebullition with weak *Aq. Regia*, makes it rise from the degree 44 to 56.

Filings of Iron, by causing an ebullition with *Aq. Regia*, make it rise from the degree 44 to 160.

A great many other Experiments I have made of the like nature, but am afraid I shall tire your patience. Give me leave, however, to observe, that if all the simple Bodies in the animal, vegetable, and fossil kingdoms were examined in this manner, beginning first with these of the same class, and carefully noting all the *Phænomena* that arise from the mixture of these; and afterwards proceeding to make the same trials upon the simples of different classes; we then should soon have a compleat and certain history of the Heat that is generated by the sole mixture of various Bodies with one another. But here let me caution you, that the Experiments thus performed before you, are not made with that care and accuracy, as they might and ought to have been, if we would have settled this affair nicely; but this the straitness of our time, and the fear of being tedious, would not admit of. And besides, as so large a number of you do me the honour of attending to these lectures, and I am willing you should all fairly perceive the event of the Experiments, I thought it proper to make use of such large Thermometers. But these, as you know, by having their large Bulbs immersed in so small a quantity of Liquor, must, by being affected themselves, make an alteration in the Heat or Cold produced in the mixture, and thus make some variation in the visible effect. These Experiments, therefore, for this reason, you must not look upon as very exact. If your own ingenuity should put you upon prosecuting these inquiries with greater accuracy, I would advise you to make use of those beautiful Thermometers of *Fahrenheit*, that are made with Mercury; which is the sort I made use of in producing the Cold with *Sal-Ammoniac*, which I some time ago gave you an account of. These have this great advantage, that they are exceeding sensible of Heat and Cold, and at the same time are so small, that they make very little alteration in the Heat of the Liquors to be examined.

Of true Fire generated in a cold Body, by the sole access of the Air.

The indefatigable industry of the Chemists is continually finding out something which former Ages were not acquainted with. Now among these discoveries, Gunpowder excepted, there is nothing more surprizing than those Bodies, which, whilst they are kept from any communication with the common Air, are as cold as others, but as soon as ever this has a free admission to their surface, presently take fire and flame of themselves, purely from this cause, without the accession of any other Body, any mechanical attrition, or the application of any Fire. These Bodies have obtained the name of *Phosphori*: Those alone I mean, here, by which Fire is really generated; not regarding the other, which only shine in the dark, and do not at the same time excite any Fire.

The Phosphorus of Crælius.

If the Juices of Animals, when they have first undergone a great degree of putrefication, are by the action of the Fire deprived of all their volatile Salt, and Oil, they leave behind them a kind of a Coal: If you mix this with three times its quantity of Sand, or powder'd Charcoal, or with two parts of Charcoal, and half a one of Alum; and then put it into a coated Retort made of crucible earth, and urge it with a reverberatory Fire, gradually increased to the greatest degree, and equably continued for a considerable time; and if at the same time you take care to dispose the Retort in such a manner, that the

the mouth of it shall touch some Water contained in the Receiver, which must be accurately luted; if you proceed, I say, in this manner, you will then with your last degree of Fire, after some Fumes, have a heavy, greyish matter, which will fall in grains to the bottom of the Water, will not dissolve in it, melts with Heat, and may by the assistance of it be formed into masses under the Water. This, which is called the *Phosphorus* of *Crafftius*, *Kunkelius*, and *Boyle*, if it is kept cool under Water, may be preserved a great while without alteration; tho' if the Air by any means grows very hot, it will shine in the dark, even through the Water it lies in; but if it is openly exposed to but a warm Air, it then becomes lucid, and if the heat is pretty considerable, upon examination with a Microscope, you may perceive a constant ebullition in the internal parts, soon after which, it bursts into Flames, consumes, and leaves behind it an Oil of Vitriol, or a Liquor exceedingly like it in acidity and weight. This, therefore, is a new method of generating Fire, perfectly distinct from all the former. Does the Air, then, when it is pretty warm, at which time it is probable it is in a constant ebullition; I say, does the Air then, by its concussions, cause an attrition in the parts of the *Phosphorus*, and, by this means, excite in this very Mobile, but at the same time pretty fixed matter, some degree of Heat, then Light, and afterwards Flame? Certainly, if it is exposed to the Air in the greatest Cold, it scarcely shines, does not grow hot, and is far from being set on fire: But as soon as ever it begins to flame out, it can scarcely be extinguished. In almost every quality, and the *Analysis* of it by deflagration, it comes very near to the purest common Sulphur, but is of a softer consistence, more easily melted, and on that account is rather of the nature of Wax. In this respect, however, there is this difference between them, that *Phosphorus* boils and takes fire with a small degree of Heat. See *Boyle. Noëtiluc. Aer. Slare. Philos. Transf.* 1683. p. 1457. *Homberg. Mem. de Mathem. & Physf. Ann.* 1692. p. 74 to 80. *Nieuwentyl. p.* 520. *Hoffman. Dissert. Chem. Physic. p.* 336.

But there has been another and much more beautiful method discovered of making a Matter, which upon contact with the Air, whether hot or cold, immediately generates Fire, and burns. This was first communicated to me by Letter, by the egregious *Homberg* of *Paris*, the 16th day of *April*, 1712, which was delivered me by the ingenious *Hasberg*, who at the same time added some considerable remarks of his own. Afterwards, when the method was rendered more easy, and less disagreeable, it was published in the *Journal des Scavans, An.* 1716. p. 60. And here give me leave to observe, that as the *Phosphorus* just now mentioned, owed its discovery to a crazy headed Alchemist, that was hunting after the *Philosopher's Stone* in Urine; so this which I am going to describe, was the invention of one of the same Sect, who was madly pursuing this occult Stone in human *Fæces*. The Operation is as follows. Take the Flesh of a tender Animal chopp'd very small, or any of its Juices, or even its Excrements; put this Matter into an iron Frying-pan over a moderate Fire, and with an iron *Spatula*, keep stirring it about 'till it is reduced to a dry black Powder: Or instead of this, you may treat in the same manner any soft Vegetables, any sort of Meal for instance, it signifying very little, which of these you make use of. Take 1 part then of this black torrifed Powder, and rub it with 4 parts of crude Alum, 'till it is brought to a very fine Powder. Put this

Igneous
Phosphorus.

this into an iron Frying-pan, and roast it over the Fire, all the while stirring and rubbing it with a *Spatula* almost red hot to keep it in form of a Powder; and whenever the Alum is melted, and with the Powder runs into lumps, these must be immediately rubbed to pieces, and the whole must be thus kept in motion, till the matter will emit no more Fumes, but is totally converted into a fine, dry, fix'd Powder, that is perfectly black. Take then this dry black Powder, and put it into a clean dry glass Bolt-head, with a slender Neck, filling the Body two thirds full; and let the mouth of the Glass be covered with a Paper, so that the Air may pass in and out freely; and that the Fumes may get readily out of the neck of the Glass. Put this Bolt-head into a Crucible, and so guard it with Sand, that the sides and bottom of the Crucible may be well secured from touching the Glass; and let there be left so much room above the Sand, that you may easily look into the Body, and see whether the Matter contained in it, is red hot. Round the crucible then, with the Sand, and Bolt-head, dispose some burning Coals in such a manner, that it may be heated gently and by degrees, 'till it grows all over thoroughly hot; and then increase the Fire, 'till the Crucible, Sand, Bolt-head, and Matter contained in it, are perfectly red. When you observe this to be the case, keep up the Fire in the same degree for the space of an hour; and then, whilst the force of the Fire continues, close the Orifice of the Glass so accurately with Wax, that no Air can possibly get into it. This being done, let them all cool of themselves; and in the Bolt-head you will have a black powdery Coal, composed of the Powder and the Alum. If any of the Matter then thus prepared is thrown out of the Glass into the cold Air, it instantly takes fire and burns; but if it has once been exposed to it, it loses intirely this vertue. And this method of generating Fire seems the most surprizing of any we are acquainted with, as this matter will retain its power of exciting Fire for the space of three whole months, if it is kept from any communication with the external Air. In this Experiment, now, we have a true animal, or vegetable Coal produced by the calcining force of the Fire, and that an exceeding subtil one too, and consequently intirely fit to feed and support a spark of Fire when once it has received it; as appeared formerly in our History of Coal. This Coal too is rendered as dry as it is possible to make it; as appeared through the whole process: For if the least Moisture, nay even that which is dispersed in the Air, comes at the Powder, the success of the Experiment is intirely frustrated. And here we must observe, that all the Air, likewise, must be expelled by this excessive Heat: For at that time, the mouth of the Glass must be carefully stopped, when the greatest degree of Fire which the Glass can bear without melting, has forced all the Air out of its Cavity, and out of the Matter contained in it; for if by any means the Air can insinuate itself in afterwards, the Experiment will never succeed. In the mean time, by this protracted calcination, the Air, Water, and volatile acid Spirit must be expelled from the Alum likewise, (which seems to be a Lime-stone prey'd upon by Oil of Vitriol, and converted into a Salt) nothing at all remaining but a very strong Oil of Vitriol, fixed in the exceeding dry Earth. These Bodies now, which are vastly attractive of Moisture, grow hot upon the admission of Air, and this rushing into their empty Pores with the *Impetus* formerly computed, p. 130, will in an instant cause a most vivid attrition of its parts, and thus, perhaps,

perhaps, generate Fire, which being received on that very fine Coal, will be easily sustained and supported. But whether this, or something else, is the cause of this wonderful *Phænomenon*, this at least we are now a-days certain of, that, without any assistance of Fire, it is possible for the common Air, by simple contact only, to set fire to a cold Body in such a manner, that it shall by this means be totally consumed to Ashes, as certainly, as by any other Fire that we are acquainted with. But to the best of my knowledge, this last Experiment is the only one by which we can always effect it. Who then can pretend to set bounds to the power of Fire? Who, five and twenty years, would have thought such a thing possible? Or who can foretell those things that will be reveal'd to future ages? should the Glas which contains this cold Powder be broke, and it should fall amongst Gun-powder, what would be the consequence?

Of Fire produced from cold Fossils by the help of Water.

If the fresh Filings of Iron, not yet rusty, are mixed with an equal quantity of very pure Sulphur, and they are strongly rubbed together for a considerable time, till they are reduced to a very fine Powder; then, this Powder, keep it ever so long in a dry Air, will continue cold, if you carefully secure it from all Moisture: But if you work this Powder with such a quantity of pure Water, as to reduce it to a stiff Paste; then, after some time, the Mass will grow warm, fume, puff up, grow hot, emit a black, hot, sulphureous Smoke, take fire, and flame: And after the Operation is over, there will be left a brown, black, fine *Calx*, by pouring Water on which, you may extract a kind of Vitriol from the Iron, exceedingly like the *Vitriolum Martis*, which in the common Method is prepared with Oil of Vitriol. If you take, now, a large quantity of each of these Fossils, for instance, 25 pound of Iron, and as much of Sulphur, and make them into a Paste, and bury it a foot under ground, after 8 hours, the Earth that is over it will begin to heave, send forth hot sulphureous Vapours, and burst out into Flames, and thus produces a true subterraneous Fire. *Hist. del' Acad. Roy. 1700. p. 52. Mem. p. 101.* And the reason seems to be this; the Sulphur being an inflammable Oil, concentered with the exceeding acid Oil of Vitriol; and Iron being a Metal, which will always dissolve in the Acid of Vitriol, and by this means generate a very great degree of Heat; hence, it seems probable, that when the very small Particles of these two Bodies are rubbed together, and thus brought into very close contact, and by the addition of the Water, are held still much more strongly together; I say, when this is the case, it is probable, that the Acid of the Sulphur begins to corrode the Iron, and thus produces the usual Heat; and by the effect of this continually augmented Heat, this solution being every moment more efficaciously carried on, of consequence the Mass grows hotter and hotter; so that at last, a Flame breaks out, partly from the Oil of the Sulphur which is freed from the Acid that is now gone into the Iron; and partly from the Vapour, that arises from the Iron now dissolved by the acid Oil of Sulphur, which is easily inflammable. That this is the Case appears from another beautiful Experiment mentioned in the place above cited, and in *Hoffman's Diff. Phys. Ch. 169*, which is as follows. Take a glass Bolt-head of a middling size, with the neck of it cut off, and mix in it 3 ounces of Oil of

Fire produced by mixing Iron, Sulphur, and Water.

Vitriol, with 12 ounces of Water; set the Glass then in a moderate Heat, and throw into it at different times, half an ounce or an ounce of Filings of Iron, and there will by this means arise a white Vapour, which issuing out of the neck of the Glass, causes a sulphureous stench like Garlick, and upon the application of a Candle, takes fire like Lightning, rushes with a vast *impetus* into the Glass, and being there violently agitated, produces very surprizing *Phænomena*; so that the Matter which constitutes these Fumes, seems perfectly like Alcohol, when it is raised by Fire into a Vapour. And thus there is discovered a new method of generating Fire in a cold Matter no ways inflammable, purely by the assistance of Water. And, indeed, we are most firmly persuaded, that there are in Nature, an infinite number of other methods, by which the same surprizing effect may be produced; and which possibly hereafter may come to light. Damp Hay laid together in a heap will do the same thing.

Of the Production of Fire by the mixture of cold Liquors.

Fulminating
Fire from
Liquids.

Take half a pound of very pure dry Nitre reduced to Powder, put it into a clean dry Retort, and mix with it an equal quantity of Oil of Vitriol very pure likewise, and perfectly freed from all its Phlegm: Distill this Mixture with a gentle and Heat, continued for a considerable time, and then a Spirit will arise in form of a yellowish Vapour, which collected in the Receiver, will be *Glauber's Spirit of Nitre*. If in a glass Vessel, now, you put a Drachm of distill'd Oil of Cloves, Sassafras, Turpentine, or Carraways, and then pour upon it an equal quantity, or half as much again of this Spirit of Nitre of *Glauber*, a violent Flame will be excited by these Liquors, which were cold before the Mixture. Here again, then, is a most surprizing Experiment, and of infinite use in Chemistry, in which we see a most rapid Flame instantly produced by two cold Liquors, which almost consumes them both, leaving behind it only a small quantity of a kind of resinous Ashes. And by this Experiment, we perceive again likewise, that very acid Liquors mixed with oily ones, which are pregnant with a *Spiritus Rectior*, compose a matter very much resembling Sulphur, and that very easily takes fire. See *Borrich. Act. Hafn.* 167. *Hoffman. Obs. Phys. Chem.* 38, 42, 123, 127. *Slare. Phil. Transf.* N. 150. p. 291.

Of the nature of elementary Fire, which is corporeal.
1. As is extended.

If we examine now carefully what has been hitherto laid down, we may, possibly, be able to assert some things with sufficient certainty, concerning the nature of Fire. First, then, it is evident, that true elementary Fire is really corporeal. For as by this we mean something, that may be measured geometrically by three Lines drawn perpendicularly to one another from the same center, or, as we express ourselves now a-days, something extended; so, that Being, which we have considered in our former inquiries, under the notion of Fire, has appeared to be always extended. If, for instance, a solid silver Sphere almost red hot, is suspended by a Thread, and let very gently down into cold Water, so that it shall put the Water hardly at all in motion; will not the Fire then of this Sphere disperse itself gradually through the measurable spaces of this Water, of which that which is nearest the Sphere will be hottest, and the rest will be heated proportionably, and thus the Fire will be really extended? For Thermometers placed in the Water at different distances from the heating Sphere, will indicate the different degrees of Fire diffused through the Body and Spaces, and demonstrate a true Mixture of

of the Fire with the Body, or Space, and of consequence, a real extension of it. And, certainly, our whole History of Fire proves as evidently, that Fire is truly extended, as space is, or the Bodies contained in it.

A second general property that belongs to every known Body, is, that it may successively exist in the place which is next to that which it took up before, and thus may be really moved: And that, whether, first, it continues in the same space, but is turned upon its own *Axis*, and so all the parts considered together possess the same Space, though every particular part is changing its place every moment; or, secondly, the whole mass leaves the place it took up before, and enters upon a new one, and continues successively to do so; or, lastly, both these motions conspire together. But it appears, by every Experiment, that Fire is thus moved likewise; nor, indeed, was there one of them which did not demonstrate a true physical motion; and therefore this needs no farther proof. But this mobility, now, is so closely connected in Bodies with a power of being at rest, that no one can deny, but that that Body which one moment exists in any particular space, may be conceived to remain for two moments in the same; which is in reality being at rest: Since, therefore, all the actions of Fire, which are constantly performed by motion, may be always increased, or diminished; hence it is no ways absurd to suppose, that Fire may be absolutely at rest in a determined space; certainly not more so, than to suppose the same of any other Body.

2. As it is
movable, or
capable of
rest.

A third Affection of Body, and which is peculiar to that alone, is this, that a solid Body, as such, existing in any particular space, infinitely resists any other similar Body's possessing the same space, at the same time. To this some persons have given the name of Resistance and Impenetrability; *Democritus*, by a most expressive term, called it ἀντίστασις, or Repercussion. Nor indeed do I apprehend, we conceive any thing else by the word Impenetrability of Body, than this Repercussion of a Body, that endeavours to enter upon any part of space which was possessed by another before. But if this Repercussion, now, does really obtain in any Body, it does certainly in Fire in particular: For this puts in motion, and changes the figures of the very solidest Bodies we are acquainted with, so that there never was yet discovered any one that does not actually suffer some alteration from it in its true solid part, and receives a motion from it, by which it is carried into other parts of space with this *impetus* communicated to it by the Fire. But again, if we consider, that true, pure, elementary Fire, when it is directed upon certain Bodies, is driven back again, or reflected in such a manner, as to return from those Bodies, on which it fell, with a vast *impetus*, nay such a one as puts in motion every thing that is opposed to it; I say, if we rightly consider this, we certainly observe in Fire the most perfect ἀντίστασις; and by this means discover its real corporeal nature. For if, for instance, the igneous rays determined by the Sun, fall upon *Vilette's speculum*, when it is exceeding cold, and consequently, when it is most elastic, and reflects most powerfully, they will then be reflected into the *Focus* in a quantity that may be pretty nearly computed, with respect to the magnitude of the aperture of the *speculum*, and will there exert a most vehement corporeal force; which evidently demonstrates, that this Fire is moved with resistance. And this consideration confirms the argument still more strongly, that if the *speculum* is very much heated, and consequently dilated, looser, less elastic, and less powerful,

3. As it resists
Body.

with regard to its reflecting vertue, then the igneous rays, when they are returned back by it into the *Focus*, will act precisely with so much less force, as the hardness of the substance of the *speculum* was diminished. Hence, then, I think it appears certainly evident, that Fire itself is corporeal, and has a resisting power, inasmuch as it is reflected from the Body it strikes upon. But here again we observe, that if these igneous rays are vastly united together, and hence have their strength greatly increased, and become so powerful as to be able to melt the metalline substance of the *speculum*, then there will be no reflection produced, but the Fire being superiour to the *speculum*, will destroy it; a very evident proof, that this reflection arises from the mere repercussion of Body upon Body. But we may consider farther, that if this very pure elementary Fire is determined by the Sun through *Tschirnhausen's* Glasses upon the iron Needle of a Compass, it will then, in the very point where the *Focus* falls upon it, turn it round, and thus by a true corporeal percussioⁿ put in motion the substance of the Iron. This percussioⁿ now being made upon an impenetrable Body, demonstrates, that that, likewise, which moved against it, was not penetrable, but yielded some resistance. Elementary Fire, therefore, is truly corporeal. And every one of its elements or atoms, will consist of particles united together; which it is very probable are not capable of farther division by any natural powers. And hence the figures, likewise, proper to these elements, in all appearance, suffer no alterations by any force these powers are able to exert upon them. This wonderful element, therefore, is immutable itself, though it induces a change upon every thing else. But whether now Fire has likewise that property, which the great men of this age judge common to all Bodies, *viz.* that it gravitates in proportion to its solidity, does not yet appear so evident as persons generally imagine. For upon examination of the whole History of Fire, I am almost induced to believe, that it does not tend towards the center of the earth, more than any other point, but that it is perfectly free from any natural determination, or tendency to any particular place, or Body: That it may be determined every way, without resistance: That it exists in every place: That if there is no other cause to disturb it, it is dispersed throughout the whole universe: Nay, that naturally it exists every where, in the same quantity, and with the same power. All which positions, if I am not much mistaken, are plainly demonstrated by the former Experiments.

The Corpuscles of Fire the least of all we are acquainted with.

But in the second place, the elements of Fire, which by their first property appear to be corporeal, seem to be the least of all the Bodies that we are hitherto acquainted with. For if they are truly corporeal, they must, of consequence, be exceedingly subtil, since they are able to insinuate themselves with so much ease into the very densest Bodies, and passing through their whole thickness, exert their proper effects in the inmost penetrable parts of 'em. If a very large sphere of solid Gold, for instance, should be exposed to a proper Fire, for a sufficient time, it might be so penetrated by the Fire, as to be red hot to its very center: And if then it should be divided into two Hemispheres, there would appear Light, Heat, and every known property of Fire, in every point of their internal Surface. But again, the Subtlety of these particles is so exceeding great, that amongst all the Bodies that fall under our observation, there is not any one so compact, and free from pores, or of so large a size, but that it may be forced to transmit Fire through it. Every thing else,

of what kind soever, we can prevent entring into the *meatus's* of certain Bodies: Air, for instance, Water, Spirits, Salts, Oils, and all other Substances, we can exclude a Glafs Bolthead, by hermetically sealing it, and by the same means include them so that they shall not possibly get out: Fire alone procures itself a free passage, both in and out, without any difficulty: Fire alone, both when it enters the Glafs, and quits it again, exerts those effects which are proper and peculiar to it. I confess, indeed, that the causes of Gravity, and Magnetism, in like manner pervade all Bodies, without having their proper activity diminished: But then, whether these depend upon the emanations of Corpuscles, or act in some other way, that we are not acquainted with, is not yet so certain. Nay, and we must farther acknowledge, likewise, that both Gravity and Magnetism, in an instant, and almost without any retardation, penetrate through all Bodies, in their full force and efficacy; whilst Fire requires some length of time before it can pervade those that are very thick: But hence, certainly, the corporeal nature of Fire appears so much the more evident, which is not so manifest in the two former. For these reasons, therefore, I asserted only, that the elements of Fire are the smallest of all the Bodies that are universally acknowledged to be true Bodies. Far be it from me to deny, that the Divine Being has in the material World created Corpuscles that are actually more subtil than the Elements of Fire: This only I affirm, that it does not appear to the human senses, by any physical effect, that any such Corpuscles do really exist. But this infinite Subtlety of the Elements of Fire appears yet again, if we consider, that the Solidity of Gold is so great, that if you gild a piece of Silver with a grain of it, in such a manner, that the thickness of the golden foliage shall be only $\frac{1}{1050000}$ of a line (*Ac. Roy. des Sc.* 1713. 10), yet even then, when it is so vastly thin, you will not be able to discover the least pore in it, by the assistance of the nicest Microscope. Nay, if you take a bit of Leaf Gold, ever so fine, and oppose it to the Sun, shining through a hole into a dark room, it will not so much as freely transmit the Light, but you will see only a greenish kind of cast through it. And yet now a very large Sphere made of solid Gold, may be penetrated through its great bulk, and this prodigious density, by the smallest, as well as the greatest Fire. For if, in a very cold season, this great Sphere is exposed a considerable time to the cold Air; it will acquire the very same temperature, that is, it will receive the Fire that is at that time in the Air: But if it is then committed to a strong Fire, so that it may be perfectly red hot, and just ready to melt, it will then have a most intense Fire in every part of it; and yet if it is then in this condition removed into the Air, all this Fire will soon quit it again, and it will return to the common warmth of the Atmosphere. Hence, therefore, it evidently appears, that the small portion of Fire contained in liquid Air, can as easily insinuate itself into all the pores of Gold, as the most intense Fire of a Furnace. But if in such an exceeding fine leaf of Gold, now, the *meatus's* were so very small; what must we think of them in this case, when such a large Body of Gold is penetrated by Fire through all its Substance? Certainly, growing hot and cold, is nothing else but admitting Fire in a greater or less quantity. These arguments, then, sufficiently demonstrate the very great Subtlety of Fire. This, however, would appear yet infinitely greater, if this opinion was true, that the Matter of Light and Colours is the very same with that of Fire.

Fire. For if a chamber is perfectly darkened all but one very small hole, and an eye that has been some time in the dark, is placed directly against it, it will then see all the external objects very exactly, by means of certain distinct igneous Rays, arising, and propagated from every visible point of so many different Bodies, and transmitted through this very small aperture, without any confusion. If we consider, now, what an infinite number of visible points are seen in such a Hemisphere; and that every one of these appears only by its own particular Rays; the idea that arises hence of the subtlety of these particles confounds the human understanding. But again, if you place a Sheet of white Paper in this dark room, at a proper distance from the Hole, and by means of a convex Glass, throw the Rays upon it, then all the objects will appear upon this paper, of a pretty large size, and very distinctly; and consequently all these Rays, and therefore, upon our present supposition, all this Fire which from so many objects must be infinitely great, may be contracted together within the small space of this aperture. From these considerations, therefore, it evidently appears, that the Elements of Fire, with respect to our comprehension, are infinitely subtil.

And vastly
solid.

In the third place, these very small Corpuscles, the ultimate Elements of Fire, appear to be of such a nature, as to be the most solid, perhaps, of all Bodies. The signification of the term I make use of is easily understood: For by a Solid, I mean only that extended Being, which makes an infinite resistance; by Space, that Extension which admits and transmits Solids. An absolute Solid, therefore, is such an extended Being, where there is not the least such penetrable Space, but which through its whole Extension, and in every point of it, is perfectly impenetrable. If any Body, now, is composed of particles thus perfectly solid, but at the same time so united together, that there are left little spaces between them that contain nothing solid; then it appears evidently, that such an extended Bulk is partly Body, and partly Space. And it is hence evident, likewise, that the smallest Elements of all Bodies will be most solid; and that when these are afterwards compounded into one Mass, then, betwixt these Elements thus united together, but not touching one another in every point, there will be formed such Spaces within that Body. The compound Mass, therefore, will be always full of pores, and consequently less solid than the ultimate Elements of which it consists; and hence, in this respect, the parts may be more easily separated from one another, or are capable of a more easy division. But again, in these ultimate Elements, it is probable, that there are not any pores, and that hence they are perfectly solid, and consequently not to be divided by any other Bodies, but remain immutably the same. As Fire, therefore, has been demonstrated to consist of prodigious fine Corpuscles, if these have any pores, they must certainly be exceeding few, and consequently these *Molecularæ* will be vastly solid. But since impenetrable Substance is real corporeal substance itself, it is possible, that all true corporeal Substance, as such, may cohere with an infinite force not to be dissolved; but that the Masses that are made up of this Substance, with intercepted Vacuities, may be so far divisible as they contain these Pores within them. Fire, therefore, according to this doctrine, will be totally corporeal, immutable, incapable of having its figure changed, nor liable to any concretion with itself, or other Bodies. In the mean time, however, it will possess a
power

power of vastly dividing others; since it can always enter the Pores of the Bodies to be divided, exert its force there, separate the concreted Filaments and Particles, and thus resolve the Compounds into their simple Elements, or at least dispose the elementary *Moleculæ* in such a manner, that it may pass equably through the *Meatus's* in every direction; as we suppose may be the case in Gold, when it is put in fusion, which afterwards suffers very little alteration from the Fire. But if this vastly subtil and solid Fire, now, is applied to the perfectly solid Elements of other Bodies, it then seems probable, that it can induce no change in them, but only put them in motion by a mechanical propulsion, or by attraction; which again is confirmed by every kind of Experiment. Fire, therefore, in respect of this property, effects the most powerful changes in the Universe, whilst of all Bodies it remains itself the most immutable.

In the fourth place, we conceive, that these corporeal, exceeding small, and solid elements of Fire, have the most equably smooth, or polished Surface. And the smoothest By this we mean such a one, that has nothing in any one point of its circumference, which stands out, or is depress'd more than any other part. For if the Surface was rough, or unequal, then those points which were highest, would strike with a greater force against the Bodies they met with than any other part of the Mass; and consequently, in every action of Fire, either upon its own Elements, or other Bodies, those Particles would receive the greatest *impetus* which had the weakest cohesion with the whole Corpuscle; whence, it seems probable, that these Particles would be continually abraded from the rest of the Mass, and of course the Elements of Fire, and therefore Fire itself, would undergo perpetual Alterations; which is contrary to what has been already delivered: Besides, the vast solidity of Fire seems most consistent with that Figure, in which all the Particles are disposed in their several Orbs most equably with respect to their common center; since by this means they acquire the most immutable form, and most powerfully resist every transposition of their parts. But farther, if we consider with what ease Fire penetrates into the Pores of every kind of Body, let it be applied in what direction you will, then certainly, we shall see that the most smooth Surface is requisite that it may pass on without any impediment; which it does not at all seem likely would be the case, were it covered with little Hooks, Points, or any thing resembling Down or Wool. For since such a vast number of little Fires may be transmitted perfectly distinct through a very small hole into a dark Chamber, and that without the least difficulty; it is easy to conceive how vastly smooth the Surfaces of these Elements must be in the points of contact, not to intangle, and obstruct one another: And lastly, the exceeding quick reflection, and refraction, which are constantly observed in the Particles of Light, and which answer so exactly to the effects of a perfectly spherical Figure, induce us to believe, that the Elements of pure Fire do in reality possess this figure. Hence therefore, we may almost venture to infer, that the ultimate Particles of pure Fire are exceeding smooth polished little Spheres.

In the fifth place, from our whole History of Fire, we infer its exceeding And most simple. great simplicity. By this we mean that condition of Bodies, where every single Particle is perfectly of the same nature with the whole: This, therefore, in Fire, would denote it to be of such a Nature, that every single Element of it,

it, should be a perfect corporeal Mass, without the least intercepted Pore, so that every component Particle should be absolutely alike ; and hence, perhaps, be a little solid Sphere. And then if we consider a *congeries* of these Elements together, all these Spherules would be perfectly the same. In these, therefore, would consist the simplicity of Fire, depending particularly upon this circumstance, that as there are no Corpuscles in nature smaller than these of Fire, it is impossible it should be compounded of less, heterogeneous Particles. And certainly, the ultimate smallness, absolute solidity, and spherical figure of the Elements of Fire, very evidently denote this simplicity. Fire, therefore, we conceive to be the simplest of all Bodies. It must be acknowledged, however, that an absolute simplicity of Fire is repugnant to the doctrine of the great *Newton*, whose uncommon genius seems to have penetrated almost beyond the limits of human understanding. For this noble Author, by an artificial separation of one Ray of Fire, has divided it into seven different ones, not only perfectly distinct with regard to their Colours, but intirely different in respect of their Reflection and Refraction ; and consequently, in these three properties, of a quite different nature. And yet, if we nicely contemplate such a Ray as this, how fine is it, and how simple? If the nature of Fire, and Light, now, has been examined by ingenious Men for so many ages, and with so much diligence, and the great *Newton* alone of our age has made these Discoveries ; who will pretend to determine the farther Improvements that future ages may be able to make in Natural History? Who knows what additions may hereafter be made to the *Newtonian* Doctrine? Certainly, it is not above half a Century, since all the Philosophers imagined a single Ray of Light to be so infinitely fine, that they unanimously asserted, that with regard to its thickness it was indivisible : And yet that incomparable Geometrician, by undeniable Experiments and Arguments, has evidently demonstrated, that such a single Ray, is, in reality, a collection of seven Rays, which are perfectly distinct, and which, it appears, may be applied to one another through their whole length, and again be so separated from one another, as to be always capable of a longitudinal division into seven exceeding subtil Filaments, or Rays of seven different Colours. If, hereafter, now, this Science should be more subtly cultivated, and dioptrical Instruments should be carried to greater perfection, who will pretend to assert, that even in these simple *Newtonian* Rays, some penetrating genius may not be able to discover a still farther composition? These instances, in the mean time, are sufficient to raise our highest admiration, when we consider the noble faculties with which the Alwise Creator has endued the human mind, which being rightly employ'd, will conduct us to a discovery of those laws which were established for the formation of the Universe. And certainly, infinite reverence, and eternal thanks, are justly due to that gracious Being, who by impressing his own Image upon us, has made us capable of distinguishing truth, and disposed us to be delighted with it, and to use the utmost of our endeavours to attain it. But this, however, is not all the variety that has been observed in the most simple Particles of Fire ; for even in such a single Ray, the same *Newton* has discovered another diversity in the nature of its opposite sides ; as he found by accurately viewing the refraction in Island Chrystal, where he perceived the Ray to have a Power on one side, different from what it had on the other. And as in one Loadstone, with respect to another, the Pole is either attracting, or repelling ; so likewise in one and the same Ray, there is a similar

lar Power with regard to its transparent substance. In Fire, therefore, tho' so exceeding simple, there is discovered a three-fold variety. 1. With respect to its seven different elementary Colours. 2. On account of the very different action of the Rays of different Colours, with regard to reflecting, and refracting Bodies. 3. In regard of the same diversity in the opposite sides of the same Rays, with respect to this Island Chrystal. In this so vastly simple Being, therefore, we see there still remains this manifold variety: What diversity, therefore, have we reason to expect in Compounds? In the smallest Bodies, we every where observe a resemblance of the greater. Had this discovery, which was reserved for the great *Newton* alone, still lain in obscurity, I don't doubt but we should all even at this time, have firmly believed, that in a Ray of Light there was somewhat ultimately small, and infinitely simple: But convinced by his Doctrine, we are now obliged to confess, that, tho' Fire is of all known Bodies the most simple, yet even in this, there is found to be a various multiplicity.

The sixth property of this Fire is its mobility, which is discovered to be so great, that we are almost certain, let it be where it will, it is never absolutely at rest. And here, I don't only mean that motion, which is constantly observed in all Bodies in general; for in this sense it is certain, that there is not one Body in the Universe, that ever for one moment enjoys a perfect quiet. The Sun, certainly, the Planets, and Comets, and their Atmospheres that gravitate with them, are all whirled about with very rapid motions: But these are the only Bodies that come under our observation. Nothing therefore is ever at rest, but the whole Universe is thus constantly kept in a swift rotation, as the Creator of all things has appointed it. But there is yet another motion which I ascribe to Fire, and which is the constant effect of its proper agility; and this is most evidently demonstrated by undeniable observations. Let us, for instance, consider Water, when it is 33 degrees cold, and it will then be in its coldest state, that is, it will contain as small a portion of Fire, as in the nature of things can possibly reside in pure Water; for if this simple Water is affected by a greater degree of Cold, it will not continue Water any longer, but will be converted into a Substance very much resembling Glass, in all the properties of hardness, brittleness, and pellucidity, tho' reducible again to Water by a Heat of 33 degrees, whereas Glass, to make it run like Water, requires a great deal more than six hundred. Hence, therefore, it appears evident, that Water is Water only by reason of the motion of the Fire residing in it, and that it is not Water from its own nature considered separately and alone. The same is true of Glass, Fossils, Sulphurs, Semi-metals, Metals, and perhaps, of all other Bodies; which appear in a consistent form in a smaller degree of Heat, as we observed just now in Ice, but are put in fusion, and converted into a kind of Water, if the same is increased to a certain degree, which will be different, according to the various natures of the Substance under examination. Since, therefore, by *Fahrenheit's* Thermometers, the natural Heat has been observed 32 degrees below the freezing point, hence, we see evidently, that through all this difference of 32 degrees, the Fire was agitated with a motion, that grew gradually less, and less, but was never totally destroy'd; and therefore, even at that time, when all Animals and Vegetables perished through the excess of the cold, the Fire was not absolutely at rest. We may safely assert, therefore, that the Fire was even then in motion. But, as it has appeared

ed since by the same Experiment, that this Fire may be artificially diminished still 40 degrees more; hence we are now certain, that Fire in the greatest possible natural Cold, is agitated 40 degrees more than it is in this artificial one, and that again through every intermediate degree, it is continually dissolving some Bodies, which a little after, in a smaller degree of Heat, appear of a solid consistence: These things the Experiments referr'd to abundantly demonstrate. Fire, therefore, is perpetually agitated in the greatest Cold, and still gradually more and more in every increase of Heat; and hence it is always in motion. The famous *Romer*, from a great number of certain astronomical Observations carried on for the space of ten years, very ingeniously inferred the vast swiftness of the Fire derived from the Sun to the *Satellites* of *Jupiter*, and thence reflected to our Earth; for from these *data* Mr. *Hugens*, to whom this was communicated by *Romer*, evidently demonstrates, that the propagation of it is so swift, that it moves more than 1,100,000,000 feet, in the space of a Second. See *Hugens, de Lum.* p. 8, 9. This velocity, therefore, of Fire, or Light propagated from the Sun, which is looked upon to be true elementary Fire, would be vastly great, if we suppose it to proceed from the Sun, and fall upon the *Satellites* of *Jupiter*, and to be thence derived to our Earth, which seems agreeable to the *Newtonian* Doctrine. And if we suppose, as others will have it, that these Spaces are perfectly full, yet still, the action of luminous Fire, be it what it will, must be communicated with the same celerity. Afterwards, however, the great *Cassini*, and *Maraldus*, Men of infinite industry, and perfect Masters of Astronomy, carefully examined this affair by the most accurate Observations of a great many years, and discovered, that the opinion of Messieurs *Romer* and *Hugens* was very far from the truth. *Mem. de l'Ac. Roy.* 1707. *Hist.* p. 77. *ibid.* *Mem.* p. 25. On this account, therefore, we don't pretend to determine any thing farther concerning the celerity of Light from these very subtle disputations: This, however, we are certain of, that the communication of it will be always so much the swifter, as it is found to be less successive.

Do not generate Fire.

Or are generated by any other means.

In the seventh place, from what has been laid down, we may certainly conclude, that tho' this elementary Fire induces an infinite number of changes upon all other Bodies, yet, it never has appeared by any Experiment, that any of them have ever been converted by it into true elementary Fire. And hence, it is not confirmed by any Observation, that Fire is able to multiply itself, by changing its own *Pabulum*, or any Bodies into true Fire, by assimilating them to its own nature. Certainly, the more carefully we consider all the effects of true Fire, the less conclusive those Arguments appear, which are brought to prove such a power in Fire, or such an aptitude in other Bodies to this transmutation. Hence, therefore, it will be evidently certain, that if Fire itself cannot from any other Matter generate Fire, it cannot possibly be generated by any other Matter. For what cause can by any action produce Fire from a Body that is not Fire, if this cannot be effected by Fire itself? In the whole compass of Nature, certainly, we discover nothing, that, with regard to such a Power, can any ways be compared with it. This seems to be the grand universal Mover, from which every thing else receives its motion, all Fluids at least, and perhaps a great number of Solids; which is itself never begotten *de novo*, renewed, or resuscitated, but is only rendered discernible where it did not appear before.

Since,

Since, therefore, we are undoubtedly sure of these things, we may now freely assert, that this elementary Fire is always, and every where the same in every Body that is heated by Fire, whatever way it is excited, whatever *Pabulum* it is fed with, or by what contrivance soever it is supported. Unjustly therefore do the Chemists complain, that in their most subtle Operations, they cannot have the advantage of pure Fire; for in these, they imagine the most pure, astral, celestial, solar, elementary, incorruptible Fire, to be intirely necessary. But had they rightly considered what has been already laid down, they would never have embarrassed themselves with this needless solicitude: For the Heat that is generated in the Bodies of Animals, Vegetables, and Fossils, owes its Being intirely to the very same Fire; and when it passes through a glass Vessel into its cavity, is as pure, as if the Vessel had been exposed to the most lucid Rays of the brightest Sun. The Heat of burning Alcohol too, and fossil Coals, when it acts upon any Matter included in a clean glass Vessel hermetically sealed, if it is reduced to the same degree with that of the Sun, and is applied in the same manner, will appear perfectly the same by every effect. Nay, I add farther, that the Fire which is generated by the fetid putrefaction of the most putrid Bodies, when it has pass'd through dense Glass, is as pure, simple, and sincere, as if it had been propagated thither by the clearest Sun. The Heat, therefore, generated by putrefaction, fermentation, and the putrifying Dung of Animals, is the very same as that from pure Fire. And hence, I see no difference betwixt the Heat of Horse Dung for chemical Operations, and any other whatsoever, that is of the same degree, and is applied in the same manner. In Nature, therefore, we meet but with one sort of Fire; for both the elementary, and artificial, are always the same.

What I have here said, however, must not be understood of common Fires; for in these all sorts of Bodies float about with the pure Fire, and being mixed with it, according to their different Natures, and the alteration induced upon them by the Fire, affect the Bodies exposed openly to them in a very different manner from what they would have been affected, had they been acted upon by a solar catoptrical, or dioptrical *Focus*: Nay, and very differently too, with respect to their own proper Nature. But then, in this case, this various action of Fire does not depend upon Fire, as Fire, but upon Fire, and the other Corpuscles, that at the same time are agitated with it, which certainly makes a vast deal of difference, falsely ascribed to a diversity in Fire itself, which in reality appears to be always the same. The effect, however, of this Fire upon other Bodies, is very different, whilst it is supported in the manner above explained, by various sorts of Fuel; for by this means it acts with more or less violence, and even mixes with them the Particles of its *Pabulum*, which is agitated, vibrated, and often united with it.

In this respect, therefore, the Fire that is excited and supported by burning Alcohol, is the purest of all, and least of all affects the Bodies exposed to it with any impurities from the combustible Particles.

The next pure to this, is that which is fed with Oil often distilled, especially from a fixed alkaline Salt, and hence rendered exceeding fine, simple, subtil, and limpid, like Alcohol. Under this head come the native *Naptba* and *Petroleum*, which are endued with the same property.

Next to this follows the Fire of well prepared Charcoal. Then that of

H h 2

pure

Nor have
any diver-
sity.

The Fire of
common
Fires the
same, but
mix'd with
other Bodies.

With Alco-
hol.

With the
purest Oils.

With Char-
coal, Wood,
Turfs,

pure Wood ; which is succeeded in purity by that from Bituminous Turfs. And these are of two sorts, the one found in Heath's, where the upper Surface being pared off, affords a pure Fuel ; the other which is made from a wet, black, fat Mud, which being dug out of proper Pits, and then dried in the Sun, is divided into Parallelipipeds: These yield a noble, wholesome, steady Fire, which the illustrious *Boyle* was formerly so mightily pleased with.

With Coal
made from
Turf,

When this Turf is burnt 'till it is perfectly red hot quite through, and no longer emits any visible Smoke, if you then extinguish it, it affords a Coal, which when it is dry, takes fire with a vast deal of ease, and is exceeding fit for a great many purposes ; for it produces no Smoke or disagreeable Smell, continues to burn a long while of itself when once it is kindled, and yields the most equable Fire of any thing we know of.

With Fossil-
Coal,

To these more compound Fuels belong likewise the Fossil Coals, which consist of an Oil like the Fossil Oil of *Naptha* or *Petroleum*, and another Matter that will vitrify.

And Dung,

And lastly, the dry'd Dung of some sorts of Animals. The vast variety therefore that is observed to happen so often from the action of Fire in its physical effects, must be ascribed intirely to the different nature of the *Pabulum* it is fed with: This may be confirmed by abundance of Examples, but one or two will make it sufficiently evident. Wood, for instance, or Turf, when they burn in the open Air, emit a Smoke that is not very pernicious, only making the Eyes smart, and affecting the Lungs in such a manner as to provoke a Cough ; and yet, if you convert either of these into Coal in the manner above-mentioned, and then dry it thoroughly, and set it on fire and let it burn 'till it is perfectly red hot, there will arise from these Coals a very fine invisible Fume, which in a close place is very quickly fatal to all sorts of Animals. And in this affair there is something very remarkable ; for it appears by Experiment, that if you take an Animal, and put it under a large Glass, and draw some of the Air out, but not so much but that the Animal might live in it for some time ; then, if by the help of a Pipe you convey the external Air into the Glass, in such a manner as to make it pass through smoaking Coals, it will not destroy the Animal ; and yet if the same passes through Coals that are perfectly red quite through, it will be instantly suffocated. And very often too, there is some very extraordinary power communicated to Fire by the Air, as we see evidently in an Experiment related by that famous Writer of *America, d Costa*. For he tells us, that the native Silver that is dug out of the richest Mines of *Peru*, cannot, so long as it adheres to its Ore, be melted by the strongest Fire that can be raised by the largest Bellows ; and yet if this Fire is blown up by an artificial Wind procured by the fall of cold Water, and convey'd, and forcibly directed upon it by proper Instruments, the fusion of the Silver is soon obtain'd without any difficulty: These, therefore, and many other instances, sufficiently point out to us, how very circumspect we ought to be, if we would rightly understand the action of Fire upon other Bodies, since the minutest circumstances very often make a great deal of difference with regard to the event. There are a few things in our History of Fire still remaining to be considered, which will hereafter be of very great service in our chemical inquiries.

In the first place then, don't let us be led away by that vulgar opinion, that Fire is a universal solvent of all Bodies: That it dissolves a great many, indeed, we readily allow; but at the same time we must deny, that it has this effect upon all. Nay, upon the very same object, in different degrees of it, we see it acts in a quite different manner. If you put some Mercury, for instance, into a Bolthead, and apply a gentle Fire to it at first, and afterwards gradually increase it, it will, in length of time, be converted into a various-colour'd Powder, something of a fixed nature, and scarcely miscible with any Liquor; and yet, if you apply as strong a Fire to it at first, as you did at last, it will all immediately evaporate. And farther, if the Mercury thus fixed by a gentle, and gradually increased Heat, is at once exposed to a strong Fire, it will again become totally volatile; so that we see plainly, what the Fire effects in one degree, it destroys in another.

Fire is not a
universal
Solvent,

In the second place, Fire is not so pure a dissolvent, as to extract from Bodies only those parts that existed in them before; for at the very same time that it separates some parts, it mixes others together. Nothing can be more evident than this in many instances. Antimony, if it is exposed to a strong dioptrical, or catoptrical *Focus*, emits a vast quantity of Fumes, and yet, at the same time, has so large a number of other Corpuscles united and fixed with its *Calx*, that it considerably increases in its bulk. If Lead, by the same method, is converted into *Minium*, there rises likewise from this abundance of noxious Vapours, and yet the *Calx* acquires a considerable addition to its weight. In Corals too, calcined by a strong and long continued Fire, their weight is in the same manner augmented. And lastly, if Mercury, that is by a particular Art purified by the help of Metals, is digested for a long time in a glass Bolthead, it will be converted into a fixed Powder, and a very small portion of good Metal, with an increase of its original weight.

Nor divides
Bodies into
their real-
constituent
Parts,

Thirdly, from some sorts of Bodies it produces nothing new, but leaves them without any considerable alteration. Gold, for instance, Silver, *Osteocolla*, *Glass*, the *Selenitis*, *Talc*, and *Virgin Sand*, are not separated, either into their Elements, or other Substances, by the simple application of Fire. Consult *Van Helmont* in various places, and *Boyle* in his *Sceptical Chemist*, from p. 10. to 33.

Nor effica-
ciously dis-
solves all
Bodies,

In the fourth place, there are every where to be met with, great numbers of Bodies, from which it is impossible, by the help of Fire alone, apply it in what manner you will, to separate different Substances, though we certainly know, that Bodies of quite different natures enter into their composition; nay, and can readily, by the assistance of other Instruments, resolve them into their constituent Parts. A great many such Bodies we find taken notice of among the learned; our present Subject leads us to mention a few of them. Gold, Silver, and Copper being melted together, and thus intermixed with one another, produce a Mass, from which the power of Fire will not easily separate again these three simple Metals. If, with twenty times the quantity of good Lead, you manage this Mixture according to Art, in an Assaying Furnace, you will soon very accurately separate the Copper, and there will remain a pure Mass of Gold and Silver. Apply, now, to this whatsoever Fire you please, the Silver will constantly remain united with the Gold; nay, and in such a manner, that the very least Particle of this Mixture will always contain the same Proportion of Gold and Silver, as was in the whole piece. But if you then throw this Mass into

Tho' they
are separable
by other
means.

pure

pure Spirit of Nitre, the Spirit will intirely dissolve every Particle of the Silver without the least remainder, and the Gold will lie at the bottom of the Vessel, in form of a black Powder. The Silver, then, which is thus separated from the Gold, and resides in the Spirit of Nitre, you will not be able to separate again totally from the Spirit, without a good deal of difficulty; for if you call in Fire to your assistance, the Mass will, by the application of this, at last grow dry, and become the *Lapis infernalis*, in which the Acid of the Nitre very tenaciously adheres to the Silver, and runs with it in the Fire without any Fumes, in the same manner as if it was one simple melted Metal; but now, if into this Solution of Silver by the Spirit of Nitre, you immerse some thin Plates of Copper, then the whole Substance of the Silver, without any remainder, will be disengaged from the Spirit of Nitre, and every thing else, and lightly adhere to the copper, from which being shook off to the bottom of the Vessel, and then washed with Water, you will obtain your Silver again, in the greatest purity: So that here we see, likewise, what the Power of Fire was not able to effect, is brought about by some other means. It's needless to make mention of the Sulphurs that are mixed among the metalline Glebes, which adhere to them in such a manner, that they either keep melted with them in the Fire, or else carry 'em off with them into the Air. How unsuccessful, and with what disadvantage, have the Metallurgists endeavoured, by the help of Fire, to dissipate the volatile Sulphur, that the Metal might remain pure at the bottom of the Cupel? And yet if with these you mix some fixed alcalious Salt, or Iron, which in the Fire greedily unites with Sulphur, or any absorbent Powders made of these or the like materials, as soon as ever the Sulphur has absorbed these additional Substances, and united them with itself, it produces some sulphureous *Scoriæ*, and gives you the pure metalline Glebe at the bottom. Examine Antimony, and whenever it is pure, it appears to be homogeneous. Manage it by Fire, in what manner you please, and it will either be intirely carried up in Fumes, or, if the Fire is gentle, will totally remain in it. But if you mix with it, now, Tartar and Nitre, or Iron and Nitre, and then set it on fire, the external, sulphureous Part will be immediately separated, and the metalline Mass will be left behind, intire, ponderous, and homogeneous. If you put the same Antimony into *Aqua Regia*, the Sulphur will be cast out unaffected by the Acid, whilst the *Aqua Regia* siezes upon the metalline part, and unites it with itself. *Sal Ammoniac*, which is truly a compound Substance, in a greater degree of Heat, rises totally, and without separation; in a less too, continues undivided; and yet, by an addition of a fixed alkaline Salt, it is very readily resolved into a fixed Sea Salt, and a volatile animal one. *Mercurius Sublimatus Corrosivus*, if it is for a long time exposed to the Fire, continues compounded of the acid Spirit of Salt, and Mercury; but is freed from its Acid by mixing with it Iron or *Alkali's*. Chemistry every where furnishes us with numberless Instances of the same kind.

Nor divides
them into
simple Elements.

In the fifth place, it deserves our notice, that those parts, which are separated by Fire from compound Bodies, how carefully soever you apply it, are not in reality simple Substances, but are variously intermixed with one another. If you examine, for instance, the simple Waters, that are drawn by Fire, does not the odour at first drawing, and the Turbidity, putrid Smell, and slimyness they naturally acquire in keeping, make it evident, how much they are still compounded, since none of these things are ever observed in pure Water? Consider the
Spirits,

Spirits, and you will find that they consist of a Water and Salt, so intimately united together, that it is not possible to separate them by any Art, except by the joint assistance of fixed Salts and Fire. But what shall we say of the Oils? The common Chemists look upon these, as most simple, pure, sulphureous Elements; but the top masters in the Art make it evident, that these too are remarkably compounded of various Substances. For in these there is that inflammable Element, of which we have so particularly treated above, a great deal of Water, and some quantity both of Salt and Earth, intimately united together. And lastly, as for the Earth that is extracted by Fire from compounded Bodies, what a vast deal of trouble is required before it can be obtained perfectly pure? Certainly it is always tenacious of some fixed Salts, even till it begins to be converted into Glass.

In the sixth place, it appears by abundance of Experiments, that the composition of Bodies is as much affected by the action of Fire as their separation; for it unites the most different Bodies so intimately together, that the new formed Substance appears perfectly simple, and is not liable to any alteration from its power afterwards. For Sand, we know, by being calcined, melted, and intimately mixed with a fixed Alkali, by the force of an intense Fire, produces Glass, which is then so simple in the whole, and every part, that we scarce know any thing more so, or harder to be dissolved, since it can be separated into its simple parts by no other means, than by melting it with a great quantity of fixed Salt, that it may become of a saline nature, and then pouring an Acid upon it, by which means an exceeding subtil powder of Sand will be precipitated from it. The various kinds of Soap demonstrate the same thing. The distillations of *Aq. Regia* evidently confirm it likewise; as well as the artificial mixing of Metals. But what need is there of more instances? Does not universal nature make use of Fire, as its principal instrument in the production of its compound Bodies? What Compound is generated, either in the animal, vegetable, or fossil Kingdom, that does not owe its origin to a soft, digesting, disposing, compounding Fire? Certainly, the gentle and steady action of that grand mover, Fire, seems to be the principal cause that every where brings about the most strict and intimate union; nay, even so much, that it may be doubted, whether Fire is most efficacious in the composition of Bodies, or in their dissolution. Without dispute, it hath a vast effect in both.

In the seventh place, it ought particularly to be taken notice of, that the very same Fire, if it is applied in different degrees, will in one, compound those Bodies, which it will again resolve in another. This the Chemists have frequently learned to their cost, for when they have spent years in fixing Mercury by a gentle Heat, successively increased through various degrees, and by this means have obtained a red powder, which remained a good while fixed in the Fire, they have found that at last, when the Fire was rendered intense by the assistance of Bellows, it has been dissipated into the Air; and thus being disappointed of their expectations, have experienced, that Fire separates in one degree, what it before united in another.

But eighthly, the very same degree of Fire applied to the same Bodies in different circumstances, produces effects that are surprizingly different, and that particularly, according to the various admission of the Air in the operation. The famous *Hook* took a Coal, and by means of a Cover that screwed on, perfectly

Nay, and it compounds Bodies.

And again, separates the Compounds.

Acts variously, with regard to the Air.

perfectly inclosed it in an iron box. In this manner he exposed it to a very strong Fire, for a considerable time, and yet when he took it out, the Coal, by such a violent action of the Fire, was not burnt up. See *his Life in his Posthumous Works*, p. 21. Hence this ingenious Philosopher inferr'd, that the Air is a *menstruum*, which, being agitated by Fire, will dissolve all sulphureous Bodies, since Fire, without the assistance of the Air, is not able to effect it. The same thing *Van Helmont*, in his Distillations, had formerly observed in his fixed Coal. And *Rapin, Recueil des Machines*, p. 25, 26. And when, before you here, I put some Shavings of *Guaiaicum* into a Retort, and urged them with a very strong Fire for a long while together, there remained at last, as I told you, some black *Fæces*, that still retained an Oil, which the utmost force of the Fire was not able to force out of the Retort. But when this powdered Coal was laid in a large Dish, and examined, by dropping a spark of Fire into it, then the black Oil was immediately consumed with an aromattick Smoke, that smelled like Cedar, and the Shavings were turned into insipid white Ashes. Camphire, if it is set on fire in the Air, will intirely consume, though it swims in Water; and yet if you expose it to the Fire in a clean glass vessel, with an Alembic over it, it will melt and rise into the Alembic, and there harden into the same Camphire again without any alteration. And though you repeat this a good many times, the event will be still the same. May not Sulphur be sublimed a hundred times in a close Vessel, and still remain the same Sulphur? And yet if during the sublimation, there happens to be a crack any where, so that the Air can have a communication with the melted Sulphur, it immediately takes fire, and is instantly resolved into a blue Flame and an acid Fume. Amber, if you set it on fire in the open Air, almost totally burns away, and supports Flame and Fire; but if you urge it in a Retort with the strongest degree of Fire, but gradually increased, you will force into the Receiver a Water, Spirit, a volatile acid Salt, an Oil of various sorts, and with the last degree will make the whole substance of the Amber come over the neck of the Retort; as I have frequently myself experienced. Fire, therefore, when it acts upon inflammable substances, without Air, or with Air that stagnates, and is without motion, produces very different effects from what it does in other circumstances.

And various-
ly in various
degrees.

Ninthly, and lastly, the same Fire applied to the very same Object, but in different degrees, is very various in its Operation; as appears, likewise, by Experiments. Take, for instance, the fresh White of an Egg, put it into a clean Vessel, to which there is a free admission of the Air, and let it be exposed to 92 degrees of Heat, in *Fahrenheit's* Thermometer, and it will in a little time be resolved into a Liquid, that grows continually thinner and thinner, becomes sanious, fetid, and putrid, and at last runs just like Water, nor will be coagulated by the Heat that makes Water boil; and thus it is converted into a most putrid, volatile Alkali: But now, if the same White of Egg is exposed to 200 degrees of Heat, in the same Thermometer, it is immediately changed into a white, solid, scissile, insipid Mass, exhales a large quantity of inodorous, insipid Water, and at last there remains at the bottom an exceeding hard, brittle, pellucid, insipid, inodorous Substance, that may be kept for years without any alteration: And again, the same White being urged by a Fire of 400 degrees, in a glass Retort, yields a Phlegm, Spirits, fetid

fetid Oils, an oily, fetid, alkaline, volatile Salt, and an exceeding black Coal that is surprizingly puffed up by the Fire. But there would be no end, Gentlemen, should I go about fully to explain the nature of the power of Fire. Let it suffice at present, that I refresh your memories with a short abstract of this Doctrine, as it has been already delivered, *viz.* that the action of Fire, as it may be varied under all the circumstances above mentioned, is capable, as a concurring cause, of producing the greatest part of the physical effects that fall under our observation. It can alter Concretes in their Figures, and Cohesions; but in such a manner, however, that a difference in the Concretes produces a variety, with regard to this power; for Fire is never able to produce the same thing from different Bodies, but some certain things from particular ones; and then, besides, there will be yet a farther difference, according to the various order, degrees, and application.

Our Dissertation of Fire, Gentlemen, is thus then at length so far advanced, that we are now able to treat of that knowledge of Fire, considered as present, and operating in a particular place, which an Artist ought to be acquainted with, in order to know how to direct and keep up such a Fire, in a given place, as is proper for the inducing such and such changes in certain Bodies. This doctrine was laid down by the ancient Chemists, and is at present almost brought to its greatest perfection by means of those beautiful Thermometers of the ingenious *Fahrenheit*. It was their opinion, that the power of Fire might be conveniently enough reduced to four degrees, and that this distinction was sufficient for the exercise of their Art: Of this matter, however, they gave us but a very obscure Account: Nor have the moderns made any considerable additions. Let us, therefore, Gentlemen, undertake this point, and call in Art to our assistance, but Art that is formed upon Nature.

Of distinguishing and managing Fire.

The first degree, then, of Chemical Fire, I call that, within the compass of which Nature brings about the work of Vegetation in Plants, and by which the Chemical Art imitates the same. This begins from the greatest degree of Cold, *viz.* Number 1. in *Fahrenheit's* Thermometer, and ends at the degree 80: For through all the degrees contained betwixt these limits, Vegetables of one kind or other give plain indications of Life and Vigour. Don't you, in the most piercing cold, see the bitter mosses growing upon the barks of Trees, and indeed scarcely at any other time? Don't the Fir, the Juniper, the oriental Larch-tree, the Cedar, the Pine, the Savine, the Yew, and the *Arbor vitæ*, retain their verdure in the sharpest Winter? Not to mention the Sea Mosses, the Land Mosses, the Black Hellebore, the *Hepatica Nobilis*, the Snow-drop, the Winter Wolf-bane, the Bastard Hellebore, and others; which in the hardest Winters put out Leaves, flower, generate, conceive, and bring forth, notwithstanding the check one would imagine they should receive from the intenseness of the Cold. In short, if you carefully examine all the Plants that we are at present acquainted with, by the degrees of Heat contained within the bounds here described, you will find some Plant or other that comes to its maturity in almost every one of these intermediate degrees.

The first degree of Chemical Fire.

Hence it appears very probable, that the Chemist, by a well managed degree of Heat, may in his artificial Stoves imitate that power of Fire, which Nature makes use of in the generating of Vegetables, so as by gentle degrees to

The remarkable use of this.

proceed to cherish the Plants, and not to destroy them. If you desire to excite such a Heat as this, upon a proper furnace place a vessel full of Water, in which dispose a Thermometer, and then you may, by increasing or lessening the Fire, easily reduce the Water to that temperature which is for your purpose. When the Water is thus found to be sufficiently warm, put the Body you would make the Experiment upon in a glass Vessel, and set it in the Water, which by this means will communicate to it a proper degree of Heat. Is it not very probable now, Gentlemen, that this degree of Heat is the best suited to impregnate Oils with the choice Spirit of some Vegetables, without dissipating the most precious Part? If one wanted, for instance, to impregnate an Oil with the most fragrant Spirit of Roses, what method is more likely to succeed, than the taking some Roses, gathered in the morning, and digesting them with some pure, inodorous, and almost insipid Oil of Olives, in a tall Bolthead, in 56 degrees of Heat? Such a Heat certainly will so unite and intangle the Spirit of the Roses in the visciduity of the Oil, that it will not be easily disengaged again, but will produce a most fragrant Balsam. And if you would enrich the most liquid Alcohol with the choicest Spirit of Saffron, make use of the very same degree; for with a less you will scarcely extract it from the Substance of the Saffron; with a greater, you will dissipate those particles which are most volatile. There are but few who have a right notion of this Affair; those, however, who are best acquainted with these things, know it to be true. By this caution in the management of the Fire, it is certain, there are incomparable Medicines prepared, which become good for nothing, if you increase it beyond its proper bounds.

The second degree.

The second degree of Fire may, I think, be most conveniently measured by the Heat that is at some time or other observed in healthy Bodies. This, in its lowest State, is supposed to begin at the 40th degree, in *Fahrenheit's* Thermometer, and in its greatest height, to rise to about 94. Within this compass Animals seem to be capable of subsisting, if their humours have any degree of Heat in them, that is contained between these Limits. There are some kinds of Insects that live with a very small degree of Heat in their vital Juices, and nothing seems to me more surprizing, than that the *Embryos* in the Eggs of Caterpillars (which they lodge, when they are impregnated, in a viscid matter circularly disposed round small twigs) should remain secure in their little Nests, during all the severe Winter of the Year 1709, and the very sharp one of the present 1729: For notwithstanding every body would be ready to imagine, that they must have perished through the extremity of the Frost, yet by the kindly influence of the warmth of the approaching Spring, we saw the Worms able to disengage themselves from their Eggs, and thus make it appear, that they had stood out against the great severity of the weather. Fishes too, belonging both to Seas and Rivers, that have Gills instead of Lungs, live and keep moving continually in Water that is 34 degrees warm; and if the Heat of it is increased from hence as far as 60 degrees, and better, they are still in some measure able to bear it. But Fishes that are furnished with Lungs, like other respiring Animals, in the time of health, communicate to their humours a warmth of 92 degrees, a little more or less; and hence they will subsist in any degree, betwixt 33 and 94. Within the compass of this Heat are included the vital actions of Animals, the fermentation of Vegetables, and the putrefaction both of

The use of this.

of Vegetables and Animals; as likewise the generation, breeding, hatching, birth, and nutrition of Animals. This degree of Heat the most experienced Chemists make use of to prepare their Elixirs, volatile alkaline Salts, both simple and oily, and their Tinctures; and employ the same in concocting their Mercury to the first preparation of the Philosopher's Stone.

The third degree of Heat begins at the degree 94, and reaches as far as 212, in which Water generally begins to boil. Through this whole intermediate space, the Water and native Spirits are separated from all kinds of Animals and Vegetables; and the *Residuum* grows dry, becomes durable, and almost immutable. The essential Oils of Plants in this Heat become volatile. The Salts and Oils, in the fresh Juices of Animals, are scarcely raised, but the Juices are dried into a thick, hard, brittle, insipid, inodorous Substance, which will keep for years without any considerable alteration. And hence it appears, with how little reason some persons imagine, that volatile, alkaline, oily Salts, are generated and retained in a healthy Body. This degree of Heat serves for the distillation of the distilled Oils, and medicinal Waters of Vegetables. The sanguineous serous Juices of Animals coagulate in boiling Water into a Mass that will bear to be cut asunder; whilst all their Solids are destroyed by it, and reduced to a thick, tenacious Liquid. And hence it is absolutely destructive to all Animals.

The third degree.

The efficacy of this degree.

The fourth degree may be reckoned from the degree 212 to 600; within which limits, all Oils, Saline *Lixivia*, Mercury, and Oil of Vitriol, recede from the Fire, are carried upwards, and by this means distilled. In this too, Lead and Tin are put in fusion, and may be mixed together. The Oils, Salts, and saponaceous Juices of Animals and Vegetables are rendered volatile and acrid, and become more or less alkaline: The solid parts of them are dried, and if they are calcined, are changed into a very black Coal, are all absolutely destroyed, quite altered in their qualities, and lose entirely their proper Virtues. Within this Heat too are sublimed Fossil Sulphur, and *Sal-Ammoniac*.

The fourth degree.

The fifth degree of Fire may contain that latitude, in which the rest of the Metals are put in fusion. This will begin at the degree 600, and reach as far as that which is capable of melting Iron. This degree, Glass, Gold, Silver, Copper and Iron, bear a considerable time, whilst it destroys every thing else. In this degree all other fixed Bodies grow white with Heat, the fixed Salts of Vegetables and Fossils are put in fusion, are deprived of almost all their Oils, acquire a greater and greater alkaline acrimony, and with Sand or Flints are converted into Glass; Lime-stones are calcined; all other things either vitrify, or become volatile, and are dissipated into the Air.

The fifth degree.

The sixth and last degree comprehends the whole compass of the dioptrical and catoptrical Fire above describ'd; which hardly any Body is able to resist: By this even Gold itself suffers very surprizing alterations. Concerning this Fire, consult the Observations of *Mess. Homberg, Hartsoeker, and Vilette*, and what we formerly delivered upon this Subject. The principal effect that this Fire commonly has upon almost all Bodies, is the turning them to Glass. The ultimate effect, therefore, of the Fire that we are at present acquainted with upon fixed Bodies, is their Vitrification. This the most ancient *Magi* of the East seem to have understood, when they prophesied, that the whole World would at length be destroyed by Fire, and that it would then be converted

The sixth degree.

verted into pellucid Glafs. Thus far, then, at least, our doctrine of the degrees of Fire stands upon a sure Foundation; as for the ultimate power of it, the human mind will never be able to fix its limits.

A certain direction for these degrees.

In the next place, now, it is of great consequence for us to be acquainted by what means we may know how to raise and keep up a Fire to any degree that we have occasion for; on this principally depends all the operations of the whole art of Chemistry.

First, the nature of the *Pabulum*.

And here it is much more difficult to preserve a great degree of Cold, for a considerable time, than it is to keep up a very great Heat; as the metal and Glafs Works, where such intense Fires are requisite, most evidently demonstrate. The first way, then, by which we may keep a Fire moderate, is by choosing such kind of *Pabulum*, afore described, as is proper to produce such a strength of Fire as is fit for our purpose. Alcohol of Wine yields a weak, and equable Flame, that may be easily increased or diminished by a greater or less number of wicks. When you are determin'd, therefore, about the degree of Heat, that you design to make use of, it is a very easy matter to light a Lamp with so many Wicks as appear by the Thermometer to be necessary to excite the degree desired. After Alcohol, follow the lighter, porous, spongy kinds of *Pabulum*, as Rushes, Straw, dry Leaves, Hair, Feathers, Shavings, dried Stalks of Buck-wheat, Chaff, and Bran. Next in order, Oils, Tallow, Wax, Camphire, Pitch, Rosin, Sulphur, and other Compounds. Then thick, heavy, hard, sound Wood, not too dry, and the Coals that are made from it. And, lastly, red hot Metals; and fossil Coals.

Secondly, the quantity.

Again, various degrees of Fire, even to the greatest, may be raised by the quantity of combustible matter thrown on; for if a vast quantity of Fuel is set on fire all at once, then the Fire that is produced by it will be always proportionably stronger, the force of it all being united together.

Thirdly, the distance.

But farther, there will be a vast deal of difference in the Heat, with respect to the Object it acts upon, according to the distances in which the Body is exposed to the Fire, the Heat always decreasing, as it is removed farther off. A great many famous Philosophers have been of opinion, that this difference might be determined by one simple rule, *viz.* that the forces of corporeal qualities always decrease in a reciprocal proportion of the squares of the distances from the center that generates these qualities; and hence that Fire too acting at double distance, has only one fourth part of the force. But before we can be certain of the truth of this, we must first be sure, that the Fire itself, when it is contracted into a narrower compass, does not acquire some new power, not depending upon the number of the Elements alone, but upon some efficacy which they acquire by being brought nearer to one another. And indeed, if we carefully examine this Affair, we shall find, that though it is true, indeed, that the farther we recede from Fire, the less Heat we are always sensible of; yet the law in which it decreases is very different from the general one, just now mentioned. For Experiments cautiously made for this purpose, plainly evince, that at a small distance from the heating point, the Heat on a sudden decreases prodigiously, but that at a greater, the proportion of the decrease is not so remarkable. Hence it appears very probable, that besides the power they have of acting upon other Bodies, the particles

ticles of Fire acquire another power, depending upon the relative motion which arises from their approaching very near to one another. For since those famous Philosophers, *Grimaldus* and *Newton*, have observed, that the Elements of Fire, as they tend towards opaque reflecting Bodies acquire new motions, as they come near their Surfaces, why may not the very particles of Fire be effected in the same manner by one another? But here I refer you to what has been already delivered upon this subject.

In the last place, the agitation, concussion, and compression of Fire, when it is excited by its *Pabulum*, and included within its aerial Arch, must enter likewise into the consideration: For by these the violence of it is very much increased, and indeed, always the more so, the stronger they are, supposing the Arch not destroy'd, as we took notice of before. And here, as we cannot by any means procure this agitation and compression of Fire, more conveniently, and more efficaciously, than by blowing, or driving the Air forcibly upon the Body of the Fire; hence Bellows are the Instruments in particular by which we direct this pressure of the Air upon the Surface of the Fire, and thus agitate the parts of it with a great deal of violence: But of this too we have treated already, when we was considering the aerial Arch that surrounds a burning Fire. And there likewise we saw, that if the Wind of a great many strong Bellows is directed from opposite parts upon the center of the same Fire, then the Fire will act with so much more strength upon the Body that is placed in that center, and consequently the changes it induces upon it will be so much more considerable. And hence the Assayers make use of this method in particular, when they want the greatest strength of Fire. In short, therefore, if the four methods abovementioned are called in to our assistance, and made to conspire in their efficacy, we shall by this means procure the most intense common Fire.

Fourthly,
by agitation
and compression.

These are the things, Gentlemen, which I thought principally necessary to lay before you, and to explain to you, in the natural History of Fire, particularly, as it is of use in the chemical Art. The disposing them in a proper manner, and setting them in an advantageous Light, has cost me a great deal of pains: Whether it has answered any valuable purpose, I leave you to judge. I think, however, that this is evidently certain from what has been said, that a chemical Fire, supported by the same *Pabulum*, and apply'd in the same manner, and the same degree, will always have exactly the same effect upon the same Bodies, either of adunation, or separation: And again, that unless these circumstances are first accurately determin'd, it is impossible to describe the action of Fire upon Bodies with any certainty. In giving an account therefore of any chemical operations, we must have a very careful regard to every thing that has been any where proposed in our Treatise of Fire: And thus at length the Art of Chemistry may be reduced to as certain and regular a Science as any other. Before, therefore, always to take notice of the degree of Fire; the succession of the degrees; the weight, and heat of the Atmosphere, and its action upon the Fire, either by draught, or artificial, or natural Wind; and then give an account of the Object: And a description formed upon this plan, will never lead a person, that would work after you, into mistakes. Give me leave now to add a few things that regard the nature of Fire. First, then, Fire, for its existence, does not stand in need of Air, Nitre, Fuel, Sulphur, or any other

Body.

Body. True *Naptba*, among Bodies we are acquainted with, is set on fire the easiest, and that, at a considerable distance from the Flame; as is likewise the purest *Petroleum*. *Journ. des Sc.* 1675. 53. Bodies that are rubb'd over with *Naptba*, and then set on fire, continue to burn, tho' they are immersed under Water. *Journ. des Sc.* 1683. 104. *Naptba* takes fire by the flame of a Candle placed within a Lanthorn, and thus prevented from coming into contact with it. *Phil. Transf.* N. 100. p. 188. Some Gunpowder was disposed in a machine into which Water could not penetrate, and with it was included a piece of Clockwork, which at a certain time, by striking a Flint against a Steel, should set the Powder on fire; it was then let down to the bottom of the Sea, and when, at the time expected, the Gunpowder took fire, they heard a very great rumbling noise, and saw a very thick Smoke, but there was not the least appearance of any Flame, *Sinclair. de arte Gravitationis*; which Experiment certainly deserves the most careful Observation, as it affords a good many *Phænomena* pretty remarkable. Sir *Thomas Sibbald*, in his *Scotia Illustrata*, gives us a very extraordinary account of the Lake *Strath-Erith* in *Scotland*, whose Water, he tells us, let the Cold be ever so sharp, never freezes before the month of *February*, and yet after that time, in the space of one Night, is often covered with a strong Ice; which *Phænomenon* seems to indicate that Heat increased in one place, produces a greater degree of Cold in another. And this again, which indeed was formerly taken notice of, seems more evidently deducible from another surprizing Observation of a little Rivulet that never freezes at all, let the Cold be ever so severe. *Phil. Transf.* N. 56. 1139. The same abridg'd, T. II. 335. But this opinion seems most of all confirm'd by the accounts we have from the Abbot *Boisotte*, in the *Journ. des Sc.* 1686. p. 336; and *Du Hamel*. in the *Hist. de l'Ac. Roy. des Sc.* p. 257. viz. that at about 5 leagues from *Bicanson* in *France*, there is a Cave 300 paces deep, which in the space of one day, when the Weather is excessive hot, furnishes so much Ice, that the Waggon and Mules are scarce able to carry it away in eight; so that it rises almost to the thickness of four feet: And on the contrary, in the Winter time, it is full of dense Vapours, and a River runs in the middle of it, which is always frozen in the Summer. When any Vapours are seen in this Cave, they certainly prognosticate immediate rain. In Green-houses, likewise, and Stoves made to preserve Plants in the Winter, the greater the Heat is in any particular places, the more Cold there is in all the others. And the same is true of the places surrounding the Furnaces used for melting of Iron, and all the works with large Fires, especially, when the Heat within is most intense.

Thus, Gentlemen, I have endeavoured to explain to you the nature of that wonderful cause, which the great Creator has placed in the Universe, with a power of exciting those motions in natural Bodies, which are necessary for bringing about the extraordinary changes that are continually effected. As far as I have been able to get any knowledge of it by a laborious inquiry, I submit it to your examination. Its abstruse and mysterious nature affords us still matter for an infinite number of Discoveries. Let me excite your diligence therefore, to continue the prosecution of these inquiries, and afterwards to communicate them to mankind, that thus, by a more perfect knowledge of the Works of the Alwise Creator, we may better understand, and more justly reverence that

immense Power and Wisdom, which infinitely surpasses all human comprehension.

Of AIR.

Order requires, that in the next place we should treat of Air; since both Nature and Art, by its concurrence and virtue, perform almost all their Operations. It is necessary, therefore, that we should be thoroughly acquainted with its nature and properties, if we would rightly understand the manner in which physical changes are effected. But as Air is more compound than even Fire itself, and consequently more difficult to be understood, hence the better to search out its hidden genius, we must here again proceed, as if we were intirely unacquainted with it, and observe the very same steps that we took in order to discover the nature of Fire. By the name Air then, we would have you understand that Fluid, which is hardly to be perceived by our Senses, but that manifests itself by its resistance to Bodies moved in it, and by its strong motion against other Bodies, at which time it is called Wind. By these Observations we know, that the Air rests every where upon the Surface of our Earth. All Men live in it, we enjoy it, and are perpetually nourished by it. The manner of our existence, and inevitable necessity constrain us, to breath in this Air, be it what it will; insomuch, that all the aids of Art are vain, and all that Nature can do for us, is fruitless, if we are deprived of it.

If we will but examine into the manner, in which Nature operates according to the Laws which the great Creator has appointed, we shall plainly perceive, that this very Air is that grand, efficacious, and necessary Instrument, which universal Nature principally makes use of, in almost all the Operations she is perpetually engaged in. For in this, all *Species* of Bodies are placed; in this they move; and in this they perform all their actions; as well those singular ones which proceed from their proper and particular Natures; as those which are produced from their mutual, or as it is called, relative, disposition. Nay, there is scarcely any Liquid, as will hereafter appear by Experiments, which has not Air intermixed with its parts; scarcely any Solid, out of which Air may not be extracted by some Art or other. So that in short, it is very difficult to mention any known Operation of Nature, which happens without the assistance of Air, or utterly exclusive of it. The Operations of Fire, the Loadstone, Gravity, and the particular attraction, and repulsion of Corpuscles, may perhaps be alone excepted, as capable of being performed without it: To all others it is absolutely necessary. Whatever the chemical Art performs, it executes in the Air without any exception that I know of; unless, perhaps, the Alchemists will have it, that the Matter of the *Philosopher's Stone*, rightly prepared, and carefully lock'd up in the philosophical Egg, is intirely deprived of all crude Air, and is brought to its maturity, rather in *vacuo*, than in Air; for indeed, they all declare to a Man, that nothing is so great an obstacle to the maturation of this most beautiful Fruit, as the crude Air: But this may be ought rather to be understood, of the other Particles that are intermixt with the Air, than of the pure Element itself.

We know with the greatest certainty, that Fire which puts all things in motion, can scarcely be either collected, preserved, directed, increased, or moderated, without Air. Hence, then, if Fire requires Air, of consequence,

Air next to
be treated of.

Chemistry.

A second
universal In-
strument,

Because it
excites even
Fire itself.

all

all its Operations will require the same; so that without it, Fire would cease to operate, nor could be applied to other Bodies. But let me caution you, that I am here talking of that Fire which is excited and fed with inflammable Fuel, by the means of which, both Art and Nature execute their principal designs, and which, as has been proved by many Arguments above, stands in so much need of this Element.

It acts upon
Animals,
Vegetables,
and Fossils.

Whoever has leisure and inclination to take a view of the more general *Classes* of natural Bodies, will find, that Air is every where required to their vitality, growth, vigour, and action. For if their vitality consists in their propelling their humours through proper vessels, and by a peculiar power, converting the foreign Juices they receive into their own nature, or at least by a singular virtue applying them to their Substance, and thus increasing in their magnitude; I cannot help thinking it utterly impossible, that any one of these functions can be performed without the perpetual assistance of Air; but that its presence and aid is absolutely necessary to them all.

Air, how far
concerned in
the life of
Fossils.

The chemical Tribe, in particular, I am aware, will be surprized, when they hear me calling in the Air, in order to set forth the œconomy of Fossils; since their excluding simple matter seems to have occasion for the efficacy of Fire alone, to be capable both to act and undergo whatever is brought about in the *Species* of Bodies. But certainly, those who have duly considered the nature of things, have long ago understood that Fossils are brought forth, and multiplied, in the deepest recesses of the mines, and are thence protruded upwards, and that all this is accomplished by the exquisite power of the subterraneous Fire. And as this is certain, so likewise it must be allowed, that this subterraneous, vestal, and perpetual Fire, is there retained, collected and apply'd, by the Air alone. This, Gentlemen, is what I am particularly desirous to set before you in a proper light, as it is a point which has hardly been clearly handled any where else. Air then is a heavy, elastic, Fluid; dense, in proportion to the weights that compress it, acts more powerfully upon the same Fire, in proportion to its acquired density; expands itself in the same *Ratio*, as it is freed from compression; rarefies proportionably to the intenseness of the Fire that acts upon it; and insinuates itself into all things; and exerts chiefly all its properties, in those parts which are deep, and towards the center of the Earth. Hence, therefore, it always operates the more violently, the deeper and denser it is, and being agitated by the Fire, which by this very attrition of the Air is collected there in greater quantity, becomes the physical cause of the most violent compression, attrition, compaction, depuration, and union of homogeneous Particles: And hence, the Fossils which are generated there, are of a nature suitable to such a cause. Without this Air, none of these would be produced. And, perhaps, this is the sole reason, why they are only formed in those places. But more of this hereafter. What I have here said is sufficient, as it serves to let you see, that the presence and active virtue of the Air is requisite to all the Operations of Nature.

In Animals
and Vegetables.

Nor will it be any ways necessary, that I should explain to you the power of this Air upon Animals, and Plants; for some late very accurate Experiments have fully instructed us, that no Eggs of Animals, or Seeds of Plants, be they ever so ripe, pregnant, and the best of the kind, and cherished with ever so kindly a warmth, will ever bring forth the Embryo's contained in them, but will

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will remain intirely unactive, if they are either deprived of Air, or are inclosed in stagnating Air in Glasses hermetically sealed. All small Plants, likewise, even the most minute Mosses, or aquatick Vegetables, when they are kept in a place void of Air, or when it is not renewed, presently wither and die. That the same also happens to all Animals, even to the smallest Insect, is true, beyond all contradiction. Thus then you clearly perceive the mighty influence of Air over all things.

An accurate knowledge, therefore, of the Air, by which its actuating properties may be understood, is absolutely necessary for the Chemist, Physician, and natural Philosopher; for by this means alone, we shall be able to comprehend a great many Operations, which are performed by Art, or Nature itself, their principal cause very often being some innate power of the Air, that exists nowhere else.

The knowledge of the Air therefore, very necessary,

In the mean time, there is not, perhaps, any natural Body, the perfect knowledge of which, is a matter of greater difficulty; because spontaneously, and of itself, it scarcely affects the organs of our Senses. This one may justly attribute to its exceeding subtilty, to which the dulness of our Nerves renders us insensible; inasmuch, as, even by the assistance of the most perfect Microscopes, we are not able to discover any thing in it. But there is yet somewhat else in the Air, which is still a greater obstacle to our rightly understanding its Nature, and that is, its containing so many various kinds of Corpuscles, that in the whole Universe, there is not found a Fluid compounded of a greater variety. Nay, when you have heard what I am going to deliver concerning this Element, it will clearly appear, that there is hardly any *Species* of Bodies that we are acquainted with, of which something doth not float about in the Air; Gold itself, the least volatile of all Substances, not excepted.

Though difficult.

It is highly necessary therefore, that we first of all take most distinctly into consideration, every single property of the Air, carefully avoiding all confusion: This done, and each being separately examined with due application, we shall by making an aggregate of the whole, obtain as true a knowledge of it, as the nature of the thing will admit of.

Method necessary.

The first property then of Air, which offers itself to our consideration, is its fluidity. This is so natural to it, that I do not remember ever to have heard of any Experiment, by which Air could be deprived of it. It is evident to every one's observation, that even in the sharpest Frost, when every thing, almost, is congealed, the Air still remains liquid; nay, in an artificial Cold, 40 degrees greater than ever Nature has been observed to produce, the Air still retained its fluidity, notwithstanding it was acted upon by such a prodigious excess of Cold. If you compress the Air with ever so great weight and force, too, into the utmost density, yet it does not then become solid by concretion, but remains equally fluid as before, and as soon as ever the compression is removed, it resumes its former liquidity: Nay, among the various coagulations I have discovered in the mixing of different Liquids together, which certainly have been a very great number, I have never yet met with one single Experiment, by which it appeared, that Air was coagulated into a solid Mass. I confess, indeed, one Noon, in frosty Weather, when the Air was very serene, I observed some very small Corpuscles floating about in it, glissening in the Sun, and by the variations of their little Surfaces sparkling with wonderful

In the first place Air is fluid.

coruscations; but after a careful inquiry, I discovered, that these were nothing but little Globules, consisting of Particles of Water, which before were dispersed about in the Air, but were now united and congealed, and thus appeared in form of a very subtil Hoar-frost. Were it possible, therefore, that Fire could admit of concretion with other Bodies, concerning which you may remember, I have treated already; Air surely would appear to retain its fluidity much more obstinately than Fire itself. But, indeed, it rather seems probable to me, that there are in Nature two Fluids, the Elements of which will never unite with each other, nor will ever harden with any other Bodies into one homogeneous Mass: And these two are Air, and Fire. In the mean time, however, while I am talking in this manner, I would not have you think, Gentlemen, that I have forgot, that this very Air grows together, and unites with every kind of known Bodies, and so serves as a kind of Element in the composition of concretes: For this is sufficiently evident from the large quantity of Air, which of itself makes its way out of almost every Body, whilst it is reducing into its Principles, and is now-a-days, perhaps not so properly, called factitious. But you, Gentlemen, who have examined this Air with me, know very well, that it is contained in all known Liquors whatsoever; that it penetrates together with them into all the recesses of concreted Bodies; that thus at length, after a coalition of the whole, it remains lock'd up in the *Meatus's* of the Bodies, as it were, in very minute Vessels; and afterwards, the Liquor in which it was convey'd thither, being dissipated, it is left there alone. Hence, then, you see very clearly, that this Air was not concreted there; but only lay concealed, being retained by the including Body. As soon as ever, therefore, it can disengage itself from this confinement, it rushes forth intirely unchanged, and returns with all swiftness to its proper Nature. But this still appears more evident, if we consider common Water whilst it is freezing. Is there not hid in it a great quantity of invisible Air? What becomes of it? Why, as soon as ever the Water begins to form itself into Ice, and its Particles are press'd nearer, and united together, as they are now deprived of that degree of Fire, which is necessary to keep them asunder, and prevent their running into their natural union; then, I say, the Particles of Air intercepted between the Corpuscles of Water, cannot congeal, but are pressed out of these interstices, are united with other Particles, are separated from the Water, collected in Bubbles, become again a most fluid Air, and thus evidently evince, that this Air was intercepted indeed, but not concreted, coagulated, or altered. The same thing being supposed to happen in the like manner in all other Bodies, the first property of Air, namely, its fluidity, is sufficiently made out.

The fineness
of the parts
of Air.

In the first place, now, the fineness or smallness of every Particle of Air, conduces to this its fluidity; for they are so exceeding minute, that no one of them can be presented to the Eye by any Microscope whatever. And yet they are far greater than those of Fire; for they can neither make their way through Metals, Glasse, Stone, or thick Wood, nor even through good Paper. And hence Air may be excluded or shut out from many places: Nay, it cannot so much as pass through those invisible Pores of Bodies, through which Wine, Oils, Water, Brine, *Lixiviums*, alcalious and acid Spirits, are able to insinuate themselves. These Observations are all evidently confirmed by the Air-pump. For if you put a leathern Ring on the brass Plate on which you fix the Receiver

out

out of which you exhaust the Air, and place the rim of the Receiver on the said Ring, then the weight of the Atmosphere, when the Air is exhausted from the cavity of the Bell, will press the rim of the Bell with so much force upon the Ring, that the external Air will not pass into the cavity through the ducts of the porous Leather, but will be intirely kept off; and yet, if you pour any one of the beforementioned Liquors upon the outside of the Leather, it will be immediately imbib'd, and it will instantly insinuate itself under the Glass into the *vacuum*; a manifest proof, that other Fluids, tho' somewhat thick and tenacious, can easily pass through the Pores of Bodies, that repel and keep off the Air. And the same thing is likewise easily made evident by an infinite number of other Experiments.

In the second place, these ultimate aerial Particles are so easily separated from one another, that this divulsion may be procured by a force so small, as does not fall under the notice of any of our Senses. Nor does it signify at all on which side, or which way you attempt this separation, it being always equally easy. This exceeding ready divisibility every one may observe, who considers the motion of a small polished Body through the still Air. Can you not move a Steel Needle with great facility in the circumambient Air, which way soever you please? And it is the same with all other Bodies. This property, therefore, you will give me leave for the future to call the lubricity or slipperiness of the Air.

The lubricity of the parts of Air.

However, when we carefully examine this lubricity on all sides, we discover, methinks, some tendency towards a union between these Particles, by means of which they readily run together into a mutual association; a slight one, I confess, indeed, and that may be easily destroy'd; but that is still a proper association. For upon examination, does it not appear, that whenever one single Particle of Air lies hid in any Liquid, nothing of it is any ways perceived; but as soon as ever a like Particle is united with it, there presently arises a Bubble from this union, which by a certain tenacity opposes its own dissipation? And if afterwards, another and another like Bubble meets with the former, is it not obvious to every one, that there succeeds, in proportion, a still greater Bubble, tenacious, as the former, of its magnitude and spherical figure? You will think, perhaps, that this is rather owing to the compressive force of the ambient Liquid; nor do I deny, that it may possibly happen by that means: But yet, the effort at least of the aerial Particles towards an union with one another, will be still greater than that between the Particles of Water and the very minute Particles of Air. The attraction, indeed, between these Particles, I acknowledge to be very small: Nay, but you will be apt to say, there is a repulsion between them, as the great *Newton* has plainly demonstrated: Nor do I deny it, and shall myself professedly treat of it by and by. In the mean time, however, it remains certain, that there is a power in these Particles, by which, when they are united in a spherical figure, they long maintain themselves in that figure against the force of the Bodies that surround them.

Their mutual attraction

For if we examine this inclination to cohesion more closely, we shall presently see, that the aerial Particles singly and separately considered, very easily suffer themselves to be mixed with any other Liquid void of Air, and that they obstinately abide in it, quietly resting in its interstices, in the same manner as

Air easily mingles with other Bodies.

any Salts are dissolved in Water. Besides it will appear hereafter, that a large aerial bubble, that is composed of many united Particles of Air, and placed on the surface of a Liquor intirely deprived of it, will resolve itself into its elementary Particles, and that these, when they are thus separated, will be carried into the empty pores of the liquid, and never gather themselves into a bubble again, unless by the additional force of a greater cause.

The imper-
ceptibility of
the Air,
what?

And hence, in the third place, we account for the Air's imperceptibility, already mentioned, to our senses. Nor would ever any one have thought of this Air which we now treat of, had not some great Bodies, and chiefly such as contain but a small quantity of matter under a large surface, been moved with their broadest surfaces through it. But in this case, the Air resisting the motion with a remarkable repulsive force, immediately manifests itself to be a hard body. And as these resistances, which are in reality actual repulses, vastly increase according to the augmented velocities with which the Bodies are moved, *viz.* as the Mathematicians compute in a duplicate proportion; hence it may happen, that this imperceptible softness of the liquid Air, may become as hard as a Stone. For if a person should take a very thin brass plate an hundred feet square, and with its surface directly forwards, try to carry it erect through the Air when it was still, with so great a swiftness, that it should move the space of two and twenty feet in a second of time, he would then find in this Air an incredible resistance or hardness, easily to be computed by *Mariott's* method. And if with this plate erect and quiescent, any one should receive the shock of a Wind rushing with the greatest rapidity, he would then likewise experience, with what hardness the Air is capable of striking, when it is hurried along so fleetly.

All this now is to be understood of the whole Air, as a compound, in which very great and heavy Bodies are capable of swimming, as appears by Birds and things of some weight carried away by the Wind, not to mention those of a lighter nature, as Dust, &c.

The Gravity
of the Air.

The next property of this Air, considered in the same manner as before, is the singular weight of its whole bulk; for in this respect all the parts together which in the aggregate constitute this Air, press with so gravitating a force towards the Center of the Earth, that by their fluidity, they form a Sphere around its surface, which we may properly enough call the Air-sphere, and which, on account of the very large quantity of Vapours exhaled into it, has hitherto by Philosophers been called the Atmosphere.

The Gravity of the Air, formerly discovered, *Torricellius*, that great *Florentine* Geometrician, ventured in the year 1643, to determine statically. After him, the famous *Otto Guericke* proved this Gravity by several experimental appeals to the senses, in the year 1655. That very ingenious Philosopher *Monf. Paschal* afterwards cleared it farther up; and the great *Mr. Boyle* rendered it more compleat. It was *Mariott*, however, who gave the beautiful finishing to it by the most curious Experiments of all; insomuch that now-a-days no part of natural Philosophy stands upon surer principles than this of the Gravity of the Air; for by the assistance of what these Gentlemen have done for us, the weight of the whole gravitating Air-sphere may be obtained to the greatest nicety, and expressed under the denomination of common weights.

It has hitherto, however, remained impossible to determine the weight of the aerial Body, comparatively with other Bodies, the weight of which is known. For upon inquiry, it very soon appeared, that no two equal portions of Air taken at the same time, but at different heights, were ever of equal weight; but that on the contrary the lower Air always outweighed the higher. And this holds so universally true, that the very same thing is observed from the surface of the Earth to the tops of the highest Mountains. Nay in the very same place you will hardly ever find, that an equal quantity of Air, at different times, will be of the same Weight; but even in this case there is observed a great variety, it sometimes weighing more, sometimes less.

How far discovered.

The Air-sphere in our climate, wherever it has hitherto been observed, is very considerably, and almost always wonderfully changing with respect to its weight, which never continues long the same. This variation is chiefly apparent whenever there is any Alteration in the Meteors in the Air, which is pretty frequent: For Rain, sudden great Showers, Fogs, Hail, Snow, Lightning, Thunder, Winds from various quarters, Storms, Whirlwinds, Drought, and the Changes of the planetary Aspects, are certain indications of the Atmosphere's becoming very soon of a new or different Weight. In this Affair the different Seasons of the Year likewise produce an incredible variation. By means therefore of this successive and incessant mutability, depending on such a number of causes which are continually reviving, it comes to pass, that the weight of the Atmosphere never continues long the same. And hence an infinite number of effects about the Earth, which almost all depend upon the action of the gravitating Air, are in a perpetual vicissitude and inconstancy: So that this single Variation of the Air alone in point of Weight, is the source of a great many causes which produce different events. In the mean time however, by the help of very accurate Observations, continued for the space of above 86 years, we are now come to the knowledge of the greatest and least Gravity of the Air that happens in *Europe*. For upon examining, it has been found, that the greatest Weight of the Atmosphere is in *equilibrio* with $30\frac{1}{2}$ inches of Quick-silver in the Barometer, but that the least would raise it only to $27\frac{1}{2}$: So that the difference appears to be almost a tenth part of its greatest Weight, within which compass the perpetual variation of the gravitation of the Atmosphere is included.

Found to vary exceedingly.

This daily alteration now is owing to many peculiar, and perfectly different causes, but yet, however, such as are intirely certain, and may be come at by diligent Observations. And whenever this shall be accomplished, then we shall be able to form a regular notion of this Fluctuation, which at present is looked upon as intirely uncertain. From whom now should we so justly expect this, as from the famous *Nicholas Kruquius*, whose genius, learning, and indefatigable industry, highly qualify him for the cultivation of these studies, and whose aforementioned Meteorological Tables composed with infinite diligence and accuracy, shew us at one view all the causes concurring to every degree of the increased Weight of the Atmosphere. It were to be wished, that these so useful inquiries of this great master in Natural Knowledge, might meet with encouragement equal to their merit; lest when he is gone, we should look in vain for another that is equally qualified for the same discoveries.

To be brought under certain Laws.

Lastly,

And compared.

Lastly, it has been likewise observed, that the Weight of the common Air, about our Earth, at the time of the middle Weight of the Air-sphere, and in the most temperate season of the year, is to that of Water, as 1 to 850: But then this must be understood according to these conditions, otherwise it would be impossible to affirm any thing certain about it.

The effects of the weight of the Atmosphere.

In the first place, then, the Air resting with its whole weight upon our Earth, presses its surface with a perpetual force. And this pressure upon any particular Body is equal to that power which at the same time keeps up a perpendicular column of Mercury to the height it then obtains in the Barometer; the Base of which Column will be a horizontal Plane cutting a Pyramid whose *vertex* is in the center of the Earth, whilst its Sides touch the horizontal boundaries of the Body thus pressed by Air. Thus then may this power be every where exactly computed, by considering the height of the Quick-silver in the Barometer, at the time the computation is made, and the magnitude of the surface of the Body, the pressure upon which is required. And hence it is inferred, in the second place, that Bodies dispersed in the Earth, are so much the more pressed by the incumbent Air, the nearer they are to its center; for it is evidently demonstrated in hydrostatics, that the pressures of liquids upon their bases are in proportion to their perpendicular Altitudes. Hence, therefore, if we consider the Air as a Liquid, every where homogeneous, and incompressible; then the proportion in which Bodies are compressed in every part of the perpendicular from the surface of the Earth to its center, might be easily discovered: But as the elastick power of the Air brings a great many very different considerations into the subject, we shall speak particularly of that matter by and by. In the third place, it appears on the other hand that all Bodies, the farther they are raised above the center of the Earth, the less in proportion they are affected by the pressure of the Air. But it must be observed farther too, in the fourth place, that Bodies in the very same situation, will be more closely compressed together, as the weight of the Air is augmented, according to the abovementioned observations. And fifthly, as soon as ever the same Air decreases again in its weight, the pressure upon these Bodies will be proportionably diminished. Sixthly, all those Bodies, therefore, that are exposed to the Air are never long compressed with the same external force; but the compression they suffer is varying continually; with this limitation, however, that the difference of the pressure is never found in the same place to exceed one tenth of the whole; within which tenth is included the whole compass of this variation. Seventhly, therefore, the Air itself, while by resting on all Bodies it thus compresses them with various forces, must likewise in proportion be repressed by them, provided they are elastic, or such as have in them an innate effort to expand themselves, or to recover that size which is the proper effect of their natural energy. And hence, therefore, it appears likewise, in the eighth place, that in all Bodies which are situated in the Air there is a perpetual oscillation of their Particles corresponding to the reciprocal augmentation or diminution of the Weight of the Air. This oscillation is but small indeed, as being confined within the length above mentioned, for the compass of its variation; but still it is a proper oscillation, and is almost continual. But we have before, in the History of Fire, taken notice of another tremulous vibration in the Particles of Bodies, produced by the various vicissitudes of

Heat

Heat and Cold, which, therefore, in conjunction with this of the Air, must bring about very considerable and continual effects. We acknowledge, therefore, two perpetual causes of the constant, internal motion of all the Particles of elastic Bodies, *viz.* Fire, and the Air-sphere. In the ninth place, however, it must be remarked, that upon Bodies, which are absolutely soft, if any such there are, that is, that are intirely destitute of a power to recover their former figure, when the force that presses them is removed; and upon Bodies, such as Water, which cannot by any external Weights be reduced into a smaller space; upon such, I say, the compressive force of the Air-sphere, with regard to its increase or diminution, has no effect; and consequently, upon such Bodies, the reciprocal Oscillation we have mentioned, will be of no efficacy. Seeing then that Fire acts equally, nay more upon these very Bodies, than on all others, it plainly appears, that the power of Fire, on this account, is to be regarded as far more universal than that of Air, and consequently of any other Body.

It will now be of service to us, if with an eye to Chemistry, we take a view of those effects which the external Air produces, considered as a fluid and gravitating Body together; for in this light it evidently appears, that it must rest with some force upon the outward surfaces of all Bodies, as has been just now explained. Hence therefore, in the first place, it will insinuate itself between the surfaces of all Bodies, the distances of which from one another leave interstices so wide for the admission of the external Air, that by its subtlety, or the loose texture of its parts, it may be able to enter into these little spaces. Hence, likewise, it is evident, that all the little invisible *Meatus's* of Bodies, which are qualified in the manner just mentioned, though they appear to our senses to be perfectly empty, are in reality full of common Air. And since this Air must certainly in those Interstices perform all the effects which are proper to it; hence an infinite number of the operations of Nature will of consequence depend upon it. Secondly, it is a curious observation in Hydrostaticks, that the heavy and fluid Air presses upon every side of Bodies with an equal force, whither the horizontal, vertical, superiour, inferiour, or oblique. This is demonstrated in that Science: But as Chemists are often unacquainted with those studies, I have thought it proper to give an ocular demonstration of a truth which is of such importance in the Chemical art. I take then three glass vessels; one cylindrical, A; another conical, B; the third, C, running, like a bolthead, from a spherical bottom, into a long, cylindrical neck. Under these three you easily conceive, all sorts of simple vessels may be comprehended, as is easily demonstrated by Geometry. Be pleased to observe, then, in the first place, I fill the Cylinder A with fair Water exactly up to the brim. Upon the surface of the Water then I put a piece of single clean paper, D, just big enough to cover the mouth of the Vessel, and this with the palm of my left hand I press equally on the surface of the Water, so that between that surface and the paper no Air can be retained. Then with my right hand I invert the vessel, as you see, in such manner, that the palm of my left hand remains close upon the paper. Having in this manner turned the vessel upside-down, so that the mouth of it, which is covered with paper, is at the bottom, I gently remove my left hand, and with my right I hold the Glass as it were freely suspended in the Air: And you see, that not the least drop of Water

The effects
of Air considered as a
Fluid and
gravitating
Body together.

runs

runs out of the Vessel, but that the Paper remains as closely pressed to it, as if the Palm of my Hand was still apply'd to it. Observe farther, I gently turn the Vessel from this vertical to an horizontal position; and does not the Water still remain in the Vessel, and the little Paper still closely adhere to the mouth of it? These things you plainly see. Do you not therefore acknowledge, that the pressing power of the heavy and fluid Air, has the same effect upwards, laterally, and downwards, and that it presses a Body placed in it with the most exact equality in every point of its surrounding Surface? And therefore, that the Air which is perpendicularly under the mouth of the Vessel, has the same force in its effort upwards upon the Paper, as the Air which horizontally presses upon the Paper, and even as that which bears upon it vertically? This effect of every heavy Liquid, the great *Archimedes* observed very nicely, as he did every thing else, and raised a great many very curious demonstrations upon it. There is in reality no end of the truths, which may be hence deduced. But these we leave to be explained by proper Masters, whilst we Chemists thus enjoy the benefit of them. The same thing again you see now in this conical Vessel. The Base of this glass Cone B being open, and its vertex E close, I fill the Vessel compleatly up with Water, apply with the Palm of the Hand the Paper D, and turn the Vessel till the Base is undermost. I now take off my left Hand, and suspend the Cone with my right. The Paper you see does not drop off; nor does the Vessel lose one drop of Water. I gradually change the vertical into an horizontal position, and still nothing runs out, but the Paper remains as closely fixed as ever. Now, if the *vertex* of this conical Vessel was open, and the *Base* closed up, and the like inversion were made of the Vessel, the very same effects would follow. This then you likewise see the truth of. Lastly, then, I proceed exactly in the same manner with the other Vessel, and you are Witnesses, that the Experiment succeeds exactly as the preceding. Since this then is the case, you conceive, Gentlemen, with me, that the Air, therefore, pressing equally upon every point of the Surface, enters likewise equally into all the Pores and Ducts to which it is applied, whether they are in the upper, lower, or lateral Surface, or in any oblique position whatsoever; and that it presses likewise with an equal force in all those different parts, with this variation only, that that part of the Air that is lowest, always presses more forcibly upwards, the lower it is, that is, the nearer it is to the center of the Earth. In the third place, the Air by these its properties, compresses all Bodies on every side, fills up their cavities, and forms upon them a Surface, which has a very strong coercive power. Hence, in the fourth place, it comes to pass, that this Air, whether external or internal, which from its fluidity is supposed to be continually in motion, and by its gravity is applied to the external parts of fluid Bodies, causes a continual attrition, concussion, and agitation of their Surfaces, by this means mixes different Fluids together in a wonderful manner, applies and excites their reciprocal powers, and thus produces continually a great number of effects. Fifthly, however, it alters not the figure or shape of the Bodies which are exposed to it, excepting only so far as there are empty spaces in them, in which there is no Air. For if in such a case they are not able to resist this force of the Air, they will, by the pressure of it, be reduced into smaller spaces, the corporeal parts will run together into a closer union, the whole Mass become more solid, and the former bulk will appear

pear diminished. But this case excepted, the Air, with all its force, is not able to break the weakest and most brittle Body that is fill'd with it, and placed in it; for as much as it presses on one part, so much exactly it sustains on the other, and thus preserves all Bodies *in equilibrio*. In the mean time we know, that the motion of the Air is always considerably swift; which is particularly evident from an Observation made in a Room that is darkened, when the Air is very still, and then illuminated only by a single Ray let in at a very small Hole: For if then any one standing on one side of the lucid aerial Cone, turns his Eye upon that luminous part, he will really be surprized at the motion of the Atoms, which with a considerable and perpetual rotation, are carried about hither and thither, and most rapidly confounded with one another. Hence, then, we are the more induced, with great probability, to conclude, that all those in the external open Air are constantly in a greater agitation, and consequently, that the motion and attrition among themselves, and upon the Surfaces of other Bodies, is very considerable, inasmuch as the motion is continual, and the gravitating force equal to the pressure of a column of Water 33 feet high. And hence we may easily conceive in the sixth place, how strong must be the attrition and motion of the Atmosphere upon the Surfaces of all Bodies; especially, as often as it is agitated by Fire, or Storms. Let us suppose, that in an *Area* of one foot square, there gravitates the weight of 2080 pounds; what a mighty pistil is this? Let this now, in a great storm, be mov'd with such a rapidity, as that in a second of time it shall run the space of two and twenty feet, will not the force of this weighty pistil, in the attrition of Bodies that are under it, be incredibly great? Thus, therefore, an infinite number of very powerful physical changes are effected by these causes, which not being regarded by the Chemists, they have, in order to account for these effects, in vain invented, I know not what very abstruse, and plainly fictitious ones; whilst in reality, the whole matter depended intirely upon these simple ones we have just mentioned, nor required such very extraordinary ones, assumed without any foundation. In the seventh place, it should be particularly remarked, that the ultimate Particles of the Air cohere together in such a manner, that they are not very readily to be divided into their minutest parts, so as to insinuate themselves easily into the smallest passages, but these are required considerable large, before this penetration happens. This I clearly demonstrate to you by the following Experiment. I have here in my Hand a glass Thermometer, filled up to the brim with Water. 'Tis four feet long, and the neck of it is so narrow, that the diameter of the Tube is only the eighth part of an inch. This, now, I invert so that the mouth of the Tube is downwards, and yet you see that not one drop of Water comes out, but on the contrary, it remains as unmoved in it, as if it had been very carefully stop'd. But again, the Barometer of *Torricellius*, with the suspended Mercury, does not transmit any Air into the *Vacuum* which is left at the upper part of the Tube, tho' the Air exerts such a mighty force upon the Surface of the Mercury, in order to fill up this empty space: For here the Air cannot be divided into so minute parts, as to enter the interstices of the Mercury, but remains excluded. If the same Experiment is made with Water, or even with Spirit of Wine, the event will be always exactly the same. From all these Observations, therefore, it is clear, that the Air is not easily to be divided into its minutest parts; for

otherwise those parts would pass through the Pores of these Liquors, within which the Particles of Air may be disposed, and lie concealed, as will appear manifestly hereafter, when we shall professedly illustrate by Experiments, how the Air may be extracted from the inner Cells of Bodies, in which it is lodged. But in the eighth place, I shall endeavour to shew you, the magnitude of those Bubbles by which the Air ascends through Water contained in Tubes. You see, I hold here a glass Thermometer which has a neck pretty long, and so wide, that the diameter of the mouth is a quarter of an inch. This being full of Water, I turn upside down. What is the consequence? Why you see the Air ascending through the Water in the neck of this Vessel, rises only in large Bubbles, nor does by any means divide itself into little ones; and besides, these Bubbles, which are of a very discernible size, stop here and there in the neck of the Vessel. There must therefore either be a power of association in the Air, or else a repulsive power in other Liquors, with respect to the Air, by which they drive the aerial Particles into mutual contact. To make this still plainer, I will exhibit to you another Experiment: You see here a glass Vessel, open at the top, in which there is pure Alcohol. This very small glass Vessel, formed like a Bolt-head, with a Bulb and narrow Neck, is full of fair Water. This now, into which the Air does not presently enter, whilst I turn it up, I thus invert and immerse the mouth of the neck which is now downwards into the Alcohol: And don't you evidently perceive the Alcohol ascending through the Water into the belly of the Glass in slow oily spirals, and the Water descending into the Vessel which is now abandoned by the rising Alcohol? The Alcohol now rests in the upper part of the Vial, whilst the insipid Water taking the place which is quitted by the former, descends from that into the Vessel. Hence, therefore, I look upon it as certain, that the Particles of the Alcohol and the Water, are, by virtue purely of their fluidity and gravity, most easily admitted into, and transmitted through those interstices, which are left between the Elements of both; but that the admission and transmission of the Air is exceeding difficult. But this will be made still more evident by this other Experiment: Instead of Alcohol, I have poured Oil into this Vessel; and the Vial being quite full of Water, and turned bottom upwards, as before, I put the neck of it into the Oil. Could you now have expected what you see? How prettily do the Globules of Oil ascend through the Water from the lowermost to the uppermost parts, till all the Oil, after much struggling, has risen out of the lower Vessel to the top of the belly of the inverted Glass. The event will be exactly the same, if I fill the Glass with strong saline *Lixiviums*, and immerse it after the same manner in Alcohol, fair Water, or Oil. Of this property of the Air, therefore, which we particularly recommend to the consideration of the Chemists, we are likewise assured, by comparing it with other Fluids, *viz.* that the Particles of Air collected together in any quantity, are not by far so easily separated from one another, as the Elements of any other Fluids that we are acquainted with. And hence, it is likewise evident, that the minute Particles of Air cannot easily be intermingled with other Liquids, but rather run together within them, and thus discover themselves by distinct Bubbles, or a collection of them which then becomes froth: Notwithstanding which, however, when the single Elements of Air have lodged themselves, separately, in the Pores left between the ultimate Particles of other Liquids,

quids, it is a very hard matter to set them free again. This we are very certain of, who have seen how difficult it is wholly to fetch out the Air which lies in this manner concealed in Mercury, and are sensible of the wonderful effects, with which this separation is attended; for *Hugens* long ago observed, that Mercury freed intirely from Air, has kept suspended in the Barometer to upwards of 50 inches. But of this property of the Air, I shall professedly discourse to you hereafter. Thus, then, I have faithfully laid before you those properties of the Air which it has in common with all other Bodies; and at the same time have carefully explained to you its efficacy, considered in this view, upon those Bodies which usually fall under a chemical Examination; having only added some Observations, which I could not avoid, concerning its miscibility with other Fluids. Let us now chearfully proceed to the consideration of those peculiar properties which are possessed by the Air alone.

The first then that here offers itself to our observation, is the elasticity which Physics has discovered in it. This is that singular quality, by which all known Air, possessing a certain space, and being confined there in such manner that it cannot escape, will, if it is press'd together by a determined weight, reduce itself into a less space, which will be always in a reciprocal proportion to the quantity of the weight that acts upon it; with this circumstance, however, always attending it, that it will constantly, by a spontaneous expansion, recover again the space it hath lost, in proportion, as the compressive force is diminished: And when this force comes to be the same as it was in the beginning of the Experiment, then the aerial Mass will always infallibly expand itself throughout the whole space, that it before filled up, provided, that no other cause, in the mean time, shall intervene to hinder it. If the pressure is lessened, Air extends itself to a larger space; if it is increased, it reduces itself into a less.

The elasticity of the Air

Now such a disposition as this, Gentlemen, yielding so readily to such a compression, and yet recovering itself with such a spring, I don't remember to have been observed in any other Liquid hitherto examined. 'Tis certain, no such thing is discovered in Alcohol, Oil, Water, Spirits, or any *Lixiviums*. For tho' all these are easily contracted by Cold, and dilated by Fire, yet they yield not to weight by proportional retreats into closer and closer spaces; nor being freed from their pressure, do they expand themselves perpetually. This, therefore, is the peculiar property of Air alone. And hence it merits an exact explication, which you will sufficiently understand, if I clearly lay before you, from *Boyle* and *Mariotte*, the wonderful Law of this elasticity.

Is peculiar to it

These Gentlemen, then, have discovered, upon the evidence of elaborate Experiments, that the following is to be looked upon as the principal Law of this property; namely, that the Air by compression is contracted into spaces, which are always exactly so much smaller, as the compressing weights are greater. Hence, therefore, the density of compress'd Air is always in proportion to the compressing weight. Let us, for instance, suppose a cylindrical Vessel full of Air, and the inside of this Vessel to be so very firm and immoveable, that it will not in the least give way to the pressure of the contained Fluid. Let the *Base* of this Vessel be exactly an *Area* of one *Rhineland* foot, its height 64 inches. The Air then contained in this Cylinder, will on its upper Surface sustain the pressure of the Atmosphere, which we will suppose to be 2112 pounds *Troy* weight;

Under a certain Law.

and the Air which fills up the capacity of the Tube, will be the same as the common Air. If then the upper surface of this Air should be compressed by a perpendicular column of Mercury of 29 inches height, the pressure in such case, would be twice as great as it was before from the Air sphere alone. And according to the increment of the pressure, the Air compressed would be reduced into smaller spaces, in the proportion hereunder mentioned.

lb. 2112	press the Air so as to make it fill this Cylinder	1
4224		2
8448		4
16896		8
33792		16
67584		32
135168		64
270336		128

and so on continually. Hence, then, it very clearly appears, to such as consider the thing, first, that it is not a very easy matter by this method to reduce the common Air into a space 64 times less than that which it naturally possesses; since so enormous a Weight, and so firm a Tube 203 inches high, are required for this purpose; and the Air in point of weight, would be then to Water, about as 1 to 13. But if the weight here assigned to the Atmosphere, viz. 2112 pounds, was eleven times doubled, then the Air, which by this means would be reduced into a space 1024 times less, would be a great deal denser and heavier than Water. In the second place, it appears certain, that this Air can never be absolutely reduced into no space at all, tho' the weight, and consequently the compressure caused by them, should be ever so immensely increased, as a view of the Table annexed sufficiently demonstrates.

How far this
Law ex-
tends.

Besides, I shall, perhaps, hereafter make it appear, that one thousandth part of the common Air, at least, consists of aqueous, spirituous, oily, saline, and other Particles scattered through it, which being united together by this compressure, form at length a Body no farther compressible. So that on this account, it seems to me quite incredible, that common Air can ever be reduced into a space, a thousand times less than it usually takes up, without being compress'd by this means into nearly solid Masses; which indeed, with respect to the elastic aerial part, may be always contracted somewhat closer, but never in a *Ratio* with the compressing weights, because then the Bodies too, mingled with the common Air, must likewise follow the same Law of elasticity, of which we sufficiently know from Experiments they are absolutely incapable. But as these Particles in the Body of the common Air, which are not compressible, rarely make one eight hundred and fiftieth part of the whole, it is nothing strange, that this proportion has always been observed, in the Experiments which have been made, concerning this Law: The reason of which will immediately appear, when I come presently to lay before you the Experiments of Mr. Townley.

This Law,
in the first
step of the
Experiment,
is very visi-
ble.

Let us then in the second place consider, that it is an easy matter, by the means of compressing weights, to contract the common Air into a space, less by half than that which it took up before: And in this step of the Experiment it has been very accurately observed, that this double condensation was effected by doubling the weight. For in this case, those compressible Corpuscles which take

take up only a thousandth part of the first Space make so little alteration, that they utterly escape the notice of the Senses. The rule, therefore, in this first step answers exactly to the Senses, and is capable of ocular demonstration.

But in the third place, those who are acquainted with these things will easily apprehend, that the less the Spaces are, into which the Air is compressed, the greater gradually does the difficulty become of demonstrating this Law. For since we are informed from Hydrostaticks, that the pressure of heavy liquids on the bottom and sides of their containing Pipes is always in proportion to their perpendicular Altitudes; hence you readily conceive how mighty strong the Tubes must be, for the carrying on of these Experiments, till the Air is reduced into the one hundredth part of its natural Space. But you know likewise, it was long ago discovered by the Academy *del Cimento*, that even metalline vessels have been enlarged in their capacities, by being filled with ponderous Liquids: How much more certainly then must this be the case in Glafs? And yet you very well know, that it is requisite, that the instrument here made use of, should be made of Glafs, that the height of the compressing Mercury in the inexpandible Tube may be compared with the height of the Air, compressed by the Mercury; because it is only by an accurate knowledge, and an exact comparison of these heights, that we can come at the thing we are in search of. But what a vast deal of caution and accuracy is here again required! The Tube must be very long, not dilatable, every where exactly of the same figure, and perfectly transparent. The Air to be compressed, throughout the whole course of the Experiment must continue exactly of the very same degree of Heat, for every little increment of it in this case will act by so much greater an expansive power as the Air is more condensed by the compressing weights. And, indeed, not only in this, but in the other parts of Natural Philosophy likewise, our Experiments are performed amidst a thousand concurring causes; any one of which being neglected, our conclusions upon the events will vary from the truth.

Afterwards
always hard-
er to be dis-
covered.

But that you may have still a juster notion of the matters we are handling, give me leave to lay before you the method by which the Philosophers discovered this Law of the Air's Elasticity. This will enable you to judge more accurately, what is justly to be thought of this Law, and of the extent of it, in which point, perhaps, they have carried it rather too far. The great *Boyle*, then, took the double-legg'd Tube, A B b C, inflected as you see in the Figure, open at A, and hermetically made at c. He took care it should be every where exactly of the same capacity in b c, and should be made very thick and strong. The Leg b c, was 12 inches long, and was accurately divided into Lines: The other, AB, contained a good many feet. By pouring Mercury then into the Tube at A, and by this means condensing the Air in b c, from 48 to 3, or from 16 to 1, he found, that the Space into which the Air was compressed was always diminished in proportion to the Increment of the Weight. See *Boyle* against *Linus*, p. 60, &c. *Mariotte*, of the Nature of Air, p. 151, 154.

The discovery
of this
Law.

Pl. VII.
Fig. 1.

As this therefore was the manner, and this the extent of the Observations, by which the condensibility of the Air, in respect of the compressing Weights, was discovered, every one sees, that this condensation was not carried beyond one sixteenth of the whole. Nor, for my part, have I ever met with any authors that have made any farther advances in this matter, who have published their Experiments. The famous Dr. *Halley*, indeed, and the celebrated Academy *del Cimento*

With cau-
tion.

(Mem.

(*Mem. de l'Academ. Roy. des Sc.* 1703. p. 102.) inform us, that the Air cannot be condensed beyond $\frac{1}{800}$ part of its natural Space; but the Experiments, by which these great men were able to condense the Air so far, as that after such condensation, it could not be reduced into a less Space, have not yet been made publick. Whatever those Experiments were, however, this is certain, that the Air so compressed, and reduced into smaller Spaces, will again expand itself gradually into greater Spaces, exactly in proportion to the decrement of the compressing Weight, which *ratio* is constantly observed to hold true. And, indeed, the ingenious Mr. Richard Townley, as the great Boyle relates in the place just cited, discovered by Experiments that might be depended upon, that this spontaneous expansion of the Air, upon the diminution of the compressing Weights, did most exactly follow this Law from 1 to 32. Upon the evidence, however, of these truths, thus far indeed certainly demonstrated, let us take care we don't launch out too far, and absolutely assert, that this Law, namely, that the Spaces taken up by the compressed Air, are in a reciprocal proportion to the compressing Weights, always holds true. For indeed, I confess, it is my opinion, we are at as little certainty on this point, as the most illiterate person whatsoever. Let us proceed, therefore, and set forth what we certainly know of it from experimental proof. In the first place, then, we are assured, that the common Air may be reduced into a Space sixteen times less than it took up before; and that therefore it may be condensed in this proportion. In the second place, we are equally certain, that such is the disposition of this Air, that it may, by expanding itself, be diffused into a Space, two and thirty times greater, and fill that Space with as equal a distribution of its parts as before. In the third place, that this contraction of the compressed Air into a Space so much less, than what it possesses naturally, is owing only to the force of the externally applied Weight, by which it is reduced into so small a Space. And again, in the fourth place, that the same Air being by any means freed from the force of the compressing Weight, does, by the power of its own peculiar nature, without the intervention of any other cause, excepting only the Fire that is present with it, expand itself in such a manner, as always exactly to recover so much Space as it had before lost by the compressure. And in the fifth place, which is pretty extraordinary, that this virtue of expanding itself, peculiar to the Air, does always remain after the greatest compressure, since it always continues so accurately proportional to the quantity removed of the pressing weight. In the sixth place, that its capacity too of compressibility is equally indestructible; for after the Air has been rarified, by removing the compressing Weights, to two and thirty degrees, there has still remained in it, so rarified, a property, by which it was again capable of being compressed, as before, by the like force of the former Weights. In the seventh place, we know from the most certain Experiments, that this dilatability, and compressibility of the Air, by the sole action of Weight, answers accurately, as far as our senses are able to judge, to the increment or decrement of the compressing Weight. In the mean time, however, the Philosophers of *Great Britain* and *Italy*, men formed by Nature for unravelling these mysteries, have declared in their Writings, that the common Air cannot be rendered above eight hundred times denser. This, therefore, we learn likewise from their Experiments, which they have hitherto concealed. Of the great probability, however, of their assertion, I shall discourse my self by and by,

by, when I have communicated to you some things that are known for a certainty, concerning the Corpuscles which float about in the common Air. In the eighth place, therefore, Spaces filled with the same quantity of Air, are so far in a reciprocal proportion to the compressing Weights. In the ninth place, this is always true, as well in that Air, which is reduced into a Space sixteen times less, as in that which is only compressed by the common Atmosphere. In the tenth place, it appears, according to the Experiments of Mr. *Townley*, already mentioned, that this proportion never varied in all the compass from 32 to 1. In the eleventh place, therefore, it is exceeding probable, that the same rule obtains likewise in a farther condensation; but so as that by little and little, as the Air is more condensed, greater Weights are requisite, for the same condensation, till at length all farther compressibility is utterly at an end. In the twelfth place, we see that the Air so contracted and compressed, does not transpire, or penetrate thro' Glafs, nay, indeed, cannot pass through the pores of the Mercury; for it still remains in the same part of the Tube, though by means of such an incumbent Weight of Mercury, it is reduced to so much greater density. Nay farther, tho' the Air, by means of Fire, is rendered warmer, and made to elevate the incumbent Mercury, it does not then penetrate either through that, or through the Glafs.

Another law, which we find to obtain in the Elasticity of the Air, is that it cannot be destroyed; inasmuch as upon examination by every kind of Experiment, it has always remained elastic; nor are its elastic parts either by long rest, or the greatest pressure, ever so disposed as to lose the Elasticity we have been just explaining. For Mr. *Boyle* and *Mariotte* having, with a particular view to this matter, kept common Air strongly compressed, and shut up in a Wind-Gun, found, upon their setting it again at liberty, that it was perfectly as elastic as it was before. And lately, that great Geometrician *Robervallius*, examining Air which had been shut up for the space of fifteen years after the like manner, found, that it had not lost any thing of its Elasticity. See *Du Hamel. Hist. de l'Ac. Roy. des Sc.* p. 368. But it will hereafter farther appear, that even those elastic Particles of Air, which are detained in the interstices of the most internal parts of fluid or solid Bodies, do, when they are set free from those confinements, and are afterwards united to other Particles, exert again that Elasticity, which they then seemed so utterly to have lost, as not to give the least indication of retaining it. For as soon as ever they recover their liberty, they produce incredible effects, which can be attributed to their Elasticity alone, and thus evidently make it appear, that neither time, nor rest, nor even their supposed concretion with Animal, Vegetable, or Fossil Substances, is ever able to destroy this wonderful property of the Air. In the mean time, however, we learn from the same Experiments, that such is the nature of Air, that its elastic Particles, when separate and by themselves, may be so united to other Bodies, by which they are intercepted, or at least may rest in them in such manner, as not, for Ages together, to produce any elastic effect; and that yet, upon their being freed from those Bodies, and mingled with others of the like nature, they demonstrate, that they have intirely retained their Elasticity. Hartshorn, for instance, may be preserved for several ages; and yet upon a chemical examination of some which had been kept above fifty years, and by this means was grown exceeding hard and dry, it's surprizing what a quantity of elastic Air it yielded in its resolution! Hence, therefore, it is very probable, that one single, elastic, aerial Particle

The elasticity of the Air not to be destroyed.

Particle is not elastic, with respect to the increment or decrement of incumbent Weights; but that this Elasticity then only has being, when two such Particles of Air come to touch and repel one another; and that, consequently, if these elastic, aerial Particles were so far distant from each other, as that this repelling force should utterly cease, then this whole Liquid would, for that time, neither spontaneously expand itself, nor in the least resist any compression; but would then only exert this power, when, by being pressed closer to one another, they should begin to come within the sphere of each other's activity. One aerial Particle, therefore, would have nothing of this elastic power; but it would be only the joint effort of several. Hence then, in all appearance, the elastic power of Air ought to be regarded as constant and immutable.

Air condensed continues fluid.

But in what manner, or to what degree soever, this Air has been condensed by the utmost power of Weights, it has always remained, even in that condition, very fluid; for after it has been contracted into the greatest density, it has constantly restored itself again in all its Particles, with the same facility, so as to fill up exactly the former Space; all the Particles retreating with the same ease with which they before came together. Since, therefore, by every Experiment that has been hitherto made, this property has been always found to take place from 1 to 520,000, we may fairly assert, that the Fluidity of the Air, in all the large compass, from the most rarified, to the most condensed, remains without alteration; and that therefore it is neither capable of being consolidated by the intensest Cold, or the greatest degree of compression.

The Elasticity of any portion of Air of equal force with the whole Body.

But nothing now in this elasticity of the Air seems a greater paradox to persons not Masters of this affair, than what Mr. Boyle has evinced with so much certainty; viz. that the elastic Power which prevails in any particular portion of the Air, can, without any greater condensation than what is owing to the compressing Air itself, sustain all the force of a whole column of the incumbent Atmosphere: And secondly, that this elastic Power, in such a very small portion of Air, can, by expanding itself, repel the Bodies which compress it, with as much force, as that which is exerted by the whole external Body of Air. The truth of these assertions, I prove to you by the two following clear and easy Experiments that are borrowed from Mr. Boyle himself. You see this Barometer, which contains in its hollow Tube, Mercury elevated to 28 inches, the lower part of which is immersed into the Mercury contained in this cylindrical Vessel. And you see likewise, that this Vessel is so contrived, that by means of a little Cock, all intercourse between the external Air, and that little Portion which is in the Vessel above the Mercury, may be cut off at pleasure. If now I so turn the Cock, as that neither any of the external Air can get into the Vessel, nor any of the Air in the Vessel can get out to the external Air, then we are sure, that the external Air can no longer act upon the Air in the Vessel; and that only the Air which is inclosed in the Vessel above the Mercury, can press upon the Surface of the Mercury in the Barometer. And you see evidently, that the height of the elevated Mercury is exactly the same as it was just now, when the weight of the whole Atmosphere press'd upon it. That elastic Power, therefore, which is in the little portion of Air contained within this Vessel, can sustain as great a weight of Mercury, as the whole incumbent Atmosphere. But if you please to observe again, you see, that while I am heating the Vessel remaining just as before, the Mercury in the Barometer rises higher and higher every

every moment. How comes this to pass? Why thus: The Air inclosed in the Vessel cannot make its way out; by the action therefore of the Heat upon it, it acquires a greater degree of Elasticity, expands itself, presses with more force upon the Surface of the Mercury, and by this means makes it ascend. Nor does it at all signify, how little a quantity of Air is contained in this Vessel above the Mercury; for the effect of the elastic, or heated Air, will in this case be always exactly the same. But in the second place, if this Vessel, with the same *Apparatus* remain shut, and is so nearly filled with Mercury, as to have but a little portion of Air above it, and then a barometrical Tube, open above and below, is fixed in the Vessel in such a manner, that no Air can either get in or out by the sides of the Tube; then, if the Air in the Tube is exhausted with an Air-pump, the Mercury in the Tube will rise to near * 28 inches, in the same manner as if the whole Atmosphere had press'd it up into the empty Tube. See upon this head *Boyle of Mechanical Experiments*, Vol. I. Part II. from Page 1. to 24. And this very efficacious power of the Air, the Chemists ought by all means to have a particular regard to; since 'tis certain, that in all chemical Operations performed with Fire in close Vessels, this elastic force produces wonderful, and often very terrible effects; acting with a violent compressive force upon the contents, often bursting the Vessels asunder, and producing many other surprizing events.

A very little portion of Air, therefore, wherever it is closely confin'd, is capable of producing the very same effects, as are owing to a very large quantity in another place. For if any portion of common Air is perfectly intercepted within a cavity that is easily compressible, it will there sustain, and from that place wholly keep out the large pressure of the Atmosphere. And whenever the Air in that place is heated by Fire, or freed from its external pressure, it immediately, by expanding itself, becomes so rare, as to produce such effects as are equal to those of the greatest Body of Air.

Hence the smallest portion of Air is equal, in its elastic force, to a large one.

Another Law, therefore, of the elasticity of the Air, is this, that when it is condensed in a certain and determinate degree, it acquires by the application of Heat, a greater power to expand itself on all sides, than it had before. And this power of rarefaction arising from the Heat, is the very same, as if that Air had been made so much denser in the degree of Heat in which it was before. The thing will be evident by an Experiment. For if in the case, and with the *Apparatus* last exhibited, the Air in the Vessel sustains the Mercury in the Barometer to 28 inches; then if the Air in this Vessel was made twice as dense, it would raise it up to 56, as the Experiments of Mr. Boyle demonstrate. But now if the former Air being still closely confined within the same Vessel, is by the application of Air made twice as rare as it was before, then would that Air, tho' the very same in quantity, but thus rarified, elevate the Mercury likewise to 56 inches. This is a truth, which the Thermometer and Barometer, being tried together, have, in every variation of the Experiment, most certainly evinced. And thus by the application of Fire to Air, there arise a great number of very surprizing chemical effects which could not be foreseen, which cannot be ascribed to any other cause, and which ought to be very accurately taken notice of.

Air rarified by Heat, acquires a greater elastic force.

* This is only true, when the Vessel which contains the Mercury is very large, with respect to the capacity of the Tube, the height to which the Mercury rises being always different, as the proportion betwixt those two is varied.

Fire rarifies
Air sooner
than it does
any other
Body.

This augmentation of space now, into which the Air, by means of Heat, expands itself on all sides, is effected by Fire sooner in the Air, than in any other Body, either Fluid or Solid, hitherto known in the Universe. In *Drebbelius's* Thermometer, an increase of Heat, not perceptible without such a contrivance, shews immediately a sensible rarefaction of the Air. But, indeed, the whole History of Fire already delivered, proves all these things so clearly, that there will be no need of the least repetition.

And to a
greater de-
gree.

It is evident from the same Experiments, that of all known Bodies, Air is the only one, which may be expanded by Fire to so great a degree. For Air, by the application of Fire, becomes so rare, that neither the measure, or limits of such its dilatation, has been yet discovered. The Heat of boiling Water expands the Air to a third part of its bulk. *Hist. de l'Acad. Roy. des Scien.* 1699. p. 101. In the Heat then which is capable of fusing Iron, certainly this expansion of the Air must be immensely great. But I refer you to what I have already delivered upon this head in the History of Fire.

Air of the
same density
is by the
same Heat
expanded to
the same de-
gree.

We find, likewise, that Air of unequal Masses, but the same density, is always expanded in the same measure by the same degree of Fire: So that these expansions in the same density of Air are, by a constant Law of Nature, always proportional to the augmentations of the applied Heat. Hence, therefore, if the expansion of Air of a given density, by a certain degree of Heat, is once discovered, it will constantly hold good in all similar cases. Upon this head let me refer you to some very curious Observations in the *Memoirs of the Royal Academy of Sciences*, 1699. p. 113. and likewise in the *Memoirs* for 1702, from the 1st Page to the 5th.

The more
the Air is
condensed,
the greater
elasticity it
acquires by
the same
degree of
Fire.

But with regard to the elasticity of the Air, this is likewise constantly observed, that the more it is condensed by pressure, the greater elastic force will it acquire by the same degree of Fire; and that nearly in a direct *Ratio* of the densities: Which very curious property, to the great advantage of Chemistry, was discovered by the very ingenious *Monsieur Des Amontons*. *Hist. de l'Acad. Roy. des Scien.* 1702, from the 1st Page to the 5th. *Mem.* 155. Hence, then, it follows, of consequence, that a portion of Air that is exceeding dense, may, by means of a very little Fire, acquire the greatest resisting force. If therefore it were possible, as I mentioned formerly, that common Air could in reality be condensed into a space eight hundred times less than what it naturally took up, then in such case, it might, by being acted upon by the Heat of boiling Water, sustain 29600 inches of Mercury; since common Air, by the same degree of Heat, will elevate it to 37: Which immense force certainly teaches us, that if the fiercest subterraneous Fire should, in the bowels of the Earth, be apply'd to Air reduced to $\frac{1}{800}$ part of its bulk, there would thence arise a most incredible power, vastly superiour to all the effects that we are acquainted with. This, however, at least, is certain, that if you increase the density of the Air, and at the same time augment the Heat that is applied to it, then the elastic Power of the Air will always be increased in a compound *Ratio* of both.

The more
rare the Air
is, the less
elastic force
it acquires by
the same de-
gree of Fire.

But on the other hand, now, the less the Air is compress'd, and so spontaneously rarer, the less is the elastic force that it acquires from the same degree of Heat. So that Air which by any means is render'd twice rarer, requires twice as much Heat to make it retain the same elasticity that it had before; and thus in any other degree of rarefaction.

These things the same celebrated Author, in the places last mentioned, has demonstrated

monstrated by the most correct Experiments. And hence we understand, that the Air in the highest regions of the Atmosphere, will scarcely acquire any increase of its elastic force from the most intense Heat, but on the contrary, will become here almost unactive, on account of its exceeding rarity; which answers, too, perfectly to Observation.

The last Law which we discover in the elasticity of Air, is, that it is contracted into a smaller space by Cold, as it is by an increase of Weights. Hence its density is always increased in proportion to the augmentation of the Cold. Since therefore the intensest degree of Cold in the northern parts of *Europe*, was discovered to be at O in the *Fahrenheitian* Thermometer, hence by descending from the degree of Heat in boiling Water in this Instrument down to O, the effect of Cold in condensing Air was known likewise. And as since that, an artificial Cold has sunk the Spirit in the Thermometer to 40 degrees below O; the power of Cold on Air, in increasing its density, is now demonstrated. We discover, therefore, that there is not a Body in the World, the dimensions of which are more contracted by Cold, than the Air.

Air is condensed by Cold.

If we recapitulate now, what has been said, we find the sum of the matter to be this. If the Atmosphere being according to *Fahrenheit's* Thermometer 46 degrees hot, has its Heat still farther increased by 166 degrees, it will then acquire a Heat of 212 degrees, which will make Water boil: But then the Air will become one third rarer, according to the Experiments of *Des Amontons*. A Heat therefore of 166 degrees, expands the Air one third. But now, if 40 degrees of Cold are added to 212, the sum 252 will be the distance between the greatest known Cold, and the Heat of boiling Water; within which distance, therefore, the Air is condensed to $\frac{2}{3}$, or about one half of the whole. If after the same method of computing, we suppose the greatest Heat of the Atmosphere, in the open Air, and from natural Causes, ever to have reached to 90 degrees, which I should think has been rarely observed; then it appears, that the rarity or density of the Air, from the sharpest natural Cold, to the intensest natural Heat, may be increased or diminished to $\frac{1}{3}$, or about $\frac{1}{3}$. And hence it is manifest, what alterations in Nature are brought about by the Air, considered only, as it is changed by natural Heat and Cold, whilst it surrounds and resides in Bodies; the knowledge of which, certainly, will hereafter be of the greatest use in accounting for fermentation, or putrefaction. The greatest distance, now, which *Mr. Boyle* discovered between the rarest and the most dense Air, he computed to be as 1 to 520,000.

How far.

In the last place, this elasticity of the Air is so proper to it, and inseparable from it, that it is not to be destroy'd by the intensest Heat; as appears by the following Experiment. Take a spherical Glass with a slender neck, put it into a Glass-house Furnace, and hold it to a part so hot, that it is just ready to melt, and in that Heat let it be hermetically sealed; then take it out, and suffer it to cool leisurely, and whilst it is yet whole and clos'd, immerse it in cold Water, and cautiously break off the top of the neck under the Water, and you will see the Water will be forced into the open neck with a very great impetus, and will fill the Glass, but with this limitation, that in the upper part of the belly of it, there will be some true elastic Air, thus evidently shewing, that the elasticity, by so intense a Heat, could not be destroy'd. And in this same Experiment, by weighing the Glass quite filled with Water,

The elasticity of the Air not to be destroy'd by Fire.

and then weighing it again filled with Water and this Air together, we may discover the expansion of the Air in that Heat, in which Glass is ready to melt. Hence the Chemists might know what changes may be expected in their Operations, when Bodies full of Air are committed to so strong a Fire: Yet all these are things but rarely thought of, tho' it very much concerns Operators to have an Eye to them.

Nor any
other way.

In a word, since after the greatest rarefactions from 1 to 520,000, and upwards, and the like reciprocal condensations; after the application of the most piercing Cold, and the intensest Heat; after the greatest compressure and relaxation; and after the Experiments continued for so many years, as beforementioned, this elasticity remain'd perfect, and without diminution, we may very probably conclude, that the Air in this respect, is created such an Element, as by means of its immutable elasticity, and mobility, is constantly vigorous and active, undergoing as is were a perpetual ebullition and *subfultus*, penetrating into, and acting upon all Bodies, and keeping them in a continual agitation.

Of the con-
tents of the
Air.

After having, for the service of the chemical Art, considered the properties of Air, the order of our subject requires, that in the next place we should treat likewise of those Corpuscles which are blended and contained in the common Air. And these, in reality, are incredibly numerous, of various natures, and perfectly different in different parts of the Atmosphere. Rightly, therefore, to conceive of the Air, is to consider it as an universal Chaos, in which Corpuscles of almost every kind being confounded together, make a composition, consisting of the most different parts. 'Twill be our business to give you a particular account of them, that we may be able to make just conclusions concerning it.

In the first
place there is
Fire in it,
and under
what Law.

In the first place then, in the common Air, there is always and every where Fire. This has been shewn already in our History of Fire; where likewise it has been demonstrated, by every trial of the Thermometer, that Fire resides in the common Air, in the same manner, and in the same quantity, as it does in any other Body whatever. Nay farther, and it there exists, just in the same quantity as it does in the *Vacuum* of *Torricellius* or *Boyle*. This I learnt evidently from the Thermometer, by comparing one that was in an exhausted Receiver, with another that was in the common Air. And this Experiment I have repeated frequently, after different methods, but always with the same success. And hence I was fully convinced, that Fire of itself, and without any other cause intervening, exists in *Vacuo*, the Air, and every other kind of Body in the same quantity, and with the same activity; and that therefore this rule was again confirmed, that Fire is distributed as the spaces in the Universe. Hence, too, I discovered likewise, that after all the Air in the *Vacuum* of *Torricellius*, and almost all of it in that of Mr. *Boyle*, is extracted out of any space, Fire never then makes its way into that *Vacuum*, so as to fill up the space deprived of Air. For if this were the case, then there would of course arise a greater Heat from the accumulated Fire in this *Vacuum*; and consequently, a very sensible Thermometer, would give some indication of such increase: Or at least, you must be obliged to allow that there is Fire there, that is not capable of expanding Bodies, which to me is the same thing, as if you should say, that Fire is not Fire. Whatever, therefore, the Followers of *Descartes*, and others, have commented upon this subject, their reasonings have never been found

found to answer to any Experiment. And again, since Bodies that under the same surface contain the greatest quantity of corporeal mass, or the most dense of all, as Gold, and Spaces the most empty, as the *Vacuum* of *Torricellius*, of themselves possess perfectly the same degree of Heat, it follows very evidently, that neither Bodies, nor *Vacuums* have any power of attraction with regard to Fire. And as I have in a former Discourse proved, by undeniable arguments, that no one Body is naturally more attractive of Fire than another, it follows, that no part of the Air is more or less hot on account of its being replete with different kinds of Bodies. Fire, therefore, of itself is always very equally distributed through the Air, considered alone, and without the intervention of any other cause; nor are there in the Air any Magnets to Fire. In the mean time, however, an infinite number of causes may arise, and be applied to the Air, by means of which there may happen in the Air a collection of Fire, scarcely to be determined in any particular place. Of which matter I have treated already in our History of Fire, and shall have occasion to speak again hereafter.

In the second place, there is Water contained always in the Air, and in every part of it, and that in such a manner, that it does not appear that it can be wholly separated from it, by any contrivance whatsoever. Does there not a watery Vapour perspire continually from every healthy person? Does not *Sanctorius* compute, that in the space of one night and day there exhales from a man in health nearly the weight of 5 pounds, much the greatest part of which is Water? Consider then, I beseech you, what a vast quantity of aqueous Steams must be continually exhaling from the animals of all kinds, that are scattered all over the Earth; and that all plants, likewise, send forth a dewy, aqueous Vapour, is a thing that has been long confirmed by observation: But the very industrious and ingenious Dr. *Hales* has lately, in his curious treatise of *Vegetable Statics*, reduced the vast quantity of aqueous Vapours exhaling from Plants to computation. Why should I mention the Water, that by means of subterraneous, culinary, private, and chemical Fires, is continually forced up into the Air? What the incomparable *Halley* has delivered upon this head is sufficient. From the observations which he made with the greatest care, and accuracy, it has long been certain, that from the surface of the *Mediterranean* alone, in the space of a summer's day, there exhales by means only of the æstival Heat, without any assistance of Wind, 52,800,000,000 tuns of Water. See the *Phil. Transf.* Vol. II. p. 109. And the Wind and Sun raise up and disperse from the surface of that Sea, still a larger quantity, *id. ib.* pag. 110. and 111. if you compare now the quantity of Fog, Dew, Rain, Hoar Frost, Hail, Snow, and nocturnal Moisture, that may be collected in the space of a whole year, with the Water which in the same time, by means of the natural Heat, has exhaled into the Air, you will find, that in one year's time, there falls upon, and exhales from the Earth, about the height of thirty inches; as the very ingenious *Krukius*, with the greatest labour has plainly proved in his Meteorological Tables. Hence it is very likely, that *cæteris paribus* there every year exhales into the Air, from the whole surface of the Earth, the value of thirty inches height of Water. And of consequence, since the *area* of the Earth's surface is sufficiently known, it is easy to compute the immense quantity of Water, that is always suspended in the Air.

And Waters.

Which appears to the eye.

And that Water is contained in every portion of the Air, is continually evident to the eye in Mr. Boyle's Air-pump; for there, as the Air, by means of the action of the pump, becomes more and more rare, and less fit for the suspension of Water, the inside of the Glass becomes cloudy with a truly aqueous moisture; the very same Experiment thus evidently evincing, that Water does really reside in all parts of the Air, and that as the elasticity of the Air is diminished, it becomes less and less capable of retaining it.

And appears likewise in the augmented weight of a fixed Alkali.

But that there is a very large quantity of Water always, and every where dispersed through the Air, appears evidently to the eye in your dry, alkaline, fiery, fixed Salts; for if these, when they are perfectly pure, are exposed to the Air, they will spontaneously dissolve, by means of the Water which they attract out of it. But that you might have ocular proofs of this yourselves, I took, three days ago, at nine in the morning, two ounces and one drachm of Salt of Tartar, dried in such a Heat, that it melted in the crucible; so that there was no Water at all remaining in it. I then laid it into this glass basin, which was made very clean; and in this manner exposed it to the Air, this cold, dry weather, from the 17th of January to the 20th, in this place, which is pretty high, and very dry. And what now is the consequence? Why you see, upon examining it by the Scale, that it weighs three ounces four drachms and a half; and consequently, that it has gained an additional weight of one ounce three drachms and a half. Nay, if we thus examine this Salt by a pair of Assay-Scales, we find it is every moment gaining something in weight. And as there appears such an increment of weight, within the compass of three days, so if it is kept a considerable time in the Air, the whole of it generally dissolves into a liquor intirely fluid, pinguious, thick, somewhat tenacious, and unctuous, and that is almost three times heavier than the Salt first exposed; and this Liquor the Artists call Oil of Tartar *per Deliquium*, besides which, there will then remain at the bottom of the Basin, a very small quantity of a white Earth. If now, as has been done, you put this Liquor thus produced by the Salt and Air, into a glass Cucurbit, and with an alembic, which is a very tedious operation, you draw it to a dryness, there will then very pure elementary Water distill into the Receiver, and a dry Salt of Tartar, purer than it was before, and less ponderous, will remain at the bottom of the Cucurbit. This Salt, therefore, by being exposed to the Air, receives from it this large quantity of Water. And here we may observe, that the Water thus communicated to the Salt by the Air, dissolves it in a very different manner from what it would have been dissolved if pure fluid Water had been poured upon it; for this dilution in the Air, being slow and successive, by the application but of a very small quantity of Water at a time, dissolves only the pure alkalious Salts that are easiest of all dissolved, and therefore most nicely separates this part from the rest that is dissolved with more difficulty, that is, that is somewhat more terrestrial; which cannot be effected in any other manner. And hence it comes to pass, that by such a dissolution, and coagulation, this whole Salt is at length converted into an Earth, and a volatile principle, which disappears, and is scarcely perceptible afterwards. This *Van Helmont* knew very well, and other Alchemists had come to the knowledge of it long before him. In this Experiment, now, it appears to me particularly surprizing, that the very moment, as it were, that this Salt is taken out of the strongest Fire, and exposed to the Air, this humectation and dissolution, commence, and the increment of weight, perceptible

perceptible by the smaller balance, is begun, and from that instant, increases every moment. And this, which I have very often beheld with astonishment, has happened even while the Salt has continued exceeding hot, and been detained in a place too, which itself was very much heated by being near enough to the Fire; so that I could not, with the utmost care, keep off the Water of the Air from the Salt. And again, now the weather is so cold, and dry, that the height of the Barometer is twenty nine inches and a half, I set the Salt with this Balon in a place, walled on all sides with a very close timber covering over head, which is always close and still, and into which no Wind can enter, and you observe the effect is the same. But there is yet another thing more to be observed, in this wonderful attraction of Water from the Air into a dry alkaline Salt, which, some years ago, a good deal engaged my attention. I wanted a very acrid, dry, fixed, alkaline Salt, in order to demonstrate to some persons, who would not believe it, nay, who even denied the possibility of it, that there might be a Tincture produced in an instant from that Salt, and pure Alcohol; a truth, which some famous chemical Authors have in their writings proscribed as a fiction. This Salt, then, rightly prepared, glowing hot, and as yet in fusion, I poured into a very hot brass Mortar, and with a very hot brass Pistil, rubb'd it as fast as I possibly could, and as soon as ever it began to come to a consistence, I shut it up into a very hot and dry glass Bottle, and immediately stopping the mouth of it with a Cork, and a piece of Bladder softened with Oil, secured it as close as possible. And what do you think was the issue? Why when I came to try the Experiment, though I had frequently before met with success, yet the event at that time would not answer. Surprized at this, I carefully examined every circumstance, that might produce this variation, and discovered at last, that the surface of the Salt was a little moistened by the Air in the Bottle, and that therefore, this being already impregnated with Water, the Alcohol could not come immediately to it.

Now whilst I carefully consider these things, I am clearly convinced, that in so small a portion of Air as can be contained in a Bottle, which will hold but three pints of Water, there is Water enough to moisten an ounce of Salt of Tartar, and to increase its weight. And having repeated the Experiment with the same success, I learnt at the same time, that the Water contained in that portion of Air, which perhaps is 850 times heavier than the common Air, must of consequence make up the greatest part of the weight, which is statically discovered in the Air itself. For if one eight hundred and fiftieth part of the common Air was Water, then the whole weight of the Air would certainly be owing to the Water alone which floats about in it, and the other parts contained in the aerial Mass, would make nothing towards the weight of it; nay, would not, perhaps, gravitate at all. Upon which subject I had some conversation formerly with my good friend Mr. Henry Van Deventer, famous for his valuable writings on Midwifery, who told me, he had thought of the very same thing.

It makes the greatest part of the weight of the Air.

Whoever now considers all these *Phænomena* with attention, must certainly hence infer one, two, or all three of the following propositions. Either, first, the Air, in all still, close, and subterraneous places, must be in a perpetual motion, that by this means it may apply that little quantity of Water, which is diffused

A wonderful property of the Air.

diffused through its whole Mass, to the surface of the Salt of Tartar, so as to leave it there; for if a cubic foot of Air contains at the most $\frac{3}{4}\frac{2}{5}$ of a pound Troy weight of Water, and communicates, within a Vessel close stopt, this Water to the Salt, then it follows, that all that Air must so revolve about the surface of the Salt, as that all its parts may successively come in contact with it; and thus deposite the Water they contain: Or else, secondly, we must conceive, that those Particles of Water, which at one time are dispersed throughout the whole mass of Air, are at another time so moved through that Mass, as that they are perpetually and successively now in one part of the aerial Space, and now in another, till at length they all happen to meet with that Salt which is placed within it: Or, in the third place, we must acknowledge, that there is a true attractive power between a fiery, fixed Alkali, and Water; so that like two Magnets, they reciprocally attract one another, in the same manner, as we read in *Sendivogius* of an Alkali of the Earth, that attracts the celestial Dew, in order to a fertile impregnation. Whoever, now, prefers this last way of thinking, must perceive, at the same time, that this attractive power between the Water of the Air and an alkaline Salt, must extend to a considerable distance, since a very little of the Salt will grow four times as heavy as it was at first, by means of the attracted Water; for an ounce of Salt of Tartar, whilst it is converted into 4 ounces of Oil of Tartar *per Deliquium*, must have drawn into it 3 ounces of Water. But 3 ounces of Water require at least two cubic feet and a half of Air to be diffused through in order to be attracted into that one ounce of Salt; which Space, with respect to that one ounce of Salt, is certainly exceeding great. But from all kinds of Experiments, it appears very probable, that all these three causes concur, at the same time, to the production of the same effect.

The elastic quality of the Air don't unite with an Alkali.

But nothing appears to me more extraordinary in this affair, than that whilst the Water is drawn into the Alkali from the Air, and thus makes Oil of Tartar *per Deliquium*, which in weight is to Water, as 7 to 5, but to Air, as 1190 to 1: I say, that whilst the Oil of Tartar *per Deliquium* is thus produced, there should be found in it nothing at all of the aerial Elasticity; so that this Alkali thus separates the Water from elastic Air, and unites it to itself, but rejects intirely the aerial elastic Quality. Hence, therefore, again it appears, that Air, free from Water, is very elastic; but on the contrary, when it is replete with watery Vapours, it proportionably loses somewhat of its proper Elasticity; and again, that by means of a great quantity of fixed alkaline Salt produced on the Earth, a vast deal of Water may be drawn out of the Air.

At what time there is the most Water in the Air.

In a continuance of serene, and very dry weather, the Air becomes always more ponderous, the Atmosphere heavier, and the Water mounts higher in the Air. So that in reality there is never more Water in the Atmosphere than at that time, when by reason of the dryness here below, people generally imagine there is the least of all: But the Water, then, is far more widely distributed, and dispersed; for you easily apprehend, Gentlemen, that the higher from the Earth the Water ascends in the Atmosphere, the greater are the Spaces into which it is diffused, and the farther, consequently, its Particles recede from each other; and that then they exist separately, and do not immediately unite, nor afford any moisture. But if the Barometer is very high, and at the same time, thick and stinking Fogs appear, then do the watery Particles almost

almost always float below along with gross, unctuous, and saline exhalations; all which, at that time, will not, in an exact mixture, be equally distributed or united. But again, when the Barometer is very low, and the weather at the same time is very hot, and very cloudy, then the Water comes down to the lower regions, but in an uniform Vapour, very moistning, but not yet producing Rain. From these observations it is manifest, that the Air, when loaded with abundance of Water, often appears very dry, bright, and perfectly clear; and that on the other hand, when there is less Water in it, it may, by the descent, collection, and unequal distribution of the Water, appear cloudy, dark, and very moist. And this is demonstrated evidently in Cucurbits, Alembics, and Glass Receivers, whilst Water is distilling in them: For if the Vessels are kept stopt very close, whilst a distillation is going forward, all appears bright and clear, and no such thing as a cloudy Vapour is seen; but as soon as ever the Water in the Cucurbit, upon the removal of the Alembic, begins to exhale freely into the Air, the whole appears covered with watery, and very thick Vapours, the equable compressure being now destroyed.

But if in the summer season, when the weather is fair and very dry, and the surface of the Earth has been for a considerable time parched with a great Heat of the Sun, then not only the watery, but other Particles likewise less volatile, as the oily, and saline, are by the power of the solar rays carried up into the Air, and fill that part of it which lies nearest to the surface of the Earth. And so long as these exhalations are kept in agitation by the Heat of the Sun, so long nothing of them appears to the eye: But as soon as the solar Heat, which at three in the afternoon is the greatest, begins to remit, the Air not long after begins to grow cool, tho' the Earth, which retains the Heat communicated to it by the Sun a thousand times longer than the Air, being yet hot, continues to exhale the agitated Corpuscles; by which means there is collected a white, dense Vapour, which is cool above, but still continues warm below. This Vapour, therefore, appears first in ditches, and watery or marshy places, whence dispersing itself by degrees, it covers the face of the Earth in the evening, and night time, with a cloud consisting of this kind of Particles, which in the morning is again dissipated by the Heat of the rising Sun. And this is what we usually call Dew; which appears, from what is here said of its production, to be a very compounded liquid; so that nothing useful can be asserted concerning its proper nature, which would in every circumstance hold true. For since it is a composition of all the Corpuscles of the Earth, which are rendered volatile by the æstival solar Heat, exhaling and descending again, and blended and confounded together, it must doubtless appear, upon the least consideration, to be a perfect Chaos. Nay, and in every particular part of the Earth, it must be likewise of a quite different kind, according to the various nature of the Bodies in the place where it is produced. In gravel-pits, for instance, and in high, dry, heathy grounds of a large extent, there is collected but a very small quantity of this Vapour, and that almost intirely watery; whilst that which is collected about standing Waters, Fens, Marshes, and fat bituminous grounds abounding with putrified fish, and other animals, is perfectly of a different nature, and very often pernicious to mankind. It is no wonder, therefore, that the Chemists, in the artificial resolution of Dew, have met with such contrary principles, and written so differently upon the subject,

ject, that you can scarcely find two of them that give the same account of it. And as for those who expect to find the Spirit of Life, the universal *Menstruum*, the Mercury of the Philosophers, and the Nitre and Steel of *Sendivogius* in Dew, they certainly scarcely seem to have read the works of these Philosophers to any valuable purpose. That this however is a very sharp, saponaceous, pinguious Liquid, abounding with a good deal of nourishment for Vegetables, I do not go about to deny. A Dew too collected in a certain part of the Earth, has yielded by distillation a Liquor that impressed upon Glass the lively colours of the Rainbow, which could neither be removed by friction, an alkaline *Lixivium*, or *Aqua Fortis*: And this Liquor was inflammable, like Spirit of Wine; as appears from the chemical Experiments related in the *Republick of Letters*, Tom. I. p. 590. And again, distilled Dew, digested for the space of eight days in a gentle Heat, and by repeated distillation rendered six times more subtil, is said to have broke three glass Vessels, and to have remained perfectly insipid; tho' it was so very thin, that it resembled pure Spirit. *ibid.* 1708. p. 152. And farther, in the *British Observations*, Dew is described as being like Butter, of a yellowish white colour, soft, melting by being rubb'd upon the hand, and growing dry and hardning by a moderate Heat, of a very fetid smell, in the Winter, and in the Spring, particularly, produced in the night time, in pretty large Lumps. *Philosoph. Transact. Abridg.* Tom. II. p. 143. But the nature of Dew is likewise surprizingly various, according to the different disposition of the weather, and according to the various and successive changes of the meteors in the Air; for hence it comes to pass, that the very minute Seeds of small Plants, and the invisible Eggs of the smallest *Animalcula* are mixed with it, together with an infinite number of other things; which being all digested, fermented, putrified, and distilled together, yield at different times principles of very different natures, and hence lead the Chemists into very extraordinary opinions. See *Abridg. Philosoph. Transact.* Tom. I. p. 141. The principal part therefore of Dew is Water; the rest, on account of their manifold variety, cannot possibly be described.

The Clouds. That the Clouds are produced in the Air, from almost Water alone, there is scarce any one that doubts. But Water every where equally disposed, is transparent. Clouds, therefore, are collected from what is beginning to be Water, but the parts of which, in the mean time, are circumvolved among one another with an unequal motion, neither resting nor moving equably; as I just now hinted. If the Water that is floating about in the Air, now, mounts higher and higher, its particles at length arrive in places so far above the Earth, that they are not any longer much united together, but receding from each other, they do not then constitute Water, but only the elements of it. But when these Elements of Water come to descend again from those upper regions, and are contracted into smaller Spaces, where they associate together, and become a kind of Water, they then form Clouds. The higher, therefore, the Water ascends in the Air, the serener and dryer the weather will be, and the freer from Clouds; and the contrary. But Water is carried up to a very considerable height in the Air; for in *Carniola* in the neighbourhood of *Venice*, there are mountains 10274 geometrical feet high, on the tops of which there are indications of moisture. *Aët. Lips.* 1689. p. 552. And on the highest tops of those Mountains, Nature presents to our view perpetual Snows; a certain Proof of the elevation of Water to such heights. Nay, and over the Mountain *Teneriff*, the

the highest in *Europe*, there constantly about noon hang Fogs, or little white Clouds, which are daily resolved into Water, which flows in such plenty down the mountains, that it supplies the place of Showers, and waters the whole Island, without Rain, *Aët. Lips.* 1691. p. 98. We are certain, therefore, that Water ascends to such a height. But had we sufficient observations to confirm the account *Maignan* of *Thoulouse* gives, in his treatise of *Perspective*, p. 93. of the wonderful *Phænomenon*, which he says he had observed, the ascent of the Water in the Atmosphere would be found to be abundantly higher: For he tells us, that in a very clear night, and that at midnight too, there appeared in the month of *August*, an exceeding bright little Cloud, which spread itself almost as far as the Zenith, or vertical part of the Heavens; and says, that *Riccus* observed the same thing, in the neighbourhood of *Rome*; and from these Observations he infers, that Clouds may be elevated beyond the projection of the Earth's Shadow. But this projection, now, if astronomically computed from the given time and place of the appearing Cloud, would give a prodigious distance from the Earth; and hence, perhaps, that appearance was rather to be ascribed to some other unknown cause, residing in the upper regions of the Air, and exceedingly lucid, since on the tops of the highest mountains, there are rarely observed any Clouds, but on the contrary, to a spectator placed there, they appear below him, towards the Plain.

The lower Air being full of Water, begins to unite the Elements of Water closer together, and by this association to form very little drops, which falling down, produce a small Rain, for the most part thick, but descending with no great force. For the less these drops are, the greater surface they contain, in respect of their quantity of Water, and consequently are the less able to descend swiftly through the resisting Air. Small Rain.

But when the Water in the upper regions of the Atmosphere is collected together, and thereupon becomes heavier, and begins to descend; then, by gradually coming down into smaller spaces, it continually unites to it the other Particles of Water which it meets with in its fall. By this means, therefore, are produced those very large drops which in *Europe* have been observed to have been three lines in diameter, but among the *Negroes*, a whole inch, *Aët. Lips. Suppl.* 1. 425.; which Drops containing a great weight of Water under a less Surface, rush more violently through the Air, and fall to the Earth with a mighty impetus. The higher, now, the place is from which they fall, the larger the Drops are, and so *vice versa*; for it has been always observed, that the Rain, in the upper part of a high mountain, is the smallest, but that, as you gradually descend, it forms larger and larger Drops, till at the foot of the Mountain it produces the largest of all. Hence it comes to pass, that the hardest Showers happen in Summer, when the Water, being driven rapidly downwards on a sudden, cause thunders, lightnings, and tempests. And hence, likewise, the Drops of the Showers, in Summer time, are usually larger than they are in Winter. Lastly, observation has made it very certain, that Rain, in every part of the Atmosphere, is there the smallest, where it is first produced. Great Show-
ers.

But now when the Air, abounding with Water, and waxing cold in the night time, is carried against the upper parts of high mountains, especially if they are disposed in a long range, then this cold and dense mass of Bodies, particu-

larly towards the North and East, during the first part of the night, and towards the South and West after midnight, stops, cools, and unites this Water of the Air, and converts it into a watery humour, which gives rise to a great many little *striae* of Water, which in the highest part of the mountain are small, but as they descend, and are joined with one another, become larger, and by this means produce a perpetual trickling down the mountain, and afford an incredible quantity of Water, which runs down, and produces various rivulets, according to the various channels of the mountain, or the land about it; and when these by subterraneous passages descend from a high part of the mountain to any part of the declivities, and there burst through outlets, and so discharge their stream, they then yield a pure Water, either falling right down, or bubbling up from a spring. And here it is very easy to conceive, that, according to the different height of the springs, in respect to the outlets, the playing of the fountains must be various. And hence, likewise, it is easy to account for the variety of springs, both in the quantity of Water, and every other circumstance. And hence again it appears farther, how it comes to pass, that there are no springs, but where there are pretty high mountains, and that wheresoever these are, there likewise are observed springs: The truth of which appears no where with more evidence and beauty, than in the fortunate valley of *Cassimire*, mentioned by *Bernier*, in his *Description of the Empire of the Great Mogul*.

Brooks, Rivulets, and Rivers.

Again, wheresoever there are such Mountains, and Springs, there the Water, after running down from the Mountains, or perpetually bubbling up from the Springs, is discharged into Rills or little Currents, continually flowing, but for the most part with a gentle course at their heads. When afterwards different currents join their courses together, the stream becomes stronger, and being continually augmented by Rivulets which discharge themselves into it, in a short time produces a River. This again, not long after, being still as it passes augmented in strength and quantity by the accession of other streams, forms a River still flowing with a more rapid course, always tending from the higher to the lower ground, and at length discharging itself into the Sea, from which it never returns again; whose contents, however, in the whole, are by this means never increased, inasmuch as what it receives by the discharge of the Rivers into it, it gives up again continually by exhalation. Sometimes it happens likewise, that the rapid torrents of Rivers sink down into passages under the Earth, disappear, and rise up again in some other place. Hence it comes to pass, that in flat countries, where there are no Mountains, or Springs, there are never formed any Rivers. And for this reason, the supreme Wisdom has thus distributed Mountains throughout the whole Earth, that they might be beneficial to mankind, by producing these collections of Water. And hence, lastly, all the World over, the courses of Rivers answer the order or rangings of the Mountains. Upon this subject, let me refer you to the discoveries of the incomparable *Halley*, in the *British Philosophical Transactions*, which he truly has a right to the merit of. All these things now, it concerns us to be particularly acquainted with, who are prosecuting the study of the chemical Art, in which there is almost a perpetual necessity of considering the variety of the qualities of Air and Water. And these Observations will likewise be of singular use in our following Treatise of Water.

By

By all that has been hitherto said, however, it does not appear certainly, how great the utmost height is, to which Water can ascend in the Atmosphere : But this, at least, in the mean time, we are absolutely sure of, that on the top of the highest Mountain on Earth, there never is any Air without some Water in it, since the top is always found moistened with humid Vapours. And hence it is evident, likewise, that it is not possible, by any manner of Art, to make use of Air in our chemical Operations, in which there is not contained Water. Perhaps, indeed, from a given quantity of Air pent up very close in a dry glass Vessel, all the Water may be drawn out : For if some Salt of Tartar, coming as hot as possible from the Fire, is reduced to a fine Powder, and thrown very dry into this glass Vessel, and the mouth of it is immediately stopt close ; then this exceeding dry Alkali will attract into it all the Water that is contained in the included Air : But then, no-body can apply this Air to any chemical Operations ; because as soon as ever the Vessel is opened, this dry portion of Air mingles again with the common Air, and is immediately moistened by the Water which that was filled with.

There is every where Water in the Air.

Water separable from the Air chemically.

But farther, we are assured from undeniable Observations, that the higher the Water is carried into the Air, the farther it disunites its parts, disperses them through wider and emptier spaces, and at the same time grows colder. For upon examination it has been constantly found, that in every part of the habitable World, the Heat *cæteris paribus* is greatest at the Surface of the Earth ; and that at the very summits of the highest Mountains, a freezing cold preserves a perpetual Snow. This is true, even at the Equator and in the Torrid Zones : So that there is not in the hottest part of the Earth a Mountain very high, whose top is not exceeding cold. Nay, and the cold increases gradually, as you ascend from the foot to the summit of the Mountain, in such a manner, that the increment of Cold is always proportional to the increase of height. This is an Observation that will always hold true, if all other circumstances are alike. When Water, therefore, ascends to such a height in the Air, that it meets with a freezing Cold, it must necessarily be congealed into Ice, unless its Elements are so separated, that none of them touch one another ; for so long as the Particles of Water are there dispersed from one another, so long there will be no appearance of Ice : But as soon as ever in this high and cold region of the Air, these Elements begin to come into mutual contact, then they begin likewise immediately to be congealed into little icy Glebules, which float up and down through the clear Air, and falling upon the Surfaces of the Bodies they meet with in that region, produce a very fine hoar Frost, but otherwise are scarcely perceptible. In the Atmosphere, therefore, there is an Orbit concentrick to the Earth, in which the Water of the Air, when it is carried up to that height, is always frozen if it is united together. And the higher it is elevated above this Orbit, so much the sooner and harder it will be frozen. But at the same time, however, it is not improbable, that when the Water arrives to such a height, its Particles will be so much the less united, and therefore, will rarely be congealed, but on the contrary will float about separately, 'till some other cause shall happen to unite them together, and by this means form them into Ice.

Water in the highest places becomes Ice, or ceases to be Water.

When the Water, therefore, in the Orbit just mentioned, is congealed, then by an adunation of a greater weight of Water under a less Surface, it must

Hence Snow.

likewise immediately become heavier, by which means, it will of consequence begin to fall downwards, and thus descending into spaces that are smaller, and are more replete with Water, will associate to itself other watery Particles, and so gradually form larger icy concretions, which will now put on the appearance of Snow, or small Hail. But as there may be a great number of causes, and those perfectly different ones too, by means of which, the Elements of Water, that were before scattered in the upper Air, may on a sudden, and in a very large quantity, be brought into contact with one another in the icy region of the Atmosphere; hence you easily apprehend, that considerable pieces of Ice may in a pretty short time be there produced.

And Hail.

But these icy Bodies may in like manner be collected together; and when this happens, there will appear little Clouds, high in the Air, and white by means of the reflection of the Sun, which suddenly falling downwards with a mighty velocity, seem to increase very fast in their magnitude, and rushing from on high upon other like Clouds, by that collision produce Thunder, Lightnings, Tempests, showers of Rain and Hail, which are always the more violent, the higher the place is from which they fall. And hence it comes to pass, that in Summer time, when the Weather has been long clear, the lower Air very dry, the Atmosphere heavy, and the Water therefore in it carried up to a very great height; then the Atmosphere being on a sudden rendered lighter, there usually very soon follow the *Phænomena* we have just mentioned, especially between the Tropicks, where, if a little white Cloud appears very high in the Air, it is a sign that a terrible Storm is just at hand. And it is exceeding probable, that the Hail, which is always formed in the upper and colder regions of the Air, as it descends by its weight into the inferiour and warmer ones, is there dissolved by the Heat, and produces those great showers of Rain, which accompany, follow, and put an end to Thunder and Lightnings. But if the Hail happens to be so swiftly brought down through the Air, as that by reason of its quick descent it cannot be melted, it then falls to the Earth in form of icy Stones, which often, by their size, weight, and motion, do a great deal of mischief. In the Abridgment of the *Philosophical Transactions*, N. II. p. 144. we have an account of some of these that weighed a full pound.

Thunder
and Light-
ning.

This certainly we are assured of by Observation, that Clouds of a very white colour, to which there presently succeeds a pitchy blackness, terrible Thunder, Lightning, and Tempests, are always accompanied with Hail. And hence I imagine, you will be more ready to believe, that the causes here assigned for these *Phænomena*, are the true ones, than to come into the opinion of Dr. Hook, concerning the concretion of Hail in the course of its descent; which you may see in his Posthumous Works, in the Life of the Author, p. 24. And hence it may likewise be questioned, whether, for producing even the greatest Thunders, and Lightnings, Nitre and Sulphur are always necessary; since the very violent collision of hard Ice suffices, perhaps, for the striking out a vast quantity of Fire; doubtless, it is sufficient for producing the loud peals and rumblings of Thunder. Especially, if we likewise consider, that the Fire of the Sun, by its heat, reflexion, and refraction, can act in infinitely different ways, upon the aqueous congealed Matter, we are here speaking of. If this then be taken into the consideration, what variety of Colours, what diversity of Figures, and what difference of Dimensions may we not suppose to happen in this aerial Ice?

But amongst the principal causes that are concerned in the production of such extraordinary and various *Phænomena* so suddenly produced in the Air, which before was calm and serene, we have a particular regard to the diminution of the weight of the Atmosphere. For the Water always begins spontaneously to separate itself from the Air, when it becomes lighter, and thus discovers itself, tho' before it did not appear. In the next place we imagine, that the Bodies of Air which are driven from opposite quarters, often strike against one another, and by this collision, very quickly unite together the Elements of Water, which before were floating about separately. Something likewise may perhaps be owing here to the various Aspects of the Planets; not to mention the efficacy of the Winds, and the vicissitudes of Heat and Cold towards these productions. Every one of which separately, or all of them together, may easily enough bring about the effects we have mentioned, with many others.

The Cause
of these pro-
ductions.

On the other hand, now, if we have a mind to turn our Eyes to the causes which mingle Water with the Air, and carry it up into it, we shall find there are a great many. The principal, however, of these, is the Sun, the direction of whose Rays upon the Water, the nearer they approach to a perpendicular one, the more Water they always carry up into the Air. Upon which head consult the Observations of Dr. *Halley*, which I have already cited in their proper place. Another cause wonderfully assisting the foregoing, is the subterraneous Fire, which is always in action, never at rest. For it has been evinced by Observations, that in Mines sunk lowest, or in the deepest Wells, you first come to a depth in which Water never freezes, but which continues almost always of the same Heat, without any alteration; as the celebrated Academy at *Paris* observed long ago in the Well of their Observatory; but that as you descend lower, the Heat begins to grow greater, increasing gradually more and more, in proportion to the depth, till at length it becomes so suffocating, that unless it be tempered by the coolness of running Water, and the Air that is thence produced, it overcomes the Miners. And we see likewise, that in Winter time, when the Water is covered with Ice, and the Earth with its hard frozen Crust, if the Ice is broke, or the Earth is opened, both the Water and the Earth smoke with heat. Nor had the Philosophers, whom I have formerly heard discoursing on this subject, any grounds for asserting that this was all a fiction, and that it was impossible that Fire should thus exist in the bosom of the Earth, because it can neither be supplied with a proper *Pabulum*, or be agitated by Air: For certainly we ought to consider, that by the sole attrition of the condensed Air, in the bowels of the Earth, this Fire may be produced and preserved without any other Air or any *Pabulum*. For should the Air at any vast depths under Ground be condensed six hundred times more than the common Air, what effects wou'd it not be capable of producing? Incredible ones without dispute, since Authors worthy of credit have declared, that Air, forcibly compressed in an iron Tube, has grown warm there. It is not to be question'd, therefore, but that, in the deepest parts of the Earth, where the Bodies are compress'd by the prodigious weight of those which lie above them, the smallest attrition must produce the greatest Heat. And hence as the action of this Fire is perpetual, so likewise must be the effect of it too, *viz.* a continual exhalation of Water. In the third place, we have regard to the very great

Causes that
carry Water
up in the
Air.

great and constantly repeated effects of the common Fires, made use of by Mankind in every part of the inhabited World, in the dissipation of Water, whether alone, or contained in Animals, Vegetables, or Fossils. For doubtless, if any one computes the measure of this exhaling Water, which such Fire carries up and distributes through the Air, he will find it to be incredibly great. Again, in the fourth place, the force of a very sharp Frost carries off from Ice every moment a surprizing quantity, so that in a little time the Mass is consumed, being dispersed into the Air by the cold alone; as the excellent Mr. Boyle plainly discovered by an Experiment examined by the Ballance. But daily Observation likewise certainly evinces, that by the piercing Cold of a very severe Winter, all kind of Bodies are strangely worn away, diminished, consumed, and dispersed through the Air. In the fifth place, it seems probable also, that every physical cause, which is capable of so disuniting the Particles of Water from one another, as to make every one of them exist separately, will also by this means effect, that those Particles will immediately acquire so large a Surface in respect of their very small weight, that they will be able to float about in the Air. And indeed, this solution of Bodies into their smallest parts, appears at length so to increase their Surfaces in respect of their quantity of Matter, that in every division of them, this aptitude to swim in a lighter Liquid is very much augmented, as the Geometricians have long ago observed. But it is farther discovered by physical Observations, that besides the gravity of Bodies, there is likewise a certain repelling force, which tends to prevent the contact of the Surfaces of different Bodies, and which consequently, is always increased in proportion to the augmentation of their Surfaces. Hence therefore it follows, that Bodies very minutely divided, descend on this account with more difficulty by the force of their gravity, than they would do, if they were acted upon by the Law of Gravitation alone. And the action of this second property of Bodies seems particularly to prevent the continual and immediate descent of all the Particles of Water out of the Air that is about the Earth. Sixthly, it seems to be the effect of the very same property, that the Particles of Water may be expanded round the Air contained in them, and thus form that spherical Body which we call a Bubble. And besides, any other Heat, or expanding Spirit whatever, while perhaps it performs the same thing, may, as well as Air, be always at length capable of rendering Water lighter: But when afterwards the Water, being so divided into very light spherical Bubbles, is carried upwards, then does every Bubble expand itself more and more continually, and so is able to ascend for a long time, and to keep aloft in the Atmosphere. And hence it is manifest, that the Particles of Water may ascend to a great height. See *Halley* in the *Philosophical Transactions*, 1692. N. 192. p. 468, &c. But in the seventh and last place, there is no cause whatever which carries up such a quantity of Water from the Earth into the Air, as the Wind; as the same admirable *Halley* has elegantly demonstrated, and as I myself have learned from various Experiments, not without astonishment; for having exposed a copper Cylinder full of Water to the Wind in stormy Weather, I was surprized at the incredible quantity of Water carried off in a little time; whereas when the Wind was down, which happened presently after, but a very little Water exhaled, tho' the heat of the Weather was still the same. For this reason it seems ordered, that pretty high Winds should follow large quantities of

of Rain; that by thus agitating the fallen Water, and carrying it up again into the Air, they may prevent its stagnating and putrifying, and by this means proving destructive to the vegetable kingdom. All these causes, therefore, when they conspire together, are sufficiently capable of dissipating Water into the Air, and there keeping it in continual motion.

If we consider, now, the action of this elastic Air, replete with Water, upon the body of a Man, Fossil, or Vegetable, we shall find it brings about very many, and very wonderful changes. For if we reflect upon its particular fineness, by means of which it is exceeding penetrating, and is perpetually insinuating itself into every little space; and if at the same time we take into consideration its constant mobility, by which 'tis always kept vigorous and active, it is manifest, that these qualities being determined upon Bodies by the force of Gravity, are capable of producing an infinite number of effects. But the Water that is distributed through the Air, will likewise be still more efficacious, being itself agitated by the motion of the Air; and by this means it will more readily dissolve the Salts, and the saline and saponaceous Substances of the Bodies it is applied to. And as there are very many such parts in most Bodies, and those parts too are the principal instruments of their action; hence you very easily apprehend, that by means of the application of the Air, the proper virtues of Bodies may be excited, as far as they depend upon their peculiar Salts, and *Sapo's*: But these virtues, as we observed just now, are often their principal ones. In the mean time, however, the chief alteration induced upon Bodies by the Water of the Air, is its rendering fixed Salts, and other compound Bodies, volatile. This *Phænomenon* was observed by all the chemists of old, and is constantly found to hold true: That is to say, all native Salts, if they are rendered exceeding dry by an open Fire, and then pounded and exposed to the Air in a Glass Bason, will there, by means of the Water in the Air, be converted into a Liquid; and from the perfectly saline part there will be separated an Earth, which did not appear before. If this saline Liquor, then, thus freed from this Earth, is again thoroughly dried by a large and clear Fire, and afterwards the Salt beaten, and again dissolved in the Air, it will afresh deposite some earthy *Fæces*. And if by several repetitions of this solution, and inspissation, you thus remove all the earth that is every time produced, you will at length procure an incredible quantity; but at the same time you will have nothing else remaining; for that other principle, which before, in conjunction with the Earth constituted the Salt, is by this repeated action of the Water of the Air so disengaged from its earth with which it was incorporated, that now, existing separately, it becomes perfectly volatile, is dissipated into the Air, nor does ever again come within the cognisance of our senses. Nor has the industry of the Chemists discovered this wonderful *Metamorphosis* in native Salts alone, but likewise in the fixed Salts prepared by Fire from Vegetables; for by this tedious operation, these Salts are likewise resolved into an Earth, which serves to fix them, and a Principle perfectly volatile, which is intimately united with it. And these resolutions which are really very singular and wonderful, can be performed by no other means than this very subtil application alone of the Water distributed in the Air, which Art, formerly held a secret, being now more put in practice, has let abundance of light into the Chemical Art; though at the same time it has often too proved of disservice to the Chemical

The power of elastic and moist Air, on human, vegetable, and fossil Bodies.

Artists, who being quite tired out with the tediousness of the work, have lost in the end both their labour and the thing they were in search of. But again, whenever the Air abounds with Water, and is at the same time agitated by Heat or Wind, then this Water will relax the parts of Bodies so suddenly and so efficaciously as must surprize every one who is not acquainted with these things. But by this means, likewise, very many bodies are macerated; and others are thrown into fermentation. And as for the putrefaction of Bodies certainly, it is scarcely more promoted by any other cause than the humidity of a hot Air, which in a very little time resolves the Bodies, which are that way disposed, into a putrid, sanious matter. And for this reason the Physicians long ago asserted, that the plague itself is generated among Animals, from an Air that has been both very moist and warm, for a considerable time. In short, therefore, since it so dissolves Salts, and saponaceuos and saline Substances, carries up all together, disperses them about, drives them against, and makes them penetrate into the Bodies they meet with, it is manifest, that by this means it must apply the particular forces of some Bodies to others, and thus brings about such actions between Bodies, as hardly ever happen from other causes. For what else appears by the fetid butter-like Dew, described in the *Abridgment of the British Transactions*, Tom. II. 141; or what else by the Salt Rain, observed at Sea? *Journal des Scav.* 1683. 435.

Other corp-
uscles in the
Air.

Thus far then, Gentlemen, we have sufficiently considered the Air, with respect to its Elasticity, and the Fire and Water contained in it. We are now to regard it in another view. Let us then carefully inquire what other Corpuscles, besides those we have examined, float up and down perpetually in this Air. But this is a field of inquiry which has hardly any bounds: For as the Earth, considered in its whole extent, receives every thing that falls out of the Air; so on the other hand, the Air receives every thing again from the Earth; and thus between these two elements, there happens, as it were, a perpetual revolution and distillation of all things.

The native
Spirits of
Vegetables.

In the first place, then, all the parts that we can observe in Vegetables, are continually changing, and dispersed throughout the Atmosphere. That the Spirits of Vegetables do always, and every where exhale and fill the Air with a continual fragrance, there is none of you to be sure makes the least question. And that the Scents scattered though vast tracts of the Ocean from odoriferous Plants, inform the Mariners, before they discover Land, of their approach to the Shore, you are as well apprised of. And you know, likewise, that these Spirits spontaneously exhale out of the Bodies, in which they are generated, and are scarcely to be confined and preserved, except in Vessels stoppt very close. Hence, then, it follows, that whatever odoriferous Spirits are at any time by Nature produced in Plants, all these are, certainly, at length, contained in the Air alone. And for this reason it is not at all to be wondered, that these Spirits should afterwards return with the Water of the Air, into the Bodies destin'd to receive them, and that the Air should thus yield up to the Earth what it had first received from it. In reality, we find nothing in Nature less imitable by Art, than the fragrant Spirits peculiar to each Plant, which we have in a foregoing passage called the *spiritus rectores*: But these, when they are once freed from the tenacity of the Sulphur that entangles and retains them, always, from their own proper nature become volatile, and are dispersed through the

Atmosphere. How various, then, and how beautiful must be the Effects that are hence produced? And how wonderful must be the grand *Metempsychosis* or transmigration that is by this means brought about?

But again, when we consider, that Vegetables, duly prepared by a proper fermentation, yield a vast quantity of vinous spirits, that are almost immutable, and of themselves continually exhaling; must we not hence conceive, that all those Spirits which have ever been produced from any fermented Vegetable whatever, over the whole Face of the Earth, have at length exhaled into the Air? And in this view we now look upon this Air again as a Cloud, as it were, of Spirits of Wine. In reality, whether Wine be drank by Men, or any other Animals, be outwardly apply'd by way of fomentation, or made use of either in Cookery, or Physick, certainly all its Spirits must sooner or later exhale into the Air, there remain for some space of time, and thence, at a convenient season, return to the Earth again. What wonder, therefore, if fermentation, which is the productive cause of Wine, should never produce Wine, without the free admission of the external Air. Does it not, possibly, return back again to Places and Bodies the Spirits which it had before drawn up, and for this reason must be always called in to our assistance, when they are to be generated again?

The fermented Spirits of Vegetables.

And finally, all those parts of Vegetables, which the Fire divides into exceeding minute Corpuscles, and converts into a volatile Vapour, the Chemists have likewise called Spirits; but these are likewise intirely carried up into the Air, and are continually floating about in it. As the Water of Vegetables, therefore, so likewise all these kinds of Spirits are perpetually tending upwards.

And those that are produced by Fire.

But farther, it is certain, that the proper native Oils of Vegetables, do by time, and the natural heat of the Air, at length intirely evaporate; and that whether they reside in compound Bodies; or spontaneously sweat out; or are forced out by pressure. For in reality, there are but few sorts of Wood, in which their Oils are so united with their proper Earth, that they are able to remain for ages together in the open Air. And as for the Oils of Vegetables, which Chemistry draws from them by Fire, whether this be done with Water, or dry, these are far more volatile, and sooner fly off. Thus, then, they form pinguious exhalations in the Atmosphere, which are very well disposed both to take Fire, and to support it. For as these oleaginous Particles are now so minutely divided, that they nearly resemble Alcohol while they float in the Air, being first heated by the attrition of the Clouds, they may be excited into a Flame by the dioptrical or catoptrical Fire, which I have already demonstrated may be produced in the Air. All these Oils, therefore, which ever were in Vegetables, a very few perhaps excepted, are dispersed into the aerial Chaos; whence, as Water and Spirits do, they return in their time, impregnate the Earth with a pinguious moistening Dew, and by thus circulating backwards and forwards, bring perpetually fresh prolific Supplies, and being deposited for a short time, return into the Air again. All this, now, happens chiefly in very hot weather. For if a long Drought, with a very great Heat, has carried upwards both the Water, and the pinguious Corpuscles of the Earth, then the first Fires that happen aloft with Thunder and Lightning, send down a Rain which is very different from that pure Snow which falls in a sharp Frost; and is far more acrid, and more disposed to froth. And hence Summer Rain,

All Oils alike

Rain, or Rain produced in hot weather, is always fruitful, whereas that in cold is scarcely endued with any such quality.

And Salts.

If you consider now the native Acid, austere, those that come the nearest to alkaline, and the saponaceous Salts of Plants, procured by crystallisation, fermentation, putrefaction, and combustion, you will find that all these do, sooner or later, disappear, not one of them excepted; since all these Bodies when they are freed from their fixing Earth, ascend up into the Air.

Nay even Earth.

Nay, and that very Earth too, which furnishes a fixed Element to Plants, does by its fineness acquire such a disposition, that it flies off, and is carried aloft. For pray, does not Soot, collected at the very top of a Chimney, from the volatile Smoke of a burnt Vegetable, yield, by a chemical distillation, a remarkable quantity of pure Earth? Hence, therefore, we are certainly assured, that Smoke which floats at liberty through the Air, carries along with it real Earth, mounts with it aloft, and widely disperses it through the Air. Not to mention the Winds, which sweep away the *Ægyptian* and *Lybian* Sands in Waves, as it were, through the Air, and carry the Ashes of Mount *Ætna* to prodigious distances. What think you of the Sparks of *Vesuvius*, scattered above a hundred miles through the Air? *Phil. Transf. Abr.* Tom. II. 142. What of the Ivy-berries dispersed over a vast deal of Ground? *Ibid.* 144. The little Fishes? *Ibid.* Or the masculine, seminal Dust of Vegetables? *Phil. Transf.* 168. p. 911. Hence, then, from these observations it is clear, that all the Elements of Vegetables may be carried into, and intermixed with the Air.

And also intire parts of Vegetables.

But it is likewise certain, that parts of Plants, and those pretty considerable ones too, are carried into the Air, and are born up along with it to an incredible height. Consider the Seeds of downy-seeded Plants, which are carried up to the tops of the highest Towers, and there, as one sees daily, if they meet with ever so little Earth, propagate their *Species*. The celebrated *Tournefort* too has elegantly shewn from observations, that the Fungus's, which are almost all seminiferous, by means of the Air, disperse their invisible Seeds all about, which meeting with a proper Soil, thrive and spring abundantly. Mosses, likewise, and the mucilaginous and capillary Plants, as also the *Epiphyllouspermophææ*, or those which bear their Seeds upon their Leaves, scatter and diffuse their Seeds to very distant places. Nay, and even the small seminal dust of the Male-Willow, being shaken from the *apices* of the Flowers, and carried by the Wind into places remote from those Trees, and afterwards, when the Wind was down, falling out of the Air, has been falsely taken, by persons unacquainted with these things, for Flower of Brimstone, and afterwards believed by the credulous Vulgar to be a Shower of Brimstone. *Vide Phil. Transf. Abr.* Tom. III. And if such a small Dust should happen to be of a remarkable red colour, why should not the Vulgar for the same reason have asserted, that it had rained Blood? Were there not Ashes thrown out of a vulcano, and carried by the Wind, in the year 1633, the space of one hundred miles! *Phil. Transf.* No. 21. p. 377. But these are things not to be wondered at, since that excellent Philosopher *Mariotte*, in his treatise of *the Motion of Waters*, p. 334. observed in a Cloud that poured forth a shower of Hail, that the Air had carried this Cloud for fifty *French* miles. If we reflect, therefore, upon these things, we must naturally believe, that there are a vast number of surprizing things in the Air, and produced

by it; all which are intirely owing to a mixture of vegetable Substances that are distributed through it.

And if you enquire, in the next place, whether the parts of Animals are contained likewise in this Air? We answer, there is certainly a great quantity of exhaling Spirits, and those wholly peculiar to every Animal, and distinguished among Physicians by the name of the perspirable Matter of *Sanctorius*, that are continually dissipated through the Air from living Animals, and adhere to other Bodies; and by these Spirits it is that your Dogs, that follow by scent, distinguish so accurately the Animals from which they exhale, and follow those particular ones over large tracts of ground. And how full the Air is frequently of contagious Particles, exhaling from Animals, appears evident from the Infection too often observed in Diseases.

The Spirits
of Animals
are contained
in the Air.

But again, the excrements continually discharged by every kind of Animal, are in so short a time dissipated and disappear, that we are hence certainly convinced, that the whole quantity of excrementitious matter will be always dispersed into the Air, hardly leaving so much as the lightest Dust behind it. In the hotter countries, the Dung of Animals, being exposed to the open Air, becomes perfectly volatile by the Heat of one single Day. And even in our own country, which is not so hot, the very Dunghills are quickly consumed. And as for Urine, how quickly does that spontaneously become perfectly volatile, and exhale?

And their
Excrements.

But there is something in this affair still more remarkable. For pray tell me, does not an intire Whale, the largest of Animals, when in hot summer weather it is by the Sea thrown dead upon the Shore, I say, does not this Animal quickly infect the places, to a great distance about it, with a pestiferous stench? And is not the whole of it resolved into volatile infectious particles, so that at length there remain only some whitish Bones, the whole mass of the other parts being converted into volatile matter, intirely scattered up and down in the Air. What vast numbers of Carcasses of Elephants, Camels, Horses, and of almost all other Animals, as well as human Bodies, that are the Carnage of War, remain from time to time unburied, and are resolved into putrefaction, become volatile, and dissipate almost all their Elements into the Air? Hence, therefore, it follows, that Bodies of Animals are, from their own natural disposition, as much entombed in the Air, as in the Earth. And those very Bodies, likewise, which are buried in the Earth, are not then preyed upon by the Worms, but are quickly converted into a very light, volatile matter, which afterwards easily exhales into the Air out of the Earth itself. All the corporeal matter, therefore, that has ever entered into the composition of the Bodies of living creatures, has been carried up into the Air, with this difference only, that if the Bodies were burnt, this was brought about immediately; if left to rot in the Fields, more slowly; and still in a longer time, if they were interred; but yet even in that case, they have in time exhaled away. What wonder, therefore, if from the Air, there should be returned a Matter, of the same nature or kind with the food of the former Animals, which is capable of affording a proper nourishment to the Bodies, that are by this means to spring up afterwards?

Nay almost
all animal
Bodies.

But there is yet another thing upon this head, which it will be worth our while to take into consideration, as the right understanding of it will keep us clear of many mistakes. I assert then, that the very Eggs, impregnated with

And their
pregnant
Eggs.

the

the fruitful offspring of their respective Animals, are carried up and down the Air. For the excellent *Redi* has demonstrated, that all Insects, without exception, are generated, by the copulation of Male and Female: *Leeuwenhoeck* has proved, that the Seed of the Male lodges the first Embryo in the Egg of the Female: And *Boyle* has made it appear, that pregnant Eggs will not exclude their young, except they are in the open and the fresh Air. Being furnished, then, with these Observations, I purposely took a piece of Flesh, which had been kept a pretty while in boiling Alcohol, and was afterwards rubb'd over with some bright Oil of Turpentine, and fastening it to a long small thread, hung it up in moist warm Air, in a place where it was imagined there were no *animalcula*, and the consequence was, that in a little time after the suspended Flesh was full of living Maggots, which were devouring whatever of the succulent parts remained in the Flesh. In this case, then, the Eggs, from which these *animalcula* were produced, could not possibly come at the Flesh, but by being born along through the Air, in which it was suspended. How much do the Farmers experience the truth of this to their detriment, when in a warm spring, certain Winds very suddenly infect the Trees with numberless Vermin, which in an instant, as it were, are produced from their invisible Eggs! But give me leave to mention one thing farther, that is still more remarkable, and that is, the Rains that frequently happen among the *Negroes*, which strike a man with such a sudden chillness, that it makes him shudder. These Rains fall in drops, of an inch diameter, which, if they come upon the Skin, eat into it; but if they lodge on any Garments, produce living Worms, and Moths, *Æt. Lips. Suppl. Tom. I. p. 425.* Many other things of this kind might be here taken notice of; but these may suffice, to let the Chemists understand, that the new and wonderful *Animalcula*, which are oftentimes produced in Bodies, and even, perhaps, while they are at work upon them, owe their Being intirely to little Eggs, which are thus carried about in the liquid Air, and not to the efficacy of any chemical Substances or Operations. Let them, therefore, be always mindful of the nature of the Air, and its very wonderful fecundity, before they deduce the origin of such appearances from any other causes. But the knowledge of these things at the same time, likewise, is not less necessary and advantageous to the Physician, and Natural Philosopher.

Fossils in the Air.

But we must not detain you too long upon this head, and therefore let us now pass on to Fossils: For Fossils, I am certain, are likewise discovered in the Air. Fossils, say you, in the Air! 'Twere as reasonable to suppose Castles there. But please to hear only what I have to offer upon this head, and then you yourselves be judges.

First Salts.

Do not, then, all fossil Salts whatever, though ever so fixed, if they are dissolved in Water, (especially in that which they attract from the Air) and are afterwards digested for a long time in a putrifying Heat, and are then distilled with a great degree of Fire, and have their fixed *Residuum* calcined with a strong open one, and then dissolved in the Air: Do not, I say, all fossil Salts whatever, managed after this manner, at length fly off into the Air? This is a Truth which a great Chemist communicated to the World more than an hundred years ago. Not to mention the distillation of these Salts, with Sand, Bole, Brickdust, Potters and Tobacco-pipe Clay, performed with the intensest Heat! Do not the Chemists every year convert, by this method, many thousand

and pounds weight of such Salts, into acid volatile Fumes, which they call Spirits? And does not every such chemical Operation infect the very Air? And does not this Air destroy the Bodies that are exposed to it? The single and simple mixture of Oil of Vitriol, Oil of Alum, or of Oil of Sulphur by the Bell, with Nitre, Sea-Salt, or *Sal-Gem*, converts in an instant those very fixed Salts into Fumes, so volatile that they can hardly be confined, with which the Air is in a short time so strongly impregnated as to carry those Salts to great distances all around. But infinite are the Methods by which the same thing is effected. Before the industrious *Glauber's* time, indeed, this admirable method of thus changing Salts, was not discovered. But who will pretend to determine how many Methods lie hid in Nature even at this day, by which the like conversion from a fix'd to a volatile matter may be brought about? The Vapours about Mines, which are often so fatal, that no living Creature can breathe in them with safety, sufficiently prove, that Nature herself thus disperses Salts through the Air, and consequently, has secret Methods which we are not acquainted with, for performing the very same Operations. In the mean time, however, it is true, that this happens only in certain parts of the Earth; namely, in those places where there is plenty of such a matter, and where likewise the means are not wanting, for working upon it after this manner. And it is likewise as certain a truth, that even those saline Vapours are elevated only to a certain height in the Air, and that not a very considerable one. And upon this foundation it was, that the Adepts asserted long ago, that the Air was divided into certain distinct *Strata* or Beds, each of which contained a distinct kind of Exhalations and Vapours. Hence, then, it is evident, that by the means of Water, Heat, Digestion, Solution, Exsiccation, Distillation, Calcination, Combustion, Mixture, Adunation, and Separation, Fossil fix'd Salts are rendered volatile, and are thus intermix'd with the Air.

And as for the principles of Fossils, which go by the name of Sulphurs, these, whenever the Fossils are burnt, are intirely carried up into the Air, and being intermixed with it, disappear, the saline acid part changing into a suffocating Fume, and the oleaginous part being attenuated by the action of the Flame, and flying off in an invisible, or a sooty black Vapour. It is very certain, that hardly any thing at all of these parts remains in the Earth. Sulphur now itself, when alone, is carried into the Air in form of an impalpable Flower, and is there dispersed about. But when it is mixed with other Bodies, it often acquires a surprizing volatility. The Chemists have taken notice of a great many methods, both natural and artificial, by which Sulphurs are so changed, that they fly off into the Atmosphere, and carry up other things along with them. In Mines, from time to time, there appear pinguious, stinking, suffocating Fumes, pretty often very troublesome to the Miners, to which, if the Flame of a lighted Candle is applied, they instantly take fire, not without extreme danger to the Workmen. But it is certain, that Arsenicks, Orpiments, Cobalts, Sulphur of Antimony, Bismuth, Zincq, and other Bodies, furnish the matter of these Vapours. We are likewise informed of the falling of a shower of Brimstone, attended with Lightnings, which when it was once on fire, could neither be extinguished by Water nor Motion. *Nov. Literar. An. 1684. p. 63.*

In the last place, Metals themselves have been found to be so far changed, that they likewise, under the form of a volatile Fume, have been scattered up
and

Next Sulphurs.

Lastly, Metals themselves.

and down in the Air. This is universally known to be true of Mercury, which when agitated only by a Fire of 600 degrees, flies off, and becomes invisible. And if the Air impregnated with it, surrounds, and is applied to a human Body, how wonderfully does it penetrate it, and how quickly does it throw it into a Salivation! But besides, while it thus flies off, it carries up and bears away with it some part of certain Metals; as appears from the distillation of Lead and Tin with Mercury. Nay Lead, Tin, Iron, and Copper, if they are disposed in a very strong Heat, at length disappear, by means of the volatility they acquire there, and thus far are dissipated likewise into the Air. A great part of imperfect Metals is carried off too by Lead in the test. But when Cobalts, Arsenics, and the like rapacious Sulphurs, are intimately united with Gold and Silver Ore, the Particles of the Ore being by this means rendered volatile, when they come to the Fire, they carry away these noble Metals to that degree, that to the great damage of the Owner, a good part of them both is lost; which by a gentle calcination, and the addition of some fixing Powders, might be intirely preserved. Hence, therefore, it appears, what an abundance of Gold and Silver may be raised up into the Air. Nothing, indeed, seems a greater Paradox than volatile Gold, and yet we are certain from undeniable chemical Experiments, that if you take common sublimate of Mercury, and rub it well with Gold reduced to Powder, and then distill it in a Retort with *Regulus* of Antimony, the very Body of the Gold will ascend in form of a red Oil, and become perfectly volatile. By Sulphur, likewise, calcined Vitriol, and *Sal-Ammoniac*, mix'd and apply'd according to Art, almost all Metals may be rendered volatile in the Fire. No wonder then that in clear Weather, there very often appear about Mines sudden Fumes, which extinguish the Light of a Torch. See *Boyle's Works*, Vol. I. p. 52. since even the most dense Bodies may, in the form of a Fume, be so carried up into the Air, as that it can hardly be determined what Bodies they were. But there is another cause which is frequently concerned in this affair, and which likewise impregnates the Air with these metallic parts, and that is the Air itself abounding with Salts and Sulphurs. For as I have already shewn above, that the whole Air is full of Salts and Sulphurs; and as it appears from what I have now delivered, that those Salts and Sulphurs can carry aloft even Metals themselves when they are dissolved, it is easy to apprehend, that the Air itself can by this means effect that the parts of Metals may be suspended and float about in it. Are not Iron, Copper and Lead, by the contact, and motion of the Air always, and that in a short time too, turned into a *Calx*, Flowers, and a *Scobs*? And are they not hence converted into Rust, a bluish Mould, and a Ceruss? And have you never observed, that when after these changes, they are reduced to an impalpable Powder, they fly away, and are carried through the Air by the Wind. I confess, indeed, that Silver, Gold, and Tin, are less incident to these alterations, because the volatile Acids of Nitre, and Sea-Salt, which are the proper dissolvents of these Metals, are hardly ever dispersed through the Air, except about the Laboratories of the Chemists. The Air in *America*, indeed, is of so corroding a nature, that it consumes the Tiles of the Houses, stony Bodies, and almost all Metals; as the *English* unanimously agree of the Air of *Bormudas*; for even Metals themselves perish there very soon. And that surprizing *Phænomenon*, which in all ages has been observed by Miners, seems likewise to be owing to the

the residence of these metallic parts in the Air, viz. that the fossil Glebes, when they are dug out of the Earth, and are exposed to the Air, are affected by it in a very extraordinary manner. How frequently is it seen, that Marchasites, the Pyrites, vitriolic Stones, and metallic Substances that are quite exhausted, are so acted upon by the Air, that they increase, come to maturation, are changed, renewed, and afresh impregnated, and become again enriched with a true metallic Offspring. In reality, the Air seems to be the grand universal distributor of the Seeds of Bodies, which being plentifully stock'd with every kind of Matter, commits to the Earth the Elements of Bodies it had before received from it, and thus generates most kinds of Bodies, rather by means of a revolution, than a new production. 'Tis certain, that Dew being changed by Distillation, has yielded a Liquor, which stained Glass with the Colours of the Rainbow, penetrating so deeply into it, that it could neither be removed by *Aqua fortis*, Oil of Tartar, or a strong and long continued friction; and yet at the same time the Liquor itself was so subtil, that it burnt in the Fire like Alcohol; *Republick of Letters*, T. I. p. 590. Certainly this effect is very like that of a metallic Tincture upon Glass. *Philosophical Transactions Abridg.* T. II. p. 143.

Thus, then, Gentlemen, the few things I have laid before you, are sufficient to instruct us in our chemical Inquiries, what notion we ought to form of the Air. In reality, it is to be considered as a true Chaos of all things intermixed and compounded together: For in it there float up and down the attenuated Particles of all Bodies whatsoever. And since these little Corpuscles are always in motion, they may, by running among one another in this aerial space, produce all those wonderful operations of Nature, which are owing to the efficacy of particular Bodies: But these are almost infinite. So that indeed, it is not at all to be wondered at, that there are produced and appear in this scene of the Air, such extraordinary, and frequently such terrible events in Nature, as never happen any where else: I mean the Meteors. In this Air there doubtless must be Bodies that are endued with a magnetic vertue, which by their mutual attraction, repulsion, cohesion, rarefaction, and by infinite other methods, must every where excite stupendous *Phænomena*. An instance of this you have here before you. In my right hand I hold a small open glass Bottle, in which there is an alkaline Spirit of *Sal-Ammoniac*; and in my left I have another, in which there is Spirit of Nitre. You see, that whilst I keep these Bottles at a distance from each other, nothing at all appears extraordinary; but that as soon as ever I bring them gradually so near towards each other, that the Vapours issuing from the two Bottles, begin to meet with one another, there immediately, in the place where they thus mix, appears a little Cloud, arising from the concurrence of the Alkali and Acid in the Air. If an Amalgama prepared with Tin and Mercury is distilled in a Retort with Spirit of Sea-Salt, it yields a Liquor, which, if it is kept in a close Vessel, produces no effect; and yet if it is exposed to the open Air, tho' many years after its preparation, it immediately goes off in a very thick Smoke. But Nature is every where full of the like instances. We know not what other hidden Salts there may be besides in the Air, that we are not acquainted with, or with what vertues they may be endued. Nor are we less ignorant what Spirits and Oils may float up and down in it; tho' in the mean time, from the particular Nature of those un-

From what has been said is gathered a true knowledge of the Air.

known Salts, Spirits, and Oils, such stupendous effects may be produced, as are never observed to proceed from any other causes. If the distill'd Oil of Sassafras happens to meet with *Glauber's* Spirit of Nitre; what a terrible effect is produced in an instant? An effect hardly to be exhibited by any other Experiment. If at any time, now, there should chance to get into the Air a number of Particles endued with the like properties, and these should be there mixed together, very strange and surprizing appearances must necessarily follow. Certain times, it is evident, do present us with *Phænomena*, that are never seen at any other. To the production now of these rare and very extraordinary effects, it is possible that the Comets, Meteors, various Aspects of the Planets, and perhaps the Stars themselves, may principally exert their influence; whose actions may be very considerable, on account of their attraction and repulsion, of their Heat, Light, and Cold, and of the *Effluvia* which they generate and emit.

In consequence now of all the things I have here mentioned, this Air is of a quite different nature in particular places; first, on account of the Land or Soil, or the part of the Earth which the Air under consideration hangs over: For according to the various Bodies with which the Earth abounds in any particular part, the Exhalations and Vapours that arise from it will possess as various qualities, and for this reason, the Air in that part will be full of Corpuscles, that are not to be met with any where else. The truth of this has always been confirmed by numberless Examples. And hence it will come to pass, that in such particular parts of the Air, certain Experiments may be made, that will never succeed in any other. In the second place, a very great diversity is here observed likewise, in respect to the Soil, in different places, according as Men inhabit it, and keep Animals there, and according as they dung and turn up the Ground, and exercise various Occupations there, and by this means raise up almost all kinds of Bodies into the Air: On which account again, an infinite number of changes are observed to happen, which are not to be effected elsewhere. A certain Chemist, for instance, in his Laboratory, where he was daily employ'd in the distillation of large quantities of Vinegar, expos'd to the Air some pure, dry, alkaline Salt of Tartar in a glass plate. The Air, of consequence, being full of acid Vapours, dissolved the Salt into an Oil of Tartar *per deliquium*, and at the same time so closely united the acid parts of the volatile Vinegar with the Alkali of the Tartar, as at length to convert the saturated Mass into a *Tartarum Regeneratum*, or regenerated Tartar, which melted in the Fire like Wax, and yielded a very noble Remedy for the resolving of viscid tenacious humours, in almost all Diseases. He was mightily pleas'd therefore with this production, for he reckoned he had now discovered the great secret of the Alchemists for Incerating, according to the language of those Gentlemen, a fix'd alkaline Salt: But when afterward he attempted to repeat the Experiment in another place, where there was not so great and constant a quantity of Vinegar in the Air, he met with nothing like the former success. The same thing might be farther made appear by a vast number of instances, but you yourselves are sufficiently apprised of it. Consider then a little, how prodigiously the Air may be changed in any particular place, when a great Earthquake has occasioned exhalations to arise there very different from what there did before. And this is again confirmed by History, which

which informs us, that certain parts of the Earth have become uninhabitable, by reason of the abominable stinking Vapours with which they have been infested after Earthquakes. But again, inundations by Rain, overflowings of Rivers, and the breaking in of the Sea, make such alterations in the Atmosphere, by means of the humid Vapours, and Exhalations from putrified Bodies hence occasioned, that the whole nature of the Air, in those places, is intirely changed. The very Winds, likewise, as they carry the Air with all its contents from one place to another, must always bear along with them something from the places from whence they began to blow, and consequently are thus always varying the contents of the Air, continually carrying off from particular places the matter peculiar to them, and supplying them again with what they just brought from some others. From which cause likewise, there must needs happen in chemical Operations, a remarkable diversity. And as for the influences of the Heavens, particularly in respect of the various Aspects of the Sun and Moon, their accessions, recessions, perpendicular or oblique irradiations, conjunctions, and oppositions, what changes must these produce in the Air, by their attraction, repulsion, and the Heat and Cold that depend upon them? What variation must they cause in the Vapours and Exhalations that are carried up from the Earth into the Air? But there is one thing farther on this head, which, as Chemists, we ought to take particular notice of, and that is, the vicissitude of the seasons of the year, which is here of such efficacy, as is wholly incredible; even setting aside that which arises from the various actions of the Sun in this stated annual course. You'll understand what I mean, in the following manner. If the Sun on the tenth of *March*, in a certain altitude, and with a certain degree of Heat exerts its Power on the Earth, it then acts on a Body, which in the preceding Winter, being lock'd up by the Cold, has kept in and accumulated, under an icy or cold Crust, its own proper Exhalations, and at the same time, has received and retained whatever came down upon it out of the Air: Hence, as soon as it begins to thaw, and the Earth resolves itself into a loose Mould, the first succeeding Heat of the Sun acts upon this fertile pregnant Body, and immediately fills the whole Air with Vapours: On which account a vernal Heat hardly ever succeeds a Frost of long continuance, but there presently follow Showers, Thunders, and Lightnings, and an igneous Vigour appears in all Animals and Vegetables. But now, when on the tenth of *September*, the Sun at the same Altitude, and with the same degree of Heat, acts upon the Earth, it then finds it parched up, and exhausted by the Heat of the preceding Summer, and not yet moistened with autumnal Showers; for which reason, neither the same Heat in the Earth, or Air, will produce the same effect, nor will excite this vigour in Animals and Vegetables, as it does in the Spring. These few things then will be sufficient to let us easily see the variety there is in the Atmosphere, according to the diversity of the season of the year, as far as it arises principally from this cause; a Speculation very useful both in Chemistry and Natural-Philosophy. And, indeed, it's plain the Chemists had some insight into this matter long ago, when they attributed to the vernal Rain, a virtue so much superiour to that of the autumnal, produced in the very same degree of Heat: For they found that this *Lixivium* of the Air brought along with it out of the Air, very different Vapours and Exhalations, according to the diversity of the season now explained.

A quality in
Air intirely
singular.

Before we leave the examination of the various Bodies that are contained in the Air, and of the different Powers which prevail in it, we must yet take under consideration one quality of it, which is very salutary and necessary to the life of Animals and Vegetables; a quality which has not been yet accounted for from any other property of the Air, but by a diligent inquiry, however, may possibly, hereafter, be come at the knowledge of. Whether, now, this latent vertue of the Air is actually drawn out of it by Animals and Vegetables, and hence is in a short time exhausted and consumed; and whether, when it does thus fail, the Animal dies, no-body is, I think, at present able to determine. This, however, is certain, that if a small Bird is put into a large Receiver, full of common cold Air, and the Receiver is then very closely stopt, the Bird will grow sick and vomit within a quarter of an hour, and die in the space of half an hour after. *Boyle, Of the Air.* 184. A Fish kept in Water in a Vessel well closed, without renewing the Air, dies in a short time. Fish likewise die in Ponds that are every where frozen over, and quickly perish in Water out of which the Air is exhausted. *Hist. de l' Acad. Roy. des Scien.* 1699. 240. 1701. 46. and *Mem.* 224. Flame, and a red hot Coal, quickly go out in Air that is close pent in. The little Eggs of any Insects whatever, being accurately stopt up in glass Vessels, do not produce their young, tho' assisted by a kindly Warmth. The Seeds of Plants likewise, duly moistened, and sowed in the best Earth in close Glasses, do not grow, or give any signs of active Life, tho' excited by a due degree of Heat. On the other hand, the upper Surface of Blood that is exposed to the Air, is of a bright scarlet colour, whilst in every other part, where the Air don't come at it, it grows as black as the juices of the Cuttle-fish: And yet, as soon as ever this black part is laid open to the Air, the black colour is immediately changed again into a scarlet. All these Experiments then make it appear, that there is in the Air a certain hidden vertue, which cannot be accounted for from all the properties of the Air, which have been hitherto discovered. *Sendivogius* maintained it openly, that there lies hid in the Air the occult Food of Life; and other Chemists have asserted the same: But what that is, or how it acts, or what is the proper effect of it, is a matter still in the dark. Happy the Person that shall happen to discover it. Let this Hint suffice for Persons that are hitherto ignorant of it, is it not the elastic part of the Air alone?

Hitherto explained by
no-body.

For my own part, I confess, I cannot apprehend, that either the Natural-Philosophers, or Physicians, have yet discovered the physical cause of this wonderful quality of Air. I have seen, indeed, a great many conjectures upon it; but they have almost all fallen of themselves. After all that has been said then, we have now a proper opportunity in the last place, of treating a little briefly of the proper weight of the Air: And to this purpose, if you please, let us take the sum of what has been laid down.

The weight
of the elastic
part of
the Air.

The Air then is full of Water, which is ponderous, solid, and not to be condensed by any weights. With this Water, the Air is so plentifully stocked, that Salt of Tartar, upon Experiment, has attracted so much Water out of a small quantity of Air, contained in a glass Vessel close stopt, as to grow sensibly moist. Besides Water, too, almost all kinds of Bodies are contained in the Air, and dispersed up and down in it: All which Bodies taken together, must at least be as heavy as the Water. But these Corpuscles, likewise, as they are there in a liquid form, can scarcely be driven closer together, by the force of any imposed

imposed weights. If therefore from a given portion of Air, all that truly ponderous Matter, which, as has been demonstrated, the Air naturally receives from all kinds of Bodies, was very accurately separated from it, how much weight do you think would there remain belonging to its real elastic part? Undoubtedly you perceive, unless I am exceedingly mistaken, that there would remain but a very little: Nay, if from the assistance of so many Experiments, we may be indulged a conjecture, perhaps there would be really none at all. For let but the eight hundred and fiftieth part of the whole space of a cubic foot of Air be filled with Vapours and Exhalations, not elastic, and with dusty Particles floating up and down in it, then the remaining elastic part of the Air will have no weight at all. And hence it might come to pass, that the Air in that compass could never be reduced into a less space than the $\frac{1}{850}$ of the whole, notwithstanding the *Newtonian* Law should constantly hold good in the elastic part; namely, that the Elements of Air always endeavour to recede from one another with so much more force, as the weight is greater by which they are compressed. And from this supposition it would likewise necessarily follow, that when the other parts are contracted into a space 850 times less than the former, then the elastic part cannot be reduced closer by any weight whatsoever, since all that space would be then filled up with Water, and other incompressible Bodies. And this exactly answers to the Experiments of the famous *Halley*, and the *Academy del Cimento*, who assert, that the Law of the reduction of Air into spaces, proportional to the compressing weights, does not hold good beyond that space which is 850 times less than that which is taken up by the common Air. *Hist. de l'Acad. Roy. des Scien.* 1703. 7. *Mem.* 102. We ought not, however, thence to conclude, that the purely elastic part of the Air, if it could be made trial upon alone without the mixture of other Corpuscles, could not, by the same Law, be condensed a great way farther. And who will pretend to determine how far? Perhaps this would always be the case.

Perhaps it has no weight at all.

For these reasons, I have frequently considered with myself, whether the supreme Being has not created both Fire, and purely elastic Air, intirely without gravity, nor tending naturally to any particular point, but equally distributed throughout the whole Universe, and that under this Law, that the Fire should always so act upon the Air, as never to suffer it to be at rest, no not even in the extremest Cold. For, if in the upper region of the Atmosphere, the Heat of the Fire is less, the Air likewise in the same proportion being there less condensed, as there are fewer heavy Bodies to compress it, must be always rarer, and consequently will be so much the easier kept in an ebullition by a less degree of Fire, and will at all times be agitated with a tremulous motion. What room is there here then for admiration! What a mighty moving power upon every thing, lest at any time they should be at rest! But it's very likely you will be apt to think with yourselves, if the Air, with respect to its elasticity, be without weight, what is the reason then, that it is not rarer about the Earth? Why, let us, Gentlemen, only consider, that its Elements are not so easily to be disengaged from the other Particles with which they are intermixed and intangled, and consequently, that by this means it will be compressed by the other Bodies that are incumbent upon it; and then the reason of this *Phænomenon* will be very evident.

A diuine rate of motion in Fire and the elastic part of the Air.

And

The properties of the elastic part of the Air.

And thus I might here have put an end to our History of the Air; but there remains, however, a small, but very valuable Article, which may still be added, *viz.* the demonstrating this purely elastic Air by Experiments, and the prosecuting it in its wonderful effects. And upon this head, whilst I have consulted a great number of Authors, I have found the excellent *Mariotte* to be the principal one, who has broke the Ice, and led the way. Pursuing then the steps of this famous Gentleman, I have digested these Experiments in the following order.

EXPERIMENT I.

Elastic Air adheres to Solids.

I have here in my Hand a Plate of pure Silver, curiously polished, and very carefully cleaned, and as warm as the present temper of the Atmosphere, *viz.* 52 degrees. This Plate, as you see, I immerse gently, without any concussion, into very clean Water, of the same degree of Heat, in this glass Vessel; and yet you see there are formed aerial Bubbles, sticking to the Surface of the Silver, thence rising up through the Water, and then bursting asunder. This, therefore, upon examination, being constantly the event, we may hence conclude, that common Air, by its invisible Particles, adheres in such a manner to the solid Surface of the Metal, that it descends with it through the Water, keeps its hold by a certain viscid tenacity, and will not give way, and leave its Surface, till it is forced upwards by the weight of the Water. When this Silver Plate, therefore, is moved through the Air, undoubtedly the Air next its Surface will adhere fast to it, till by Wind, Heat, or a rapid motion, it is dislodg'd from it, and then at last it yields up its place to some other Air that succeeds it. This property now of merely elastic Air, ought well to be taken notice of in chemical Operations. For since it sticks only to the Surface of Bodies, not being able to enter into their solid Mass, 'tis evident that Bodies, when they are minutely divided in the Air, and consequently have their Surfaces greatly multiplied, always carry far more Air with them into the Receiver, than they would have done in a single solid Mass. And for this reason, the Air that is generated in the solution of Silver Dust by Spirit of Nitre, is not to be supposed to proceed from the Spirit of Nitre, or the solid Mass of the Metal alone, but partly likewise from the very Air which is convey'd on the Surfaces of the Particles of Silver. If the Experiment is made with a Plate of Gold, the *Phænomena* are the same. If very solid polish'd Gold then attracts Air after this manner, all other Bodies certainly will do it much more. All Bodies, therefore, when they are immersed in Water, carry Air along with them; tho' those Bodies do it more so, which are rough, and whose Surfaces consequently are greatly increased. If at the same time too they are fungous, spongy, and full of Pores, they will carry with them still a much larger quantity of Air through the Water; especially, if such Bodies are dissolved into their smallest parts by the dilution of Water. This then is the first method of demonstrating the adhesion of elastic Air to solid Bodies.

EXPERIMENT II.

And Fluids.

Again; you see this pretty large Cylinder, which is bright, clean, transparent, and dry. Please to observe, into this Cylinder I pour pure Water, till the Vessel is almost full. This Cylinder, now, thus full of Water, I so apply to the Air-pump, that by means of it, I exhaust the Air that rests upon the Surface

Surface of the Water ; and at first you perceive no alteration in it. As the Atmosphere, however, now, is a great deal diminished, you perceive Bubbles of Air appear ; and in what numbers ! How swiftly are they carried upwards ! How quickly do they increase in magnitude ! But whence now do they arise ? Why certainly, as far as we can any way discover, from the Surface of the bottom and sides of the Vessel, or of the Water. And hence an unwary person, who should see this Experiment only, might be induced to imagine, that all the Air, which by this method is fetch'd out of the Water, lay concealed only between the concave Surface of the Glass, and the convex Surface of the Water. But this opinion will by other curious Experiments be refuted hereafter. In the mean time, however, this we are assured of, that Air adheres to the Surface of Glass, and Water, with the same tenacity that appeared in the preceeding Experiment.

EXPERIMENT III.

But the very Air itself, by its Surface, adheres to the Surface of other Air, with a pretty remarkable tenacity, notwithstanding its Elements seem to fly from one another. The demonstration of this, which indeed has been given in a former part of this work, I repeat again in the following manner: This Glass Vial, which from a large spherical Belly, runs out into a long cylindrical neck, the diameter of which is nearly 4 geometrical lines, I have filled with Water ; and now I invert it in such a manner, that the mouth of the neck, which is open, points directly downwards, and yet not one drop of Water falls out ; nor does there enter one bubble of Air ; a manifest indication, that the fine Elements of Air do not here easily recede from one another, but, by a certain adhesion, cohere together. (This Experiment I exhibited formerly, when I was treating of the divisibility of Air ; but as I am now considering Air as elastic, or very light, I am obliged to repeat it again). For if the very light elastic Particles of Air were as easily separable from one another, as the united parts of Alcohol are, then the elastic Particles of Air passing through the Water, would make their way upwards ; and the Water would proportionably run out of the Glass, as we saw on the foregoing occasion, when we set this same Glass in Alcohol that was coloured. See p. 258. and the following. And that the effect we are speaking of is chiefly to be attributed to such a tenacity of the aerial Particles, is confirmed by the following Experiment. The same Vial, filled with a very strong *Lixivium* of Salt of Tartar, I immerse again, thus, into distilled Oil of Turpentine. Do not, now, the viscid parts of the Oil ascend, through this more ponderous *lixivium*, far more slowly than Water or Spirits of Wine ? Most certainly. You will say, perhaps, that the repulsion there is between the aqueous Particles, and the oily ones, is the cause of this *Phænomenon* ; and that the Air is repell'd in the same manner by Water. I grant it. But in the mean time, you see, that this slowness in the Air in ascending appears equally evident, whether the Vial is filled with Water, Alcohol, Brine, any *Lixivium* whatever, or even with Mercury. Hence, therefore, It seems not altogether improbable, that the tenacity of the elastic parts of the Air, among one another, is greater, in these instances, than in the other Liquids. When the elastic parts of the Air, therefore, are once united together, they seem to be less easily separable, and less easily divisible into their minute parts ; and, consequently, they appear to be mixed with other Liquids, with more difficulty than any other Fluid we are at present

present acquainted with. I know very well, that all the Philosophers I have hitherto consulted, are of another opinion, and think nothing more true, than that the Air immediately enters any Liquid whatever that it can but come at. But careful observation obliges me to think in a quite different manner. For if I fill two thirds of the capacity of this Vial with any Liquor whatever, and the other third contains nothing but Air, and I perfectly close it with a glass Stopple, and then shake the Vial over so long, I shall never bring the Water to be wholly mingled with the Air, but only large bubbles will be produced from the Water, within which the aerial Particles are entangled and rolled up, whilst the agitated parts of the Water form little spherical Bodies that keep them in; and thus, from a number of such Bubbles there arises a white Froth, consisting purely of Air and Water, into which they are again resolved; the diameters of these Bubbles being nearly three lines. But that you may see the truth of this Paradox still more evidently, be pleased likewise to take notice of the following Experiment. This glass Vial, the Mouth of whose Neck is open, and not four lines wide, is full of our common Air. This Vial, now, I sink thus perpendicularly under Water, so that the mouth of it, which is open, and points upwards, is quite below the Surface. The Water, therefore, now rests upon the Surface of the Air, and nevertheless does not descend into the Vial, but the Surface of the Air bears it up. Water, therefore, which is eight hundred times heavier than this compounded Air, cannot so divide the Particles of the Air asunder, as to insinuate itself among them, and descend through the Air. But there is another thing remarkable upon this head, which is as follows. This glass Vial is full of Water, and the mouth of its neck is 5 lines wide. This, as you observe, I so invert, as that the mouth points downwards; and now you see, that there arise not small, but large capacious Bubbles of Air; that they enter into the neck, through the Water, and make their way upwards, thus whole and united; and that they are not, while they pass through the Water, divided into very small parts, but ascend in form of large intire Bubbles. You perceive at the same time too, that the Surface of these Bubbles is at both ends convex, and that the Water accommodates itself to them in a Surface that is concave. But this appears still more distinctly, when I place the neck of this Vial in a horizontal position, for then these aerial Bubbles remain equally large, and being on all sides confined within the Water, shew very clearly their bulk, which they retain a long time together with their Figure, which is convex at both ends, as you see in the Plate. The same thing holds true likewise with regard to this convexity of the Air, in narrow glass Tubes full of Air, and open at both ends. For if you set them perpendicularly in Water, the Water will rise in the Air in such a manner, as to form a concave Surface on its upper ascending part; whilst the surface of the Air that is contiguous with this of the Water will be convex. This too you see in the Plate. All these things, then, considered together, seem to evince, that the Elements of the elastic part of the Air possess a determined and pretty considerable tenacity, with respect to one another. Those things, I say, taken all together, for I am not ignorant, that very celebrated Authors explain some of them from the attraction which is observed between Glass and Water.

Tab. VII.
Fig. 3.

Pl. VII.
Fig. 4.

Fig. 5.

EXPERIMENT IV.

I have here, three conical Glafs Vessels A B C growing narrow towards the top, and open ; and with plain or level bottoms. In one of them there is Water, as cold as the Air is at present, viz. 44 degrees. In another there is Water of the same warmth with this place which we are in, which is about 91 degrees. In the third there is Water heated to the 150th degree. And I have chosen the Vessels pretty tall, that the Experiments I shall exhibit may be the more conspicuous. These Vessels then, thus prepared, I forthwith set upon the Air-pump, under the Bell ; and immediately exhaust the Air. Do you not now very plainly perceive, that as soon as I have drawn out a little of the Air, a very large quantity of Bubbles are generated in the hottest Vessel C, which are formed at the bottom and sides of the Vessel, and ascend, grow larger, and break asunder at the Surface of the Water, just in the same manner as if the Water was now really boiling, which notwithstanding is, perhaps, 70 degrees below the Heat of boiling Water in the open Air. In the Vessel B, however, where there was but just now a heat of 91 degrees, you see, there is yet no such agitation. But having now drawn out more Air by the Pump, there appears in B too, the like production of Bubbles ; so that there is now an ebullition both in A and B, but none yet in C. Having now, however, drawn out a great deal more Air, an ebullition at length is produced in C likewise ; and all of it being now exhausted, the boiling continues for a very considerable time. Hence then we infer, that pure elastic Air, in a certain quantity, lies insensibly concealed in Water, without any discovery of itself in the cold, and under the pressure of the Atmosphere ; and yet in the Experiments of the *Academy del Cimento*, Water, though it contains in it this latent Air, which is so compressible, could not in any manner be itself condensed by weights. For this reason therefore we conceive, that the Air which insinuates itself into Water, is there lodged in the interstices which are left between the Elements of the Water, which are in contact with one another, and cannot themselves enter into those vacuities ; but that it does not interpose itself between the Elements of the Water, where those Elements can naturally touch one another, and by this means hinder them from coming together ; for in such case, the Water, which contains this Air, would likewise be compressible. Thus, then, we are certain, that the Air possesses only those vacuities, which are constantly left between the immutable Elements of the Water, and which are not to be altered or disturbed by any varied situation of these Elements, being, perhaps, whilst it is at rest there, divided into its perfectly distinct elementary Particles. Hence farther, we are induced to believe, that this Air, so lodged in the Water, and not discovering itself for so long time in the Cold, requires, in order to its being retained there, that the Water be compressed by the force of a ponderous Atmosphere ; but that when the particles of the Water are compressed together by an effort less strong, then these latent Elements of Air elevate the incumbent Water, disengage themselves from the interstices where before they lay quietly hid, and then leave those interstices empty of Air. In the third place, we see likewise, that Heat disposes the intercepted Air to extricate itself with greater ease from the surrounding Water ; and that in such manner, that the hotter the Water is, the more readily, in proportion, will the Air get out of it. Hence therefore,

Q q

when

There is elastic Air in Water, as appears by this Experiment.

Pl. VIII.
Fig. 2.

when Water has boiled on the Fire for a considerable time, having by that means acquired its greatest Heat, it will have expelled almost all the Air that was contained in it. And in the fourth place, we learn likewise from Experiments, that every sort of Wine, Malt Liquor, and Spirits of Wine, do in Mr. Boyle's Air-pump discharge themselves of these aerial Bubbles so much the sooner as these Liquors abound with a greater quantity of inflammable Spirits.

And another.

Fig. 2.

But this other Experiment, which now follows, will make all these things more evident. You see I take a cylindrical Vessel AB, with a flat bottom, and fill it half full of common clean Water. I have likewise a spherical glass Bottle CD composed of a Belly C and a Neck D which I fill quite full with the same Water. Then with my Finger laid upon the Mouth D, and touching the very Water at the top of the Neck, I so immerse this Neck D into the Water in the Vessel AB that no Air can possibly enter into it, and hence the Bottle remains still quite full of Water, without the least Air at top. Both these Vessels then thus disposed, I put, as you see, under the Bell upon the Air-pump. And you observe, now, whilst I exhaust almost all the Air, that the Water in the Belly of the Bottle C descends by its gravity through the Neck D, into the Vessel AB, because the Surface of the Water in the Vessel AB is no longer pressed by the weight of the Atmosphere. In the upper part therefore of the Belly C above the descending Water, there is now formed a *Torricellium Vacuum*. Hence the Water is there pressed by nothing, but exists in *vacuo*. And by this means the Air which is in the Water in this Bottle, produces a vast number of Bubbles; all which make their way through the Water in the Neck and the Belly, towards that upper *vacuum*, and there bursting asunder, give you all the Air which is collected out of the Water in the Bottle CD. I leave every thing now in this state till no more Bubbles are formed, nor ascend into the upper part of the Bottle; and then, as you see, I let the Air into the Bell, which immediately pressing upon the Surface of the Water, in the Vessel AB, forces up the Water thro' the Mouth D into the Belly C; and now you perceive, that tho' there is a free communication with the external Atmosphere, yet the Water does not quite fill the whole Belly C, as it did before, but there remains in the upper part an aerial Bubble, consisting of true elastic Air, which was forced out of the Water in the former operation, in those little Bubbles, which were then produced, and there burst asunder. Nor were those Bubbles generated there, till the greatest part of the Air had been exhausted out of the Bell. Nor indeed do these little Bubbles ever arise from this Water, 'till it appears by the Mercury in the Barometer, that the weight of the Atmosphere under the Bell is diminished more than one tenth of the whole. Since, therefore, the greatest variation of the weight of the Atmosphere with us never exceeds one tenth part, hence there will never be any danger of Water's discharging the Air that is contained in it. But Water, likewise, made ninety degrees hot, and then freed in the Air-pump from a tenth part of the weight of the Atmosphere, does not even then send out its Air by Bubbles; and hence the Air likewise in the Fluids of our Bodies will never be separated from our Blood, or Humours, by the greatest lightness of the Atmosphere that ever is observed amongst us, as by a particular Experiment too I shall demonstrate hereafter. It happens, indeed, sooner in this hot Water, than it does in colder; but yet even here it is not observable, upon a diminution only of a tenth part of the aerial pressure. But you will

will be apt to ask me now, Gentlemen, and that very justly, how I know that the great Bubble in the upper part of the Belly is true elastic Air? This, I confess indeed, it is absolutely necessary that I should demonstrate. The reason then that I look upon this to be true elastic Air is, first, because, as you saw yourselves, it expands and contracts itself in proportion to the compressing weight; and in the second place, because if Heat is applied to it, it expands itself into a much larger Space, and if Cold acts upon it, it contracts itself into a far less: But that these are the peculiar and most certain marks of Air, who will go about to dispute? But there is another Thing still that must be cleared up, and that is, whether the Air produced in this manner be really exhausted out of the Water; or whether it only comes from the interstices between the Surfaces of the Water and the Glass; for this indeed seems to be evident to the Eye, as I observed to you but very lately.

But if I am not very much mistaken, there are not wanting arguments to prove, that it arises out of the very Water itself. This is very evident, if we consider, first, that a very different quantity of this Air is produced from the same quantity of different Liquors; for Mercury, Water, Wine, Spirit of Wine, Beer, Alcohol, Wine that is foul, and that is fermenting, Beer not duly work'd, and Must, differ incredibly in the quantity of Air which they thus generate *in vacuo*; whence it plainly appears, that this Air is separated, not from the Surface only, but from the inmost recesses of Water, and other Liquors. And if we add to this, that there are some Fluids, which in this way generate no Air at all, our opinion will be still farther confirmed. Thus, for instance, Oil of Tartar *per Deliquium*, tho' it is produced itself in the Air, will scarcely yield any Air, if it is treated in the same manner. And, which one would hardly believe, even the Spirit, which we call the alkaline, volatile Spirit of *Sal-ammoniac*, if it is very strong, will afford but an exceeding small quantity of Air, in the same Experiment. But there is another Argument, which will serve as a farther confirmation of this truth, of which I shall quickly give you ocular demonstration; and that is, that the whole quantity of that Air, which was produced after this manner, may intirely be absorbed again by the same Water out of which it was drawn, and that no more than that quantity, exactly, can by any art or power be forced into it. All which considerations, if you weigh them with due attention, will furnish you with arguments sufficient to convince you, that far the greatest part of that Air was really exhausted from the very Body, or inmost parts of the Water.

And finally, we may add, that this Air, by the same Experiments, has been drawn likewise out of Vinegar, Spirits of Wine, Urine, Spirits of Urine, Oil, Water and Oil, express'd Oil, distill'd Oil, Milk, Blood, the Serum of Blood, Eggs, the White of Eggs, nay, and lastly, even from Mercury itself. But here let me observe, that if this Experiment is made with boiling Water, which has boiled continually for the space of an hour, hardly any Air at all will be got out of it; so that this doctrine stands upon a firm foundation.

EXPERIMENT V.

If Water is by boiling accurately deprived of all the perfectly elastic Air that is dispersed through it, and afterwards, being cooled to the temper of the Atmosphere, is exposed to the common external Air, then will the elastic Air spontaneously,

Within the Water itself.

And in all other Liquors.

Air will enter into Water that is void of Air.

neously, and pretty quickly, enter into this Water, which is now void of Air, and again lodge itself in the spaces left between the interstices of its Elements, and that always to a determined quantity. This wonderful relative property between Water and elastic Air, is demonstrated to the eye in the following manner. Take the whole *Apparatus* of Vessels, made use of in the second part of the 4th Experiment, just now exhibited, where the elastic Air was collected at the top of the Belly of the inverted Bottle. If, then, that aerial Bubble is compressed with the machine used for condensing of Air, the Bubble will not by that means intermix with the Water: But if I expose this whole *Apparatus* to the external Air, then this Bubble will in a little time begin to diminish, and at last will so perfectly vanish, that there will not be the least Air left at the top, but the Belly of the Vessel will be again quite filled with Water only. And this Experiment is constantly observed to proceed in this manner, namely, that in the beginning, a great portion of this collected Air enters pretty quickly into that Water, deprived of Air, but that the little quantity that then remains makes its way in but very slowly. Hence, therefore, it follows, that Water will always imbibe again exactly the same quantity of Air as has been drawn out of it before.

But not into
Water satu-
rated with
Air,

* The event, now, of this Experiment is pretty extraordinary, when it is attempted with Water, which is already naturally saturated with Air. If therefore, instead of drawing the Air out of the Receiver, and thus forming a Bubble at the top of the Bottle, I take the same Bottle, and not filling it quite full, with my finger upon the Mouth, invert it into the other Vessel, then a Bubble will retire to the top of the Water in the Bottle, and if I then set by the Vessel in this manner, for the space of a year, the aerial Bubble I let in will never enter into the Water, but will always remain at the top, without being mixed with it. Nay farther, in what manner soever I shake these Vessels, I shall never be able to make that Air insinuate itself into this Water. This Bubble indeed would be divided into other small ones, but do what I could, it would never be mixed and distributed through the Water, in such a manner as to become invisible. I have tried what could be done by pressing, heating, cooling, shaking, and laying it up for some time; and yet still that Air constantly remained at top in the same quantity; nor was it possible to intermix any more with the Water, than what it had spontaneously taken in from the common Air.

* This Doctrine of our Author, that Air will not be absorb'd by Water that is already saturated, does not appear constantly to be agreeable to Experiment, as upon trial, at the hint of the learned Dr. *Jurin*, I observed in the following manner. I took a common *Florence* Flask, and filled it almost full of Water, and after letting it stand some time, with my Finger upon the Mouth of it I inverted it, and by this means procured a Bubble of Air at the top. I then, with my Finger still applied to it, immerg'd the Neck of the Flask into a wide-mouth'd Square, full of Water, upon which, drawing out my Finger, I left the Flask standing in the Mouth of the Square. In this manner I put it out of the way, and examining it from time to time, found the Bubble gradually lessen, till it at last intirely disappeared. This I repeated several times, with the same Success. When the Bubble was small, it was taken in in a few days, and as near as I could judge, faster in proportion than the large ones. The Diminution too of the large ones, at the beginning, was more sensible than afterwards, as I saw evidently in one of an inch and three quarters in diameter, set the 4th day of *June*, which, though it was considerably diminished the first month, yet is not this 10th of *December* reduced to an inch. Whether this, therefore, will be totally imbibed by the Water, or not, I cannot yet determine, not having made trial of so large a one before, but one of about $\frac{7}{8}$ ths of an inch, by standing in the same manner, in time was perfectly absorb'd.

In the prosecutions, now, of these Experiments, I could not help being surprized, when I observed how small a part of the Surface of the Water was come at by the Air, collected into a Bubble on the upper part of it; and yet saw, at the same time, that all that Air insinuated itself by so small a part of the Surface throughout the whole body of Water, out of which it had before been drawn. And doubtless, it had then distributed itself equally, throughout all the interstices of the whole Water. There must necessarily, therefore, be in Water, a certain attracting, imbibing power, in respect of that Air, thus drawn from so little Space, through all its parts; for this Air stands in no need of concussion to force it into the Water; let it but alone, and it will make its way in of its own accord.

It extends itself from a small space through the whole Body of the Water.

The illustrious *Stairs*, in his very elaborate Philosophical Works, was induced by many reasons to be of opinion, that there never was any true Air in Water, and that those Bubbles produced from Water, in the Air-pump, did not arise from true elastic Air; but that in Water there always reside little active Fires, which making their way through the Water, when this is freed from the pressure of the Atmosphere, and by their levity tending upwards, form those little Bubbles which presently burst asunder. I am apt to believe, however, if that worthy Gentleman, whose candour and virtue are every where spoke well of, had sufficiently considered these last Experiments, he would have been of another opinion: For then, in these collected Bubbles, thus produced, he would have found all the true characters of pure Air. See *Stair's Philosoph. Experim.* p. 572. Let these things suffice then, touching the first method of separating elastic Air from Water, by removing the compressing weight.

These Bubbles do not proceed from Fire.

EXPERIMENT VI.

It is very entertaining to see the manner in which Fire separates this Air from Water, and to observe this Air, when it is thus separated, and collected together, which is very easily performed by the following curious Experiment. Take a large wide Vessel AB, able to bear the Fire, let the bottom of it be flat and plain, and let it be filled with common Water. Then let there be put in this Vessel, a Funnel, so large, that the broadest part of it may nearly cover the bottom; and let the Neck of the Funnel CD be wholly immersed under the surface of Water contained in the Vessel AB. Let there then be provided a little glass Bolthead or Vial EF, the mouth of which is wide enough to admit the Neck of the Funnel. I now fill this Vial up to the top with Water, and having stopt the Mouth of it close, with my Finger, I invert it, and thus let it down into the Water in the Vessel AB, so that no Air at all can get up into it; and then, as you see, I put the Mouth of the Vial E over the neck of the Funnel CD. This done, I put the Vessel AB with all its Apparatus upon the Fire, so that the whole may grow hot gradually, and at length the Water in the Vessel AB may boil briskly. And when this is the case, then the Water of the Vessel boiling under the Funnel, will determine the Air of the Water, which is now formed into Bubbles and tends upwards, through the Funnel into the Neck of the Vial, and thence into its Belly, and so collect it together in the upper part F. This then being continued for some time, there will at the top F be contained true Air thus separated from the Water which boiled under the Funnel in the Vessel AB. And this Air, again, will have a perfectly elastic quality,

Air is separated from Water by boiling.

Fig. 3.

quality, and can be drawn out of the Water only in a certain and determined quantity, beyond which no more Air can be procured, how long soever the boiling is continued. In this Experiment, now, there occurs a *Phænomenon* that is pretty remarkable; for when the boiling Water has thus sent up in Bubbles all its contained Air to F, there nevertheless, in the course of the boiling, are produced other Bubbles, with a sudden and considerable *impetus*, which bursting with a great force, shake the Water and Vessels, but do not by this means produce any Air. These Bubbles, therefore, arise not from Air, but from the Fire which acts in the Water. These therefore continue to the end, tho' you boil the Water ever so long; whereas the aerial Bubbles are quickly over: These likewise are large; whereas the Air-ones are but small: These burst asunder with an *impetus* like that of Wind; whilst the others discharge themselves very quietly: Nor do these, as I observed before, generate any Air, though so exceeding large. And for this reason the excellent *Mariotte* gives to these Bubbles the name of Fulminations. And if the famous *Stairs*, in the Place above cited, means these Bubbles, he is so far in the right. These things, then, being done, and the Air being collected at F, if the whole *Apparatus* is set again in the cold, the generated Air will return into its proper Water, out of which it was exhausted. Having gone through this Experiment, with the success I have now told you, I had a mind to prosecute this inquiry farther. Accordingly I took Rain-water, and kept it boiling very briskly, for the space of two hours. This Water I then placed, boiling hot, with the *Apparatus* of the 4th Experiment, under the Bell, and drew out the Air, as carefully as I could; and at that time, no Air was produced in the upper part of the Belly of the Bottle. Afterwards, however, having thus kept the Water in this *Vacuum* for some days, there arose from it at last a pretty large quantity of Air. Surprized at this event, I was in doubt, whether, perhaps, the very Water was not transmuted into Air, by remaining so long in *Vacuo*? Or whether the Air was not so intimately mixed with the Water, that it could not be intirely expelled by boiling; though by the Water's being thus left *in vacuo*, it might, by length of time, have thus slowly disengaged itself from it?

EXPERIMENT VII.

Air is separated from Water by Frost.

I took some Rain-water, and put it in a very diverging, conical, glass Vessel, and then exposed it in a hard Frost. Some time after the Particles of the Water began to be constringed by the Cold, though it is not possible to condense it by the pressures of the greatest weights. But when the Particles of the frozen Water, thus more closely contracted, begin to lessen the little Spaces intercepted between them, the Elements of the Air, which before were lodged in them, being now pressed out of 'em, become united with one another; and by this means, while these elastic Elements, which before existed separately, come into mutual contacts, they seem, by their reciprocal repulsive force, to acquire an Elasticity, which they had not while they were apart from one another. Hence then, little Bubbles begin to be generated, which grow larger and larger, increase in number, become at length of a considerable size, and tending upwards, and being lock'd up within the hard Ice, remove it by means of their Elasticity, and, notwithstanding its hardness, make it swell out on every side, and by this means break asunder the Vessel that contains it. And here we observe, that

that the harder and longer it freezes, the greater, always, more numerous, and so much the stronger, likewise, are these aerial, elastic Bubbles. Hence it comes to pass, that Water seems to increase in magnitude by Cold; whereas, in reality, the Ice itself is less than the Water was; but these Bubbles of Air, thus generated, whilst they form within the Ice pretty large Spaces, where there is no Ice at all, must necessarily increase its dimensions; and by this means, likewise, they acquire that prodigious power by which they become capable of splitting the Vessels in which they are confined. If, therefore, the Frost is very sharp, and of a very long continuance, then all the Air, before distributed through the whole body of Water, extricates itself from the pores of the Ice, is united into those icy Bubbles, and disengaged from the Water. This then is another, and new method, by which Air is separated from Water.

EXPERIMENT VIII.

Whilst Oil of Tartar *per Deliquium* is prepared from the Water diffused through the Air, one would readily believe, that this frothy ponderous Liquor must be full of elastic Air; and yet upon examination in the manner just described in the preceding Experiments, it evidently appears, that whether the pressure of the Atmosphere is taken off of it, is boiled at the Fire, or constricted by Cold, this Liquor will afford no Air at all. Hence therefore we learn, that a fixed alkaline Salt, whilst it insinuates itself into Water, expels the Elements of Air which are lodged there, and takes possession itself of those little vacuities, and thus constitutes a Fluid which is the heaviest of all we are acquainted with, except Mercury, being in weight to Water, as 7 is to 5. See *Boyle's Mech. Exper.* p. 26, 27. Or rather, don't it fix the Air?

Air is separated from Water by an Alkali.

EXPERIMENT IX.

The following Experiment concerns both the Chemist, Mechanic, and Physician, and therefore deserves their attention. I took the Urine of a very hearty Man, made in the morning, after he had his full Sleep, and whilst he was fasting, and put it into a Glass Vessel that was warmed to the same degree of Heat as is observed in a Man in health. This Vessel and Urine, the very moment it was discharged from the Body of the Man, I put upon the Air-pump, under a glass Bell, and drew out the Air as fast as I could; and yet, for a long time, I perceived no sign of any Bubbles of Air in this Urine, though it was so warm. I imagined, therefore, that there was no Air in Urine that could be shewn by this Experiment. And since this Urine was 90 degrees hot, and the Air was exhausted to 26 inches, and yet there did not appear the least sign of any ebullition, would not any other person have been of the same opinion? When I had drawn the Air out however to 27 inches, then some Bubbles began to arise; and as I proceeded to draw out more, all on a sudden, the Urine in this *vacuum* began to boil with so much violence, as it never boils in a Vessel upon the open Fire. At the sight of this I confess I was very much surprized: For whence could proceed so sudden, and so violent an agitation in a Liquor which was before so quiet? How comes it to pass, that the very little portion of elastic Air, which was exhausted at last, should (after it had born the Atmosphere's being removed to 27 inches, without any ebullition) at once produce such a prodigious alteration? Did this sudden alteration arise from the Air of

Air out of a hot animal Liquor.

the

the Urine, or from the Fire then residing in it, or from both together? Many other Experiments of this kind I made with various animal Fluids, with very strong *Lixiviums* of Sea Salt, *Sal Gem*, Salt of Nitre, *Sal-Ammoniac*, volatile, alkaline *Sal-Ammoniac*, and with Mercury. If you would do the same, you would not at all think your time ill spent. To enter into a particular account of these things, would be tedious both to you and myself.

COROL. 1.

Elastic Air, therefore, notwithstanding its Particles adhere to one another, with some kind of tenacity, dissolves itself into its minutest Elements, that it may spontaneously insinuate itself into the vacuities of Liquids that are void of Air, and so disperse itself throughout their whole mass. That Air, therefore, is drawn into those Liquids, and those little Spaces.

COROL. 2.

And the Air so attracted into the Interstices, between the Elements of Liquids void of Air, is in that very action dissolved into its least parts; inasmuch as it is distributed through the large body of the whole Liquid.

COROL. 3.

But the quantity of Air, which after this manner is imbibed by Liquids, and distributed through their whole large Masses, is very little in quantity, and takes up but a very little room in those Liquids.

COROL. 4.

And when those Liquids, of whatsoever kind they be, are once saturated with that small portion of Air that they have imbibed, they will then receive no more of that Air afterwards, whatever art, motion, or compressing force is used to effect it; but they reject the Air, which is then super-added, repelling it from them in Bubbles or Froth.

COROL. 5.

But Liquids also, particularly aqueous ones, when they are perfectly saturated with certain Salts, will not dissolve any Air after this manner.

COROL. 6.

One Particle of Air thus dissolved, when it exists separately in the Interstices, which remain between the contiguous Elements of Liquids, does not seem to be Air, as Air is described by its physical marks. For one such intercepted particle, so long as it remains alone, within the Elements of Water which surround it, and by this means cannot touch such another like Particle, does not appear to be elastic; for this is not evinced by any Experiment. Nor, besides, is such a single Particle so easily dilatable by Heat, inasmuch as it requires a pretty considerable one before it begins to make its way out of its Liquid. Nay farther, though the Mercury in the Barometer descends 25 inches, such a Particle does not extricate itself out of the Water. As therefore one Magnet, by itself, in respect of another Magnet at a distance, would not effect any magnetical Operations, and could hardly in this circumstance be said to be a Magnet;

Magnet; so in the same manner may we conceive of the Particles of Air: But as this Magnet, when it is brought so near the other, as to be within the sphere of its activity, immediately discovers its vertues; just so again it happens with the ultimate Particles of elastic Air.

COROL. 7.

But when two such ultimate Elements of Air are by any cause whatsoever forced out of their little watery Receptacles, and so united as perfectly to touch one another, they then seem immediately to exert a reciprocal repulsive force, and thus at last to form a Bubble of the very smallest size.

COROL. 8.

This little Bubble then, which is the least possible one, as it consists only of two Particles, acquires again all the qualities of elastic Air abovementioned. And this which is generated at the very bottom of the Liquid, as it tends upwards, passes through the Interstices left between its Elements, where meeting with other single Particles of Air, it unites with them, and by this means forms a larger Bubble; and this likewise still tending upwards, and joining itself in like manner to other Particles all the way from the bottom to the top, is always the less pressed, the nearer it approaches to the Surface of the Liquid.

COROL. 9.

From what has been advanced, it seems likewise to follow, that Salts are less attractive of this elastic Air, than Liquids are, especially aqueous ones.

COROL. 10.

In every Liquid hitherto known, there seems to be contained one certain determined portion of Air; always, indeed, a very small one, but very different in different Liquids.

COROL. 11.

Hence it may be questioned, whether that Air, which in the juices of Vegetables produces the mighty effect of fermentation, is, in reality, that Air which exists in single Particles in their smallest Pores? Or rather, whether that united and truly elastic Air, is not contained in the Air-pipes discovered by *Malpighi*, and called their Wind-pipes? Or lastly, whether it is not the external Air, which commonly intermixes itself with these fermentable vegetables, during the stirring and working them about?

COROL. 12.

The elastic Air, which is divided into its minutest parts, and is thus contained in the Fluids of Animals, does not seem to be the cause of the putrefaction which they are spontaneously disposed to; because, without the admission of the external Air, they are hardly brought to putrefaction; but when this is let in upon them, they putrefy immediately.

EXPERIMENT X.

The quantity of Air in Water, is greater than the Water itself.
Pl. VIII.
Fig. 4.

This elementary elastic Air, which is thus divided into its smallest parts, and dissolved and dispersed through Water, seems there to take up but a very little room, which does not fall under the observation of our Senses: And yet, when it is drawn out of the Water, and collected into one space, it then takes up a larger compass, than all the Water does out of which it was exhausted. The truth of this paradox is exhibited to the Eye by the following very elegant Experiment. Take a parallelopipedal Vessel AB made of Copper. At the bottom let there be made a very little impresson or cavity C, big enough only to hold a drop or two of Water; let there be provided likewise a very small conoidal glass Vessel D, open at the base, like a common Thimble; by which name I shall here call it. Let then the Vessel AB be filled so high with very pure expressed Oil, that the Thimble D standing at the bottom of the Vessel AB, may be quite covered. This done, let the Thimble be laid upon its side as in F, so that there may be no Air at all in it, but that by this position, it may be quite full of Oil. These things being thus disposed, let the Vessel with the Oil and Thimble be set on the Fire, that the Oil in the Vessel, and consequently in the Thimble, may boil; and let the boiling be continued, till the crackling noise of the Oil is quite over. By this means, then, the Air, and Water, which happened to be in the Oil, or about the sides of the Vessel, or the Thimble, will be intirely expelled, and the Oil will be totally freed both from Water and Air. This done, take the Vessel off of the Fire, and let every thing in this situation stand to cool; and then, let a drop of Water, by means of a little glass Pipe, be convey'd through the Oil into the little cavity C, which by means of its own weight, will be kept there under the Oil. Then let the little glass Vessel D, keeping it always under the Oil, lest any Air should get into it, be placed with due caution erect over the little cavity C, so that the middle of its open Base may be very exactly over the drop. By this means then, as very evidently appears, the Thimble will be quite full of Oil, all Air and Water being excluded. This duly performed, let the Vessel AB, with its *apparatus*, be so placed upon a stand, that the Flame of a Candle may be commodiously applied to the little convexity, at the bottom of the Vessel, in the hollow of which is lodg'd the drop of Water. Let then the Flame be applied to that part, but in such a manner, that the drop of Water may not be made hot at once, but very gradually. The drop then heated in this manner, and at length boiling, will produce a wonderful crackling noise, and being under the Thimble, or little glass Vessel, and kept down by the Oil, will discharge itself of its Air into the upper part of the Thimble, where it will take up a very large space while the Heat is continued, and will proportionably drive out the Oil; and the motion of this little crackling drop, will often be so great, as to lift up the whole Thimble. When at length, by this method, all the Air is expelled out of this little drop of Water, let the whole stand and cool. The Air then in the little glass Vessel growing cool, will be pressed into a Bubble, collected at the top of it, and appear of a greater bulk than the drop of Water out of which it was thus drawn. When you are perfectly satisfy'd of this, let the whole *apparatus* be put under a glass Bell on the Air-pump, and let the Air be exhausted; and you will

will then see how that Bubble of Air in the upper part of the Glass will expand itself, and drive out the Oil, and thus evidently demonstrate a true aerial elasticity upon the removal of the compressing Atmosphere, as it did before upon the augmentation of the Heat: But as soon as ever you let in the Air again, the Bubble will be reduced to its former size; so that you cannot doubt, but that the Air, which is generated by this Experiment, is true elastic Air.

From this Experiment, therefore, we learn with the greatest certainty, that Air, whilst it is dissolved in Water, is by no means such a Liquid, now its Elements are thus divided, as the same Air constitutes, when it is drawn out of the Water, collected, and has its elastic Particles united into one Bubble.

And it is farther certain, that the Air which lies concealed in Liquids, has not, there, those physical vertues, which it possesses, when it is united out of them: So that it will never perform the same Operations in both these circumstances. Those Gentlemen, therefore, appear not to reason so justly, who, after they knew that Air might be procured from Liquids, have concluded, that the Air, whilst it remained in those Liquids, had there all the active force, which it discovered when it was drawn out of them. But in this affair indeed, almost all Authors, even Men of great penetration, have been deceived. Of this let the great *Borelli* be an instance, in his very excellent Treatise of Animal Motion, where he talks of a vital oscillation of elastic Air in the Blood. Warn'd therefore by these Examples, let us learn to reason cautiously, and prudently, lest at any time we should be refuted by our own Experiments. But here again, we discover another wonderful Paradox, and that is, that the elastic Particles of the Air, while they exist separately, and apart from one another, take up a less space, than the whole of them possess, when they are collected into one Body.

The power therefore which the Air has of expanding itself into larger spaces, arises from the approach of its Particles nearer to one another. Do they then, when they are very nearly united, repel and fly back from one another? This was the opinion of the incomparable *Newton*, and the continual advances that are made in experimental Philosophy, make it every day more and more probable.

Now, from our Doctrine of the nature of the elasticity of the Air, we learn, that Air, when it exists in single distinct Elements, can make its way through very small passages: For Water, which always of itself contains a certain portion of divided Air, will pass, together with its own Air, through every thing, through which it can itself naturally make its way. This appears evident from the Experiments upon Animals, Vegetables, and even upon Fossils; since in the Water drawn out of all these, there is always elemental elastic Air. For this reason, therefore, such Air cannot be excluded those places, into which the Liquids which conceal it can enter: And hence elastic Air, in this sense, disperses itself through Bodies very extensively.

But now, when these aerial Elements are united, and constitute a part of the common Air, they will not then make their way through those *Meatus's* into which they could easily insinuate themselves, when they were intermixed with Liquids. Nor will the smallest bubble of Air be able to pass through those places through which a Liquid with its Air would be admitted. And farther,

Air, whilst
in Water, is
not Air.

Nor does it
act like Air.

The elasticity
of the
Air,
owing to the
union of its
Elements.

The elastic
parts are very
penetrating.

Air itself is
not very penetrating.

these Elements of Air can hardly by any means be made to pass through Liquids, which are already saturated with Air, tho' at the same time they will spontaneously, and very quickly insinuate themselves into those that are void of it.

For these reasons, then, at length, we may perhaps fairly conclude, that it is nearly true in general, that Air, whilst it is distributed through, and intermix'd with Liquids, does not act in those Liquids, with any power which is ordinarily ascribed to the common Air. For it appears from Hydrostaticks, that when a very deep Vessel is filled with any Liquid, the pressures of the Liquid at different depths, are as those depths, or the distances from the upper Surface. At the bottom, therefore, in this case, the pressure will be greatest of all; at the top very inconsiderable: And yet the Air in that Liquid, so long as it remains divided into its Elements, gives no manner of indication of this diversity of pressure; since it neither appears below in a greater quantity, nor above in a less; nor does it spontaneously pass out at top; nor in *vacuo* do the Bubbles appear to be generated in the upper part. But as soon as the Air, by the means abovementioned, begins to be separated from the Liquid in which it is contained, it immediately puts on the nature of true Air, and acquires all its properties. In the Chyle, therefore, the Milk, Blood, *Serum*, *Saliva*, Bile, Pancreatic Juice, and Urine of Animals, there is naturally Air; but Air that is dissolved after this manner into its distinct Elements, and therefore in that state, does not act as Air. And as it has already appeared from some former Experiments, that this Air, whilst it is divided into its Elements in the Pores of Liquids, is not able to disengage itself thence by the assistance of any alteration of the Atmosphere, which naturally happens, even tho' the Liquids are heated to 92 degrees, which is the greatest Heat of a healthy Person: Hence it follows, that the Air which is distributed through the Humours of a living human Body, cannot naturally extricate itself from them in such a manner, as to collect itself within our Vessels in form of aerial Bubbles, and thus produce there the effects of true Air. And it at any time this should be the case, as the famous *Ruyseb* makes mention, who found the Heart in a dead Body distended with an aerial *Flatus*, and as *Hippocrates* intimates, in his Treatise *De Flatibus*, where he supposes such flatulencies to happen in the Blood-Vessels, it presently becomes fatal; as has long ago appeared to be true by some anatomical accounts of Injections. See *Harderi Apiarium*, p. 114. and many other Authors, who have made the same Experiments, and always with the same success. From these Observations, therefore, which are undeniably true, we may see what we ought to think of that Doctrine which has been laid down by very famous Men, concerning the mixture of the Air with the Blood and other Fluids, and the continual return of it from them again.

Air produced
from Crabs-
eyes and Vi-
negar.

It now remains in the last place, that by a few other Experiments which I shall make before you, we examine into some other Methods, by which elastic Air may be produced from Bodies, in which it before lay concealed. For this purpose, I have so prepared my Air-pump, as to be able at pleasure, to mix Bodies together in *vacuo*, which by proper contrivances, you will see, I shall be able to do very conveniently. You see here then, the whole Machine duly fitted up. Under this glass Bell, there is as perfect a *Boylean Vacuum*, as by pumping I was able to procure. In the barometrical Tube affix'd to the Pump,

Pump, to serve as an *Index* to the *Vacuum* produced, the Mercury stands at the height of twenty-eight inches and a half. In the little glass Vessel under the Bell, there is a drachm and a half of whole Crabs-eyes. On these now I pour in *vacuo* an ounce and a half of distill'd Vinegar, which being warm, the greatest part of its Air is thereby drawn out, as the Air is out of the whole Bell: And you see now, as soon as I have poured in the Vinegar, there arises an incredible ebullition in the glass Vessel; and immediately the Mercury in the barometrical Index descends, and that at such a rate, that in the space of half an hour, it sinks twelve inches. This Receiver, out of which the Air is drawn, and under which this Experiment is performed, will hold seven pounds and two ounces of Water; and the Thermometer at this time stands at the degree 52. Hence, therefore, it follows, that there is here produced a quantity of Air which fills a space capable of holding 114 ounces of Water, which Air is in density to the common Air, as 12 to 28 $\frac{1}{2}$, or as 24 to 57; and consequently, if the Air here generated was reduced into a space capable of containing but 48 ounces of Water, which is 81 cubic inches, supposing a cubic foot of Water to weigh 64 pounds, then this Air thus contracted, would be in *equilibrio* with the whole Atmosphere. And by the way, in this Experiment you have observed in the first place, that this ebullition is much brisker in *vacuo*, than under the weight of the whole open Air; and that therefore, the pressure of the Vinegar upon the Crabs-eyes is not requisite to this agitation: In the second place, that so much elastic Air is produced from these Bodies thus mix'd together, as fills up the space of 81 cubic inches; and such Air too, as by its elastic power is able to resist the pressure of the whole Atmosphere: In the third place, that this surprizing quantity of Air can lie concealed in these Bodies, so as not to discover itself in any manner, till this effervescence has disengaged it from its confinement: In the fourth place, that hence it is exceeding probable, that the elastic Air thus produced here, has no weight, as the common Air has which is filled with Vapours. In the fifth place, we hence discover, what would be the consequence, should an Absorbent like Crabs-eyes, an Acid like Spirit of Vinegar, and a *Vacuum* ever happen to meet together in the Vessels of a human Body: For which reason alone, we begin to suspect, that Effervescencies of this kind cannot be brought about in our Vessels, since they would hereby produce such a quantity of Air; whereas a little Air in the Veins becomes fatal. And in the last place, it hence appears, that a *Vacuum* within us would be of vastly dangerous consequence.

After I had made this Experiment, I took a drachm of Chalk, and poured upon it in this *vacuo* two ounces of distilled Vinegar; upon which there arose a more violent Effervescence, nay an exceeding violent one, much stronger than in the open Air. The whole *Apparatus* being the same, the Mercury in the Index fell from 28 $\frac{1}{2}$, to 6 inches: So that the generated Air reduced to the density of the external, would fill up a space capable of containing 90 ounces of Water; and consequently, the space of 151 cubic inches.

But again observe, if you please, this Experiment, while I pour, in *vacuo*, Oil of Tartar *per deliquium* upon distilled Vinegar; what a sudden and violent ebullition is hence produced! and yet when we mix these two Liquids in the common Air, there is at first hardly any agitation discernible by our senses; as you yourselves have so often seen, whilst I have prepared before you the purging

From Vinegar and Chalk.

From Oil of Tartar per deliquium, and Vinegar.

purging Salt of *Sennertus*. This, therefore, you will again take notice of, with regard to the difference of an Effervescence produced *in vacuo*, or in the common Air. But what a large quantity of Air is here suddenly generated? and yet you remember, that upon examination of Oil of Tartar *per deliquium*, it did not discover any: And you know likewise, from the Observations of Mr. *Homberg*, that Vinegar is saturated with a very small quantity of the Alkali of Tartar; namely, with one 14th part. *Hist. de l' Acad. Roy. des Scien. T. I. p. 52.* Notwithstanding which, however, they are capable of producing so much Air. What mischief therefore would follow in a human Body, if such a *Vacuum* should ever happen there, with the like Effervescencies in it! But *in pleno*, as is evident, these Effervescencies would be far less dangerous. How plainly, likewise, do we discover, that the pressure of the Atmosphere, in order to apply and force these Bodies to one another, is not at all requisite to the producing these Effervescencies; since we see by Experiment, that on the contrary, they are more impeded and restrained by it. They rather arise, therefore, from some peculiar innate power in these effervescent Bodies, which is the cause of all this their motion even *in vacuo*. And here, farther, we observe, that by means of such Effervescencies, the Air which was in the Bodies before the Effervescence, is disengaged, and separated from them.

From Oil of
Tartar and
Oil of Vi-
triol.

The Experiment which I am now going to make, is a very dangerous one, and therefore requires the most cautious management. We will try what will be the consequence of mixing the best Oil of Vitriol, with the strongest Oil of Tartar *per deliquium in vacuo*: And since we learn from the Observations of Mr. *Homberg*, in the place last cited, that eight parts of the best dry Salt of Tartar will be saturated with 5 parts of Oil of Vitriol, I shall here make use of that proportion. We know very well now, that in the open Air, an incredible ebullition arises from the mixture of these Bodies; and therefore, in the first place, I shall endeavour, as much as possible, to draw out all the Air that is contained in these Liquids, that the aerial expansion may afterwards be so much the more moderate. And for the same reason, likewise, I have chosen for this Experiment, a Vessel twenty times bigger than would be necessary to contain these Liquors not expanded; for there is danger, lest by the ebullition that arises *in vacuo*, it should be burst asunder. And this Vessel likewise, in which this Effervescence is to be excited, should be set on a large flat glazed Plate, lest the acrid Liquor, which would corrode the Brass, should run over and damage the Pump. With these cautions, then, I thus perform the Experiment. You see here under the Bell, upon the Air-pump, these two glass Vessels, in one of which is the Oil of Vitriol, in the other the Oil of Tartar *per deliquium*. In the first place, then, I draw out all the Air that can be exhausted by the Pump. Whilst this is doing, you plainly see, that no Air at all is come out of the Oil of Tartar, nor so much as one little Bubble is produced in it. But on the other hand, having now exhausted a great deal of Air, you perceive that abundance of Air arises from the Oil of Vitriol, and continues to pass out of it for a considerable time; for great numbers of large Bubbles are here generated, which as you hear, make a considerable noise. I leave now this Oil of Tartar, and Vitriol *in vacuo*, for the whole space of fifteen hours, that I may, as much as possible, extract all their Air from them. After then they have stood thus long, I mix this Oil of Tartar and Vitriol together,

gether, both, as any one would imagine, void of Air; and what is the consequence? Why there arises, in an instant, the most violent Effervescence; such a one as every way disperses the conflicting Particles through the whole Bell, and throws them upwards with an incredible force. But to what a prodigious degree at the same time does the rarefaction of these Liquors thus mix'd together extend itself. Certainly, they are expanded to far more than twelve times their former bulk, so that if we had not been cautious in chusing a large Vessel, they would have run over the Brim of it. Here now we made use only of * four drachms of Oil of Tartar, and a drachm and a half of Oil of Vitriol; out of these too, all the Air was exhausted; no Air appeared at all, except only in the Oil of Vitriol; and yet the Air produced by this Effervescence, has depressed the Mercury from 29 inches to 12 $\frac{1}{2}$. Hence, therefore, it appears very clearly, that all the elastic Air, which is contained in Fluids, cannot be drawn out of them by means of the Air-pump, but only so much of it as can extricate itself when it is quite freed from the pressure of the Atmosphere; whilst in the mean time another part of it, and that much the greatest, is so closely united with them, that it cannot be separated in this manner, but may be procured from them by means of this Effervescence. The action of the pneumatic Machine in this affair, therefore, is very much limited; and hence any body would be deceived, who should imagine, that Fluids would be exhausted of all their Air, by letting them stand 24 hours in *vacuo*. If again, we carefully consider all these things together, that have been here proposed, we may almost venture to conclude, that the Effervescencies, which happen in this manner, between Acids and Alkali's, arise principally from the prodigious reciprocal attraction which there is between these Salts, by which, when they are placed at a certain distance from one another, they rush together with a mighty force, and by this means expel those Corpuscles which lie in the middle between them, and hinder their coming into an intimate union with one another. Supposing this then to be the case, then by the violent excussion of these aerial Particles effected in the very act of adunation, the elastic Particles of Air, here disposed, would be expell'd, which uniting with other like Particles, might produce the ebullition, agitation, and hissing noise, arising here from the continual displosions of these little crackling Bubbles. And then all the violent motion that is produced during the Effervescence, would not be owing to the mutual repulsion of these Salts, but rather to their reciprocal efforts towards a union. And for this reason it seems to happen, that all this agitation is intirely at an end, as soon as ever this adunation is perfectly compleated; whereas, so long as there remain any Salts not united, so long there likewise remains an Effervescence. In this Experiment we see likewise, that the Water is forced out of the interstices, which were between the Acid, and the alkaline Salts; for the Oil of Tartar, and the Oil of Vitriol, were both of them liquid before their mixture; but after they had been mixed together, and had undergone a violent ebullition, there was produced, by this union of their Particles, a white solid Salt in the middle of the Water that was forced out, and an aqueous Fluid impregnated with a little dissolved Salt, swam at the top. It must, however, be confessed, that the Salts so generated by the union of the Acid and Alkali, in

* This is only in the proportion of 8 to 3, not 8 to 5, as is mentioned in the beginning of the Experiment: These, however, our Author thinks, are the quantities he made use of.

this Effervescence, still contain Air, which is wonderfully elastic, and discovers itself plainly enough in other Experiments. For Sea-Salt, Nitre, and vitriolated Tartar, thus regenerated from their proper acids in the Alkali of Tartar, if they are mixed with Bole again, and distilled in an open Fire into their proper acid Liquids, produce a large quantity of a very elastic *Flatus*, which sometimes bursts asunder very large and strong Vessels. And hence, to persons who have frequently reflected upon these things, the nature of that violent and irrestrainable *Halitus*, or Vapour, which *Helmont* the Elder called, the *Gas Sylvestre*, has always appeared very wonderful; and it has sometimes been doubted, whether all that might be thus generated, would be so far of the same nature, as that it ought to be called by the same name of elastic Air? Or on the other hand, whether Bodies being resolved after a certain manner into their minute parts, might not have their nature altered, and, by a real transmutation, be changed into this elastic Air, which afterwards, being again concreted with other things, might produce new solid Bodies? And consequently, whether, besides the common elastic Air, there was not in nature something else very much resembling it, and yet not perfectly the same.

From Spirit
of Nitre and
Iron.

But to return to our Experiments. Please to observe, then, I put under the Bell, with the same caution as before, a Glass, with very strong Spirit of Nitre, and then exhaust the Air as carefully as possible, and you see now, which is surprizing, that this Spirit of Nitre, though all the Air is exhausted, scarcely causes any ebullition *in vacuo*, neither did it whilst the Air was drawing out; whereas, in the former Experiment, Oil of Vitriol, which is more acid than Spirit of Nitre, yielded, from the same cause, a large quantity of Air. There seems, therefore, something extraordinary to obtain in this case, which appears to be still so much more wonderful, as Spirit of Nitre, as soon as ever the Vessel is open, and the Air comes at it, emits very volatile Fumes, and those pretty active ones too; whereas pure Oil of Vitriol, in the open Air remains without any such alteration. Let the cause, however, of this *Phænomenon* be what it will, let us see now what will be the consequence of throwing into this Spirit of Nitre, thus *in vacuo*, a grain or two of the Filings of Iron. You see, then, what an enormous ebullition is hence produced, and what a quantity of very red, dense Fumes diffuse themselves through the whole Receiver. And at the same time observe, what an incredible swelling and puffing up there is of so small a matter, now it is thus rarefied, together with an explosive Fulmination, so strong, as to make one afraid, that the Vessels would burst asunder. But what is most of all remarkable in this Experiment is this, that there is indeed an elastic Air immediately generated, but yet not with that power of depressing the Mercury, nor consequently in such plenty, as seems to answer to so great an ebullition, so violent a fulmination, and to such dense, red, and agitated Fumes. But you observe, now, every thing grows quiet the very instant I let in the Air, and the mass is no longer inflated, but reduced almost to nothing. Thus then, Gentlemen, you have seen two Experiments, by which it has appeared, that the greatest and most violent explosions of Bodies may happen, without a proportional concurrence or production of elastic Air; namely, the Experiment where the Water boiled in the inverted Vial, and this, where Spirit of Nitre fulminates with Iron: A circumstance certainly worth the maturest consideration.

But

But give me leave to mention yet one more Experiment, which was formerly made, nor is to be attempted again without a great deal of caution. You have an account of it in the *Philosoph. Transact.* No. 213. p. 212. and it was thus performed: Upon the Air-pump was placed a glass Bell, 6 inches wide and 8 inches high. Under this was set half a drachm of Spirit of Nitre, in a little Vessel, and a drachm of distill'd Oil of Caraway-seeds in another, and then as much Air as possible was exhausted. These Liquors were then mixed together in *vacuo*; and in an instant the whole Bell was thrown up into the Air, and the mixture was set on fire. From a drachm and a half, therefore, of Liquids, an Air was here produced, which forced up 468 pound weight, with a very great force. Nor did it by this means appear accurately, how much more weight it might have raised; since it toss'd up the whole Bell with so violent a motion. And yet all the Air which was both in the Spirit of Nitre, and the Oil of Carraway-seeds, was drawn out by means of the Air-pump. But this power, or if you will, elastic Air, was produced in an instant, without any succession of time: And since the whole Receiver that very moment was filled with Flame; hence the Air, by virtue of this Fire, being so much the more expanded, acquired so much the greater force, and thus acted both by its spring, and the rarefaction from the Heat, together. This force therefore could hardly by any method be brought to a calculation, unless, perhaps, by gradually increasing the size of the Receiver, till the column of the Atmosphere pressing upon its surface, should at last be greater than the force of the explosion should be able to elevate; for then in the last elevation, you would have the weight, which the effervescent matter would but just be able to raise, or be pretty nearly equal to. And to prevent the Bell's being broke by its rising and falling down again, there may be fasten'd a cord to the top of it, which running over a Pulley, may be kept nearly upon the stretch, by means of a small weight hanging at the other end.

From Spirit
of Nitre and
Oil of Car-
raways.

I should now inquire into the last method by which Art and Nature produce an incredible quantity of very elastic Air, called by *Van Helmont* the *Gas Sylvestre*; namely, by combustion, or an agitation caused solely by Fire. This usually obtains in fermentation, putrefaction, distillation, and combustion. But this is a very fruitful subject, and of a vast extent. The wonderful expansive force of a fermenting Vegetable appears to every one's observation, in Malt Liquor put up into Bottles before it has done working. That putrefying Substances generate a great deal of such Air, the illustrious *Boyle* has expressly demonstrated. *Van Helmont* too, before this, had informed the World, that in the distillation of crude Tartar in Vessels accurately luted, the Vessels, tho' very strong and capacious, were burst to pieces. And in the distillation of Flesh, Bones, or the Humours of Animals, managed with the utmost caution, unless there be some crack open, or the Receiver is very large, do not the Vessels burst asunder? Not to mention the distillation of Nitre, Salt, Vitriol and Alum, in which are produced an incredible quantity of elastic Vapours, which by their violence often cause the loss of the Vessels, contents, and labour, and frequently prove very dangerous to the Operator. In these different ways then, which, however, all agree in this, that they act by the assistance of Fire, it evidently appears, that this elastic Air concurs, as a pretty considerable and remarkable constituent part in the composition of almost all kinds of Bodies. Or if

Elastic Air
produced
from Bodies
by Fire.

any one yet doubts of it, this certainly he must readily acknowledge, that by the action of Fire there is somewhat separated from every known Body, which after such separation, is fluid, elastic, compressible by Weight, and contractible by Cold, and again expanding itself by Heat, and when it is freed from the cause that compresses it. But as for that part of the Air, now, which when separated from all the rest that are mixed with it, we call the elastic part of the Air, we know nothing of it besides the properties just enumerated. By Fire, therefore, at least, elastic Air is always separated from those Bodies; and consequently, such a matter was in them before, though whilst it was lock'd up there, it did not produce the effects of Air; but as soon as ever any of its Particles are separated from them, and united with others, then it immediately returns to its former genius of elastic Air, and remains such, till it is some how or other again divided into its distinct Elements, and united with other non-aerial Particles, with which it may for a time be concealed, grow together, and form one mass: Tho' even in this state, it still so far retains its pristine nature, that it will again become perfect Air as soon as ever it is disengaged from this entanglement, and the aerial Elements come into union with one another. In all these cases, therefore, Air is immutable; becoming, after its separation from Bodies, what it was before it was united to them; and being able, when 'tis freed by resolution, to return again, by concretion, into the same Body, from which it was separated. This resolution and composition appears by no Art more clearly, than the chemical one. I should now therefore give you some instances of both kinds, as I have formerly in this Laboratory made a great many Experiments to this purpose: But having seen, and to my advantage perused, a very elaborate treatise, published about two years ago by the famous Dr. *Steph. Hales*, called *Vegetable Statics*, in the sixth chapter of which he has, with very great labour and accuracy, given an elegant account of his Experiments, which illustrate this Affair, and in short quite compleat it, I chuse rather to refer you to that work, which will give you a plain View of Nature, as discovered by Art.

Permit me now, then, Gentlemen, to put an end to this Discourse upon Air; in which I have principally endeavoured to shew, how necessary the knowledge of Natural-Philosophy is to a person who would make himself master of the chemical Art; and consequently, how necessary it is likewise to be acquainted with all the Arts by which Natural-Philosophy is promoted. Without these helps the Chemist is continually falling into errors himself, as well as deceiving others, whilst he mistakes the true causes of things, and assigns false ones in their room; whereas if he is sufficiently furnished with these, he has paved a way by which he may readily arrive at the true knowledge of Nature.

Corollaries
concerning
the Air, for
the use of
Chemists.

I shall only add, therefore, the few following Corollaries, and so conclude. In every chemical operation we are engaged in, the Bodies to be examined under their various changes, are exposed to this Air, of which we have been treating. All those Bodies therefore, and all those Operations, whilst they are directed by the Chemist, according to the rules of his Art, must at the same time undergo whatever the Air, by being applied to them, is capable of effecting upon them. When the Chemist therefore goes about to compute the effects of his Art, he must always likewise have a very particular regard to the action of the Air, and what share that has had in the Operation; which how-

ever is but very seldom, and very slightly attended to. I have subjoined therefore to every property of the Air, which we have been considering, the peculiar effects which properly depend upon it. I shall now, with your leave, repeat, in a very few words, those things which the Air performs by the concurrence of all its powers together. In the first place, then, it encompasses, is in contact with, confines, and compresses all Bodies, insinuates itself into their penetrable passages, and being received into them, it there exerts all its power, as well upon solid Bodies, as fluid ones. In the second place, being by its gravity determined upon those Bodies, and being at the same time divisible by its fluidity, whilst it thus insinuates itself by its minutest Elements, it meets with Bodies there, to a union with which it has a natural tendency, and hence unites its Elements with them, loses its Fluidity and its fluid Elasticity, and remains there closely confined, till by Effervescence, Fermentation, Putrefaction, or Fire, it is again set at liberty. In the mean time, however, by virtue of the other Particles which it contains in it, it brings about an infinite number of effects. In the third place, it performs particularly the office of intermixing Bodies very intimately with one another, whilst by such weight, and such perpetual velocity of motion, like the mechanical Pestil, it puts them in motion, and rubs, and mingles them together, producing after this manner very singular effects, not easily accomplished by any other means: This the ancient Alchemists, *Van Helmont*, in particular, was well apprized of, and made use of it to very valuable purposes; as you will see, if you consult him p. 151. § 45. 334. §. 84. and in a great many other places. And indeed if we expect to meet with the same success in a place void of Air, or where the Air, by reason of the height of the place from the Earth, is pretty light, or rare, our labour will be all in vain. How evidently does this appear in the combination of distilled Oil of Turpentine with Salt of Tartar? How easily is this performed in an open, heavy Air, whilst in very high places it is not to be effected? And in the defæcation of Salt of Tartar by the Air, the same thing appears as clearly. Of consequence, therefore, in the fourth place, it determines and applies the action of one Body to another. For all things which are heavier than the Air, are compressed by the Air, which rests upon them, and, as we observed in the last article, are moved by its motion, and intimately mixed together. Hence, therefore, if among these Bodies there are any which acquire some particular virtues by coming into contact with one another, then these virtues will by this means be excited by the Air, and discover themselves by their effects. And hence it comes to pass, that there are many dissolvents, which in the *vacuum* of Mr. Boyle hardly discover any corroding quality; though if the Air is let in upon them, it becomes manifest immediately. This Mr. Boyle himself remarks in the Filings of Copper mixed with the alkaline Spirit of *Sal-Ammoniac*, and in Vinegar applied to Copper and Iron, *in vacuo*. But it appears likewise, in almost every instance, that, by the pressure of Bodies upon one another, mechanical powers are brought into action; and that they cease again, as soon as ever this pressure is removed. A Diamond will not cut Glass, unless it be pressed against, and moved upon it. Attrition begets no Heat, if Bodies are not forcibly compressed together. This appears no where more evident, than in *Papin's* Digester. Here the Bones of an old Ox, for instance, with some Water and Air, are so closely included in a Copper Cylinder, that no Air or Water can

by any means possible make its way out. Fire is then applied till the Water boils. The Air therefore acquires a power of expanding itself proportional to the applied Heat; and so likewise does the Water. Hence the pressure of the Air and Water upon the Bones, must be exceeding great. In the mean time too, the Air and Water, within this Vessel, are moved against one another, and upon the Bones with an incredible velocity; and by this means, within a few minutes, the Bones are softened, and converted into a viscid Liquid, or into a soft, tender Mass, very readily yielding to the knife. In the *Fabrenheitian* Experiments, formerly mentioned, it appeared, that when the Atmosphere was made but one tenth part heavier, the Water immediately took in more Fire before it would boil. What, now, could be the cause of this, but the Atmosphere's pressing the parts of the Water more closely together? In the fifth place, the Air, considered all together, is the occasion that hardly any Body continues at rest; because this, by the smallest alteration of Heat, is immediately expanded or contracted, and, consequently, suffers a reciprocal oscillation: But these changes of Heat and Cold are perpetually happening; and hence there must of consequence be a perpetual agitation in the Air. This appears likewise evident, from the continual variation of its weight; for Barometers set in a very oblique position, and thus, upon the least difference in the weight of the Air running through a large Space, have been observed to be almost always in motion. But since two inches of Mercury are equal to 23,800 inches of common Air; hence, upon the smallest variation in the Barometer, the Air immediately runs through * 23,800 times the same space. As therefore the Mercury in this respect never rests at the same Altitude, we discover how much less the Atmosphere remains of the same weight. And since this Air insinuates itself between Bodies, and into their Pores, it seems certainly, with regard to these, to have the nature and power of a perpetual mover. Hence, perhaps, it comes to pass, that all the principal Operations of Nature are brought about in the common Air, but will not proceed, in an exhausted Receiver. Fermentable pasts, duly prepared, and disposed in the *vacuum* of Mr. Boyle, will not ferment there though they are acted upon by a proper Heat, but discharging their Air, remain unchanged. The parts of Animals, which very readily putrefy, being shut up in the like *vacuum*, and freed from their exhaling Air, do not afterwards putrefy, tho' they are kept warm. The same thing is likewise true in your Summer Fruits, which being set in *vacuo*, puff, emit a *Flatus*, and then remain at rest. So that the parts of Animals, Vegetables and Fossils, being here included without Air, seem to undergo very little alteration. In the sixth place, this Air seems always to contain in it such Particles as are fit, by their application and motion, to perform the office of a *Menstruum* upon all Bodies whatever: For as it contains and carries along with it almost all kinds of Bodies, in a state of solution, it can scarce possibly happen, but that by the successive application of such a variety, certain particles will be sometimes applied, which are proper, as a *Menstruum*, to dissolve every kind of Body. And in this respect it may be said to perform the office of an universal *Menstruum*.

* This in the original is 13,800. which our author says should be 23,800; but it still does not appear to me to be right; for since the specific gravity of Mercury to Air is as 11,900 to 1. supposing Water to Air as 850 to 1, and Mercury to Water as 14 to 1, hence the Air, I think, will run only 11,900 times the same space as the Mercury does. This I could not mention to the learned author, when I wrote to him first, because I did not know how he would alter the original; nor did I take notice of it afterwards, till it was too late to write to him again.

It is very certain, there is neither Metal, nor Semi-Metal, which may not, sooner or later, be dissolved in the Air, and by the Air, and converted into its proper *Calx*. Gold, indeed, Silver and Antimony, are less dissoluble there, and with more difficulty, because they are hardly dissolved, except by Mercury, Spirit of Salt, or Spirit of Nitre; but these rarely float about in the open Air; and hence it comes to pass, that these Fossils are not often dissolved there. If Gold and Silver Vessels, however, are for a considerable time exposed to the Air in a chemical Laboratory, where Spirit of Salt, or Nitre, or *Aqua Regiæ* are preparing, these volatile Acids, very easily, so affect the polish'd Surfaces of the Metals, as to corrode them, and turn them into a *Flos*, or Mould, peculiar to each, and then into a *Calx*. In all other Bodies this dissolution happens much more frequently, as being much easier. But not only these, but an infinite number of other things may be effected, by those Corpuscles, which the Air always, or sometimes, at least, carries along with it. For by this means it discovers Bodies that before lay concealed, and conceals others that before were manifest; it makes acrid the soft, and softens the acrid; it fixes the volatile, and renders volatile the fixed; and it produces colours, and destroys them: But of these things there is no end. In short, therefore, you may learn from hence, that it often happens that the very same object, treated exactly in the same manner, shall have very different effects, if it is managed in a different Air. In every account, therefore, of chemical operations, a particular regard must be had to the Atmosphere, in which they are performed; since otherwise the event may very much deceive the operator, without his being in the least aware of it. In any chemical process it is impossible the issue should be the same in a different Air, where it happens, that the Air has any considerable influence upon it. And finally, how great the effect of the Air is, whilst it has free power of concurring with Fire towards the changing of Bodies, we have already observed in the history of Fire. Camphire melted in a Vessel upon the Fire, and so inclosed, that the Air cannot come at it, ascends, is purged of its impurities, and remains perfect Camphire, purer than it was before: But if while the Fire thus acts upon it, there is a free admission of the Air to it, it is consumed, producing a Flame, which burns even in Water, and sends forth thick, black Vapours, convertible into a very black Soot. Sulphur sublim'd by the Fire, remains always Sulphur, if the free Air cannot enter the Vessels in which the Sublimation is made: But if the Air once comes to it, it is immediately converted into Flame, and an acid Liquor. Thus then we may finish what we had to offer concerning the Air, for the service and advancement of the Chemical Art.

Of WATER.

As of all Bodies that lie continually before us, Water is the commonest, falling perpetually under the observation of our senses, and being made use of for most of the purposes of Life, hence it comes to pass, that every one is ready to imagine, that he perfectly understands its nature. Those persons, however, who have enquired into it, with the greatest care, have scarcely found any thing among natural Bodies which it is more difficult to form a right notion of. And the cause of this difficulty lies chiefly in this, that it is so exceeding hard a matter to separate Water from other Bodies, or other Bodies from Water. For this Element mixes itself with all the Substances that come under

The Nature
of Water
difficult to
be under-
stood.

under the examination of the Chemists, and resides in such a manner in the Air, in which all chemical Operations are performed, that it is scarce possible to secure any thing from it. Hartshorn, after it has been kept for half a Century, and is grown so dry, that a Stone itself is not dryer, and so hard, that it resists a File more than Iron, if it is distilled with a strong Fire in a dry Glass, will yield a Spirit; and if, according to Art, you accurately separate from this, both the Oil, and the Salt, you will procure a good deal of Water. Stones too, and Bricks, if they are reduced to powder, and exposed to the Fire, in the driest Vessels, always afford some Water; nay, to the Water, as a *Gluten* by which they are held together, they even owe their being what they are. What can be more evident than this? If fat Potters Earth is exposed a good while to the scorching Heat of the Sun, it is converted into troublesome volatile Dust, which is easily blown about with the least Wind, and never grows together again, so long as it is kept dry; and yet if you work it with Water, it becomes a ductile Paste, and when it is burnt, becomes a hard, stoney Substance. Of the Air's always containing Water, and applying it to the Bodies that are placed in it, I have treated already. The Air without all dispute is always full of Water in motion, as one may see evidently, indeed, in the following pretty Experiment. If in the summer time, when the Air is exceeding hot and dry, you expose to it a piece of Ice, just taken out of an Ice-house, there will presently appear a Vapour about it; and if you hold your hand very near it, you will then perceive a Steam betwixt that and your hand; thus both instances evidently demonstrating that the Water, which before being equally dispersed through the Air, did not appear, does now, being condensed by the Cold, discover itself in a visible form. If in the summer time you pour Water into a large Glass Vessel, that is perfectly dry on the outside, it will still continue so; but if you take $\frac{1}{3}$ of its weight of *Sal-Ammoniac*, reduced to Powder, and very dry, and mix it with the Water the whole external Surface of the Glass will be immediately covered with a Dew, which will soon run down in drops. This you understand, to be sure, arises from the Water, which before was by the summer Heat diffused through the Air, but is now by the sudden Cold forced to unite, and form a Vapour, Dew, and Water; just in the same manner as ones Breath, which does not appear in the Summer, discovers itself in the Winter in form of a Vapour. By these then, and infinite number of other instances, it is certainly demonstrated, that the Air has always Water in it, and therefore that it is impossible to keep Bodies that are placed in it free from Water. But now, if Water, is separated with so much difficulty from Air; so on the other hand, many other Bodies are not separated with less, from Water, so as to leave one sure that one has pure, simple, elementary Water. Who then will venture to affirm, that he is possessed of pure Water? Or who can pretend to show it perfectly unmixed with any thing else? Every body knows, that there are infinite numbers of Bodies, and that as well compound as simple, which may be dissolved so intimately in Water, that they shall not discover the least sign of their being there. Custom, indeed, which fixes the meaning of Words, calls the Liquor thus adulterated, Water; but certainly, in a philosophical sense, it is very far from being so. But farther, if we examine its peculiar nature yet more nicely, we shall find, that most of its properties, and that its principal ones too, it possesses in common with other Fluids, and hence again
it

it will be so much the more difficult to find out such a character of Water as shall perfectly distinguish it from every other Fluid whatever.

If a Person, however, would in a philosophical manner inquire into the nature of Water, he must have some certain character by which he may define that Water, concerning whose genius he is making his inquiry : For this, for the present, will serve to distinguish it from all other Bodies ; and when afterwards all its properties are discovered, they must then be referred to the thing thus distinguished.

Its Character, however, must be found out.

Following this method, therefore, by Water we mean a Liquor, very fluid, inodorous, insipid, pellucid, and colourless, which in a certain degree of Cold, freezes into a brittle, hard, glassy Ice ; for these marks every body knows point out Water. If, therefore, such a fluid as this could be readily procured perfectly free of every other Body, then the examination of Water Chemically, Hydrostatically, Hydraulically, Mechanically, and Philosophically, would be very easy ; for in this case we should be absolutely sure, that whatever we discovered by these Helps, would belong truly to the nature of Water, as upon supposition there would be no Body in it to which it could be referred ; whereas, if there are other Bodies mixed with it, we shall be always in doubt, to which of those any property we observe belongs, and ought to be attributed.

A definition of Water.

But it is absolutely impossible ever to have Water quite by itself, because, so long as it subsists in the form of Water, it has always Fire in it, which can never leave it, nay, and is always in it in a large quantity ; for as soon as ever the Fire in it is so diminished, that it comes to the degree 32 in *Fahrenheit's* Thermometer, the Water continues Water no longer, but becomes a very different Body from what it was before, that is to say, Ice. But in that degree of Cold, there remain a great many Bodies still fluid, which will congeal in a greater. Nay, if the Heat is decreased 73 degrees below this freezing point, even in that intense Cold, neither Alcohol, nor Mercury, lose their fluidity. From these Observations, therefore, it evidently appears, that a great deal of Fire is necessary to prevent its being converted into Ice. Certainly, between the state of Water just beginning to freeze, and the same made as warm as the Blood of a Man in health, there is a less number of degrees, than between the same state, and the greatest observed Cold ; as in the former case there is only 58, in the latter 73.

Which is never alone, but always contains a good deal of Fire.

But all Water is constantly exposed to the Air, which enters into it in a certain quantity, as has already appeared. And there, likewise, it was observed, that the Air abounds with the Particles of, perhaps, all volatile Bodies. It is impossible, therefore, but that the Air should continually mix both itself, and its contents, with the Water, which by this means will be rendered impure, and be constantly receiving from it different Particles. This, perhaps, appears by no Experiment more evident, than by the examination of Rain Water, which comes from the upper regions, when after a long drought there happens Thunder, with very large Showers ; for if the Rain-water is catch'd at such a time, it is found to abound with great variety of Bodies, as the Chemists have often taken notice.

And is rendered impure by the Air and its contents.

But this Air, when it is once got into Water, cannot easily be disengaged from it again ; for if it is placed under a Receiver upon an Air-pump, you must remove almost the whole weight of the Atmosphere, before the Air will make

And almost inseparably.

make its way out in 32 degrees of Heat. And if in a middle Atmosphere, you would separate from Water the Air that is mixed with it, you must increase your Heat to 150 degrees. Hence, therefore, the greatest Heat that is naturally produced, and the lightest Atmosphere that was ever observed, tho' they conspire together, are not able to fetch Air out of common Water. Fix'd alkaline Salts, indeed, when they saturate Water, seem, perhaps, to dislodge the Air that was in it; but then, at the same time, they fill it with Salt; and if afterwards you attempt to draw the Water from them, by its passing through the Air, it is filled with it again. In the mean time, however, there is a great deal of room to believe, that the reason why Oil of Tartar *per deliquium* don't discover any Air in *vacuo*, is only, because by a very strong attraction peculiar to its nature, it retains it very tenaciously. For in boiling the strongest fix'd alcalious *Lixiviums*, in any open Vessel, I have often observed, that when they became so inspissated as to be just ready to grow dry, then at last, there diluting Water being carried off by the excessive Heat, they began to rise into a very large frothy collection of Bubbles, which unless properly provided against, would run over the sides of the Vessel in such a manner, as perhaps one shan't see in any other Liquors. This remarkable *Phænomenon*, now, seemed to me plainly to evince, that a large quantity of true Air is very strongly attracted by a fix'd, pure, dry Alkali, as soon as ever it comes out of the intense Fire, in which alone it is made, and that it unites it with itself so very powerful, that it will not afterwards suffer it to be separated from it, except, by the action of a very strong Fire, or by its attraction of something else to which it has a greater tendency, as an Acid, upon its Effervescence with which it lets go its Air. Hence again, then, it appears, how seldom there exists any Water, without being impregnated with Air, and its contents. The consideration, therefore, of these things, puts us in mind, before we pretend to reason from Experiments concerning the nature of Water, to treat distinctly of the Methods by which it may be obtained in its greatest purity, that when we have got some of this sort, and have examined it by every kind of Experiment, we may be able to come the nearer to the nature of the purest. To this purpose, therefore, let us carefully take a view of all those properties, which can by any means be observed in Water so long as it continues to be so. And as we proceed to examine all these in order, we must particularly take notice how any discovered property appears in that Water which is most simple and freest from every heterogeneous Body; for this, I conceive, is the only method by which we can come at a true knowledge of it.

The proper weight of Water difficult to find out.

In the first place, then, the particular and proper weight of Water offers itself to our consideration. But to persons acquainted with these things, how difficult does it appear to find this exactly? For there are naturally in Water many things that are lighter than pure Water itself. This appears particularly in Rain-water, and that which in a chemical distillation in close Vessels rises into the Receiver. Whatever there is of fermented Alcohol mixed with either of these, it will most certainly render them lighter than if they were pure. And the Spirits likewise produced from putrify'd Vegetables or Animals, dispersed in the Air, and mixed with these Waters, will have the very same effect. In the mean time, however, there are many more Bodies found dispersed through Water, that are really heavier than simple Water, and which, consequently,

quently, by their admixture, render it much heavier than it is naturally. Hence Fountain, River, and Well-water, have by this means their specific gravity increased; as saline, saponaceous, and vitriolic substances are frequently mixed with them in very large quantities.

Well-water, is properly that which comes from that subterraneous *stratum*, which is called a (*Sabuletum scaturiens*) springing Gravel. For if you dig through the upper crust of the Earth where it is not rocky, at a certain depth you will come to a *stratum* of very pure Gravel; and if you then proceed to dig any deeper, you lose your labour, for after you have removed a quantity of Gravel, there will in a little time as much be brought again from the neighbouring parts; and hence they have called this place a springing Gravel. In this Gravel, now, the Water always rises from the bottom, and runs down from the places about it. Hence this collection of Water is called springing Water, or a Living-spring, and the Water itself (*Aqua Viva*) Living-water. If you take care now that no Water shall come into this Well, but what passes through this Gravel, then in that place the Water will be exceeding pure. For the Sand is nothing but a collection of very small clean Flints, whose figure, and size, are so various, that they can never be so disposed among one another, as not to leave little empty spaces among them: Hence the Water is always able to insinuate itself between them, tho' they intercept almost every thing else; and by this means, when it has been so filtered for a considerable time, it loses its impurities, and becomes very limpid. If there are no Salts therefore about this Gravel, this Well-water will be pure and pellucid. But if on the other hand there are any Salts, saline, or saponaceous Substances near the Spring, then these being intimately united with the Water, cannot be separated from it, by this its passage through the Gravel, but will communicate their weight to it as well as their other properties. And this, in reality, is found to be the case almost all the World over: For the Earth is the grand Chaos from which all things arise, and to which they all return again. Since, therefore, this Water by running through the Earth, becomes a *Lixivium* of all those Bodies which it meets with, and is capable of dissolving, it appears evident, how seldom this can be pure, and that it must be very different according to the place in which it is found. If you take, however, that Water that is drawn from the purest Well, and therefore is the most simple of the sort, and compare it with the purest Gold which is always exactly of the same specific gravity, then its weight to that of Gold, is found to be as 250 to 4909, or as 1 to $19\frac{1}{2}\frac{5}{9}$. This you find in the *Philosophical Transactions* of the *English*, which they have confirmed by repeated Experiments. The same Water is found to be 850 times heavier than the common Air: And an *English* cubic inch, examined with the utmost care by the great Boyle, weighed 252. 256. 260 grains. *Boyl. Med. Hydrostat.* p. 110. *Act. Leips.* 91. 196. That there should here now be this difference of 8 grains, that is near a 32d part of the whole, is not so much to be wondered at, since heat easily renders Water lighter. To fossil chrystal Water was in Weight as 1 to $2\frac{1}{2}$; to Marble as 1 to $2\frac{7}{10}$. In giving an account, however, of the comparative gravities of Bodies, we should take notice of the degree of Heat in which the Experiments were made: For as the expansion of Bodies of the same kind arising from the same Heat, are in a reciprocal proportion to their densities, Fluids, however, being more expanded than Solids; hence

Metals are vastly less expanded by the same Heat than Water. For this reason, therefore, if the weight of Water is compared with that of Gold, or any other Metal in different degrees of Heat, the Observations will never be found to agree : But if two quantities of different Water are examined and compared with Gold in the same degree, then that which is found to be the heaviest, will always have dissolved in it some other Bodies which are heavier than the Water itself. Hence the heavier Waters are, the more they are always to be suspected of having something heterogeneous in them ; and for this reason, the Physicians always condemn such Waters, as most prejudicial to health, on account of the foreign Bodies mixed with them, which are often very pernicious. There have been some Well-waters, however, found to be lighter than in the proportion abovemention'd : And these are always so much the purer, and more wholesome ; except this should happen from any Spirits being mix'd with them. *Hippocrates*, in his Book *De Aere, Aquis & Locis* §. XVI. speaks of Waters that boil easiest and pass quickest. And again, §. XVI. he says, that *Rain-water, which is the lightest, sweetest, and clearest, is best for medicinal purposes.* And *Herodotus* has this passage, L. III. c. 125. *The Ethiopians live to the age of 120 years, and some of them more. Their food is boiled Flesh, and their drink Milk. They have a Water upon which nothing will swim, neither Wood, nor things that are lighter, but in it all Bodies sink to the bottom ; and by means of this, they arrive to such a great age.* But where is there any such Water to be found now-a-days ? Certainly no where : If there was, we might then compare our Water with it. But neither Nature or Art affords us any such thing, no not by the most careful and repeated distillation. When I formerly, therefore, read this Passage of *Herodotus*, which I absolutely believe to be true, I was induced to suppose, that the Wood in that part of *Ethiopia* was exceeding heavy, and at the same time the Water, in comparison of ours, very light. And, indeed, we know, that in *Asia, Africa, and America*, especially in the hottest parts of these Countries, there grow some sorts of Wood, which in hardness are equal to Iron, and in weight almost to Stone, and are hence called (*Sideroxyla*) Iron-Woods. Nay, how solid and heavy is our own Box, if it is but old and sound ? Not to mention that sort of Oak called generally the Iron-Oak, and *Guaiacum*, if it is but good. And if we will but reflect upon that Wood in *America*, of which the Inhabitants make their weapons, we shall have no room at all to doubt, but that there were exceeding heavy Woods in those places which *Herodotus* makes mention of. And, indeed, modern Observations confirm almost every thing, which that great Man has asserted, notwithstanding some persons who have but little learning, and are unacquainted with Natural Philosophy, look upon many of them to be fabulous, and false. The lightest Water, however, that we are now-a-days acquainted with, either natural, or rendered pure by Art, is always heavier than any Wine or Beer, prepared with Water from Vegetables by Fermentation.

Fluidity of
Water.

A second property of Water, which it has in common with other Liquors, is its Fluidity ; which in this is very remarkable. For it is here so great, that the ultimate Particles of Water, by a gentle Heat, or small degree of motion, will recede from one another : So that Experiments made carefully, and on purpose, have determined how much Water in a certain degree of Heat, and a given time, will exhale from a known Surface not agitated by the Wind. In
which

which examination, this is particularly observed, that, *ceteris paribus*, Water exhales so much the more, as it is more pure; and so much the less, as it is the more saturated with Salt. If it is pure, therefore, it has scarcely any tenacity in its parts, which upon being drawn, do not run out in long cohering Spirals, but are divided rather into dewy Particles. And when in distillation in any clean glass Vessels, a warm watery Vapour arises with a gentle Heat, and sticks against the cooler sides of the glass head, it never runs down, and forms tenacious *striae*, like Oils and Spirits, but discovers its dissipated Particles in appearance of a fine Dew. But very salt Water, on account of the Salt and *Bitumen* mix'd with it, does not suffer its Particles to be separated so easily as sweet. Hence Fountains, Brooks, Rivers, Lakes and Ponds, send up more Water, in proportion, than the salt Sea. The exhalation of this, however, which is very considerable, has been calculated by the ingenious Dr. *Halley*: For after, with pure Water, he had mix'd $\frac{1}{40}$ th part of Sea-Salt, and thus brought it to the Saltiness of the Sea, he put it into a cylindrical Vessel $7\frac{8}{10}$ inches wide, and 4 deep, and then exposing it to a degree of Heat equal to that of the hottest Summer, in a still place where there was no Wind, it exhaled 6 ounces in 24 hours; and consequently, in that space of time, it had evaporated to the thickness of $\frac{2}{3}$ ths of an inch; tho' the Water in that degree of Heat is scarce sensibly warm, and by no means emits any visible Vapour. *Phil. Trans.* N. 189. p. 366. If Water, however, is set in a close place, where the Sun never shines, nor any Wind blows through, and is kept there for a whole year, it then exhales only to the depth of 8 inches. *Halley. Ibid.* p. 183. N. 212. But I have experienced myself, as I formerly took notice, that Water being exposed to the Wind, in a cylindrical Vessel, was in a short time, by the motion of it, dissipated into the Air. This I learned, by setting a brass Vessel 8 inches high, in which there was some Water at bottom, in the open Air, and between two Walls when the Wind was very high. The ingenious *Kruquius* has observed, that the Rain, Snow, Hail and Dew, collected in the space of one year, considered as Water, rose to the height of near 30 inches, and that in the same time the same quantity exhaled from Vessels that were placed in a still shady place, but in the open Air: Hence then it appears, that by the Heat of the Sun, and the Winds, Water is perpetually carried off, dispersed, and rendered volatile, and preserved from stagnation and inspissation; and hence we see the vast service, and necessity of Winds. And again, which makes it as much as possible to our present purpose, hence we learn the great mobility of the Elements of the Water among one another, when by so light a cause, it suffers itself to be totally divided and resolv'd in its ultimate Particles.

This very great fluidity of Water, however, depends intirely, and solely upon Fire, which acting upon it in a certain degree, gives it this fluidity. For if the purest Water we are acquainted with, is so exposed to the Air, that it may be perfectly reduced to its temperature, it then loses its fluidity, when *Fahrenheit's* Thermometer is fallen to the degree 32. Three and thirty degrees, therefore, of Heat, or Fire, serve to keep Water in a state of fluidity. And so long as Water has this degree of warmth, so long it retains a motion in itself, nay and exhales too, and consequently keeps fluid by means of this Fire present in it.

Depending
solely on
Fire,

And that a
pretty consi-
derable one.

But the natural cold of a very severe Winter, was observed at *Gedanum* to decrease to the first degree in the same Thermometer, as we formerly mentioned in our History of Fire; and in a natural way, the Heat of the Air seldom increases from that degree to the degree 80; whence it appears, which is pretty surprizing, that Water, tho' exposed to more than $\frac{1}{3}$ of the greatest natural Heat, becomes and continues Ice, whilst in the remaining part only, it becomes and continues Water. This certainly, was it not demonstrated by indisputable arguments, had never been believed. In Nature, therefore, there must be some weighty reason, that makes it necessary, that Water should be Water only in that degree of Heat, and should harden into the form of Ice, as soon as ever that is diminished.

Nor can its
fluidity be
farther in-
creased.

When the fluidity of Water, now, is once produced by this determined degree of Heat, it then continues exactly the same in every farther increase of it. Nor has it been possible, by any means whatever, to render Water still more fluid, tho' you make your Fire ever so strong. Water, therefore, always exists in its most fluid state, or becomes immediately Ice, and consequently, the Fire cannot by any action divide its Elements any farther, but only removes them from one another, which being accomplished, it at once becomes as fluid as its nature permits. This again, which otherwise would have been incredible, the incomparable *Newton* has made appear by a famous Experiment; for *Pendulums* oscillating in the very coldest, and hottest Water, discovered that they met in both cases with equal resistances. *Opt.* p. 312.

This, however, must be understood, to regard those changes of Bodies only, which our senses are capable of perceiving; and here we must consider only the lubricity of the Particles of Water, which we suppose affect one another with so small a cohesion, that it cannot, by Fire, be sensibly lessen'd: For otherwise, we know very well, that from the 33d degree of Heat, to the 212th, Water grows continually lighter and rarer, and consequently less resisting to the motion of the same Body, supposing it to continue of the same specific gravity. This increased rarity of Water we have determined already in our History of Fire. If we suppose then, that boiling Water takes up $\frac{1}{83}$ th more space than it did before, how little difference can that make in the oscillation of a *Pendulum*, with regard to our senses? But then, besides, as the Body of the *Pendulum* too will grow hot in boiling Water, it will hence make this small difference still less sensible. And, indeed, if this was not the case, it is certain, first, that the resistance yielded by Fluids to the Bodies moved through them, depends upon the corporeal Mass of these Fluids, which is best express'd by their densities. Secondly, this resistance arises from the force with which the Particles of the Fluids, when they are at rest cohere with one another: Thus Wax, when it is cold and hard, will not transmit any Body through it, as it will when it is rendered fluid by Heat: Many express'd Oils, likewise, harden in the Cold; and even Water itself, when by its proper degree of Cold, it is frozen, loses for the future its power of letting Bodies pass through it. And thirdly, the quantity of this resistance depends likewise upon the magnitude, or smallness of those Particles, which together make up the Fluids, and into which they are at last resolved.

The Ele-
ments of
Water small.

But if we farther examine the ultimate Elements of Water, we find, that when they are singly and separately considered, they are exceeding small;
and

and that to such a degree, that it has hitherto been impossible to discover their true smallness, so as to compare it with any known measure. For one of these Elements, when it is by itself, cannot, by any helps whatever, be rendered sensible; nor does it discover its size by concretion with other Bodies.

If we compare, however, the ultimate Particles of Water with those of true elastic Air, the former seem to be much more penetrating than the latter, and disposed to insinuate themselves into smaller Pores than these are capable of entering; as we have seen already in our history of Air. Does not Water pass through the invisible Pores and Interstices of Wood, which never transmit the least elastic Air? And in the *Apparatus* for pneumatical Experiments does not the Water soak through the Leather, under the edge of the Receiver; which perfectly intercepts the passage of the Air? It must be confessed, however, that this does not demonstrate the true smallness of the corporeal Mass which every such Particle contains; for here we argue only from its penetrability, which depends more upon the figure of a Particle, than its true quantity of Matter. And if this consideration is not properly attended to, we may fall perpetually into Mistakes, by reasoning from the penetrability of ultimate Elements to their true magnitude. Nor will it in this case be of greater service to us to know the weight of these Particles; for from this, likewise, we cannot pretend to conclude certainly of their size. A grain of Gold, for instance, if it is formed into a perfect Sphere, will produce a Particle that will pass through a small *meatus*; but if you beat it out into a very thin plate, and then roll it up together, with how much difficulty will it pass through a great one? But what particularly gives me reason to doubt whether the ultimate Particles of Air are not in reality less, with respect to their corporeal bulk, than those of Water, is this, that the Elements of Air may be placed in these Interstices that are left betwixt the contiguous Element of Water, without making the Water at the same time condensable; which you remember I demonstrated before in our History of Air.

Tho' we cannot however certainly determine the smallness of the Particles of Water, yet this, in the mean time, we are sure of, that there is no known Fluid, whose parts are more penetrating than those of Water; except Fire, which penetrates every thing; Magnetism, if you suppose that to act like a Fluid upon Magnets and Iron; and Light, if you will have that to be different from Fire, and at the same time to have the nature of a Fluid. Setting these aside, then, I ask the Philosophers, if they can produce any Liquor, which *cæteris paribus* will pass through any passages that are impervious to Water? I am very sensible, indeed, that Oils will sometimes soak through wooden Vessels, in which Water might be contained; but then the Oil dissolves the Oil, and Resin of the Wood, and so they both run out together; whereas the Water, not being able to dissolve the resinous oily Substances, is very well secured, just in the same manner as we see Water won't run through Paper that is well soaked in Oil, though Oil itself drops through it readily. And hence it happens, that Syrup of Sugar, though a pretty thick Liquid, will penetrate through wooden Casks that will hold Water; for Sugar diluted with Water is a *Lixivium*, which by its saponaceous quality dissolves the tenacious Substances of the Wood, which the Water cannot. Hence, too, saline *Lixiviums*, especially from fixed Alkali's, can scarcely be contained in wooden Vessels, which serve very well for pure Water.

Perhaps less
than those of
Air.

Certainly
more pene-
trating than
others.

Water. Water, then, among all simple Liquors, that we are hitherto acquainted with, is the most penetrating, and most fluid.

Tho' there
are many
Bodies thro'
which they
cannot pass.

All Metals, however, though they are beat out into thin Plates, and then formed into Vessels, will hold Water, nor suffer it to pass through their Pores: All Gems exclude it, both the more precious and the less: No known Flints transmit it: Stones that are naturally hard, and hard, heavy, rocky Substances, perfectly resist its passage though them: Sulphurs are not penetrable by it; nor any Glass hitherto known, whether made from Flint, and an Alkali, or from Metals, if it is but well united, and has no Cracks in it: Some dense, hard, heavy, resinous Woods absolutely prevent its penetrating through them; though the lax, soft, light, watery, saline ones, are not capable of containing it, but suffer it to run through them; as do likewise Pumice-Stones, and other porous, spongy Stones: Our earthen Vessels made of Clay, and burnt Bricks, common Mortar made of Sand and Lime, and that made of the *Lapis Tophæus*, which vitrifies by drying, will hold Water likewise. Glass, however, which neither makes any alteration in Water, nor suffers any from it, affords us the best Vessels for keeping it. *Clavius*, the Mathematician, poured some Water into a Bolthead, and then sealed the mouth of its long neck hermetically, and marked with a Diamond the place to which the Water rose at that time; he then hung it up, and 80 years after, it was found in *Kercher's* Study, just as full as it was at first; and perhaps it is so still, tho' it is now, since the Water was first put into it, 120 years.

Tho' agitated
by Heat.

If Water is contained in a Vessel perfectly close, that will not melt when it comes to be hot, and the Water cannot pass through when it is cold purely on account of the smallness of the Pores of the Vessel; then, if it is agitated by Fire, it will still remain incapable of making its way out. This we see evidently in all our distillations made in proper Vessels: This the Experiment of *Christopher Clavius*, just mentioned, plainly evinces: This we see clearly in *Papin's* Digester, and in the *Æolipile*, which being thrown into the Fire when full of Water, confines the Vapour of the Water, though agitated with a violent *impetus*, and only transmits it through the mouth when it's open'd. I know some great Masters in the Art are of another opinion, imagining, that the very ultimate Elements of Water are attenuated by Heat; so that after a great number of distillations, they acquire so great a subtlety as to be able to transpire through the Substance of the Glass. See the famous *Stahl*, in his *Fund. Chem. Dog. & Exp.* p. 38. § 7. But what he mentions there is upon the authority of other persons; and certainly it is a very difficult matter to lute the Vessels so accurately together, that nothing shall be able to insinuate itself through the cement. *Joachim Becker*, indeed, asserts, that Water, by a great number of repeated distillations, may be brought to have a surprizing, corrosive faculty. *Statbl.* 18. p. 120. § 6. But for my own part, in the great number of Experiments I have been engaged in, I don't remember ever to have seen the least sign of any such penetrability or acrimony. In the mean time, however, I have been abundantly convinced, that there is nothing more difficult in the chemical Art, than to repeat a distillation a great many times in an Laboratory that is hot, and full of Vapours, without losing something of what you are distilling, and having something foreign mixed with it.

But

But it has been farther observed, that Water being contained in a strong Vessel, which it was not able to penetrate, could not, by being compressed by a vast force and weight, be made to pass through its Pores, but remained totally included in it. Please to think only what a prodigious compressure there is in *Papin's Digester*, and yet not a drop of the Water is forced through. The same thing was tried formerly in the Hydraulic Machine ABCD. This consisted of a hollow Cylinder AB, made of Brasses, and closely soldered up. At B only it opened into the Tube BC, which was soldered to it, and at C was produced upwards at right Angles to the height D of six feet, so that there was a free communication betwixt the Cavity AB, and that of the annexed Tube BDC. At A there was a Cock E, a little above the top of the Cylinder AF, by which you might keep in the Liquor in the Vessel AB, or let it out at pleasure. This then being open, the Vessel AB, by pouring Water in at D, was perfectly filled; after which, the Cock being turned, more Water was poured into the Tube BC, which, according to the laws of Hydrostatics, pressed the Water in AB so forcibly, that the Vessel was distended, and the Copper Plate AF was forced outwards, and raised up, though there was a great weight set upon it, and yet not one drop of Water sweated through. But when the Water came to be raised almost as high as D, then by the prodigious pressure, the soldering was burst, and the Water run out at the Cracks. From these instances then, Gentlemen, it plainly appears, that Water, though it is compressed by the greatest force, will not pass through those Pores, through which, by the fineness of its parts, it would not have insinuated itself spontaneously.

Or by pressure.

Pl. IX.
Fig. 1.

There is a plausible Experiment indeed mentioned by the *Academy del Cimento*, in their History of Experiments, p. 203, 204. which seems to make against this assertion. For a hollow metal Sphere, being perfectly filled with Water, and then accurately closed, they put it into a strong press, and upon compressing it very strongly, they observed the Water to ooze through the Pores of the Metal. But here, as a Sphere is the most capacious of all Bodies, that are isoperimetrical, it cannot, by the force of the press, be changed into any other figure, upon the incondensable Water, without the cohering parts of the Metal receding from one another, and its substance being rendered thinner; and as the Water at the same time being compressed, acts as it were like an Augre upon the Pores of the attenuated Plates, it is possible, that the metalline, elastic *Lamina* may be so distended upon the Water which is not condensable by any force, and consequently of infinite resistance, that the Water may be pressed through the Pores of the Metal, which when the pressure is over, may by its contractile force restore itself, and close up the Pores again.

We are persuaded, therefore, that as on the one hand the single Elements of Water cannot be increased by any cause, except Fire alone, which seems to exert this power universally upon all Bodies; so on the other, that they cannot be lessened but by the absence of Fire, or Cold, or which is the same thing, by being left to themselves, or freed from Fire. But this sensible diminution, now, of the Elements of Water, considered as they constitute Water, does not extend itself lower than to 32 degrees of Heat, for then Water continues Water no longer, but is converted into Ice. And that contraction of the Elements of Water, which happens after they come to be Ice, cannot be observed any longer, because the Air, being expelled by the closer adunation of those

By Cold alone they become less.

those Elements, begins to form itself into elastic bubbles, which then by their elasticity expand the Ice, more than the Cold contracts it. Hence, however, we understand a Paradox, which the Masons affirm they have often observed, *viz.* that cold Water soaks through walls more easily than hot. For when we were treating of the dilating power of Fire, it appeared, that Water is more condensed by Cold than Stones; so that the Pores of Stones are less contracted by the same Cold than the Elements of Water, whence it may happen, that Water, in its greatest degree of Cold, may pass through those *Meatus's* which were too small for its Elements, when it was hot.

Not to be attenuated by Fire.

This then being constantly observed to be the case, we conclude, that Fire, let its force be applied and continued in what manner you will, can never divide the Elements of Water into smaller Particles, but can only with its utmost effort extend them into a larger Bulk, and then strongly agitate them among one another; which seems to be the limits of the efficacy of Fire upon Water. Rain-water, which was caught upon the Observatory of our Academy, I distilled in very clean Vessels, and with a gentle Fire, and after having kept it some Years well stopped, I found it exactly the same, without the least difference, whether chemically examined, or hydrostatically.

But always kept in motion by it.

Since 33 degrees of Heat now dissolves Water in such a manner, as to render it fluid, hence we are certain, that the particles of Water are always in motion, so long as by this Heat it continues to be Water: For this Heat, in which Water is turned into Ice, is more than $\frac{1}{3}$ of the greatest natural Heat; and certainly a Fire so great as is able to melt hard Ice, must necessarily be capable afterwards of keeping its Particles in motion. Hence, therefore, we suppose, that Water, though considered together as at rest, has its Particles kept in a constant agitation. Nay, and the solution of Salts, too, in Water, seems to evince, that its Elements are in continual motion; though this solution, indeed, appears rather to be attributed to attraction, than repulsion: In the mean time, however, it don't seem likely that the whole Mass would be dissolved, unless the agitated Elements of the Water were kept constantly moving from one place to another, and by this means were successively applied to the solvent Salt. By the help of Microscopes, likewise, we are able to perceive a motion in the Particles of Water. And lastly, it is plain, Water must be rarely at rest, in any Vessel whatever, as every thing almost on which it can stand, is continually affected with a tremulous motion.

And immutable.

Hence, therefore, are not the ultimate Elements of Water perfectly immutable? Certainly they seem so firm and constant to the Figure, which once they are formed with, that no power of Art or Nature has yet appeared capable of altering it. And this will always hold equally true, whether you consider them singly and separately, or as they are collected together, and compose one Body. For since from every Operation it returns constantly the same as when it was applied, neither becoming denser or rarer, heavier or lighter, thicker or thinner, it plainly demonstrates, that both the bulk and figure of its Particles have remained the same: For if by the force that acted upon them, their figure had been changed, then the contact of the Elements had been changed likewise, and consequently, there must have been some alteration produced in the Interstices between these Elements, whence would arise some difference in the density and gravity of the whole Body. Suppose, for instance, the Elements

ments of a Body to be spherical, and that these afterwards, by being compressed together, are changed into Cubes, then the Interstices between the spherical Elements, in the first case, being the greatest possible, would produce the greatest lightness, and rarity, which being quite filled up by the Cubes, in the last, the Body would acquire its greatest density and gravity: But nothing of this nature is ever observed in Water. In the *Æolipile* exposed to a very strong Fire, the Water, by the violence of the Heat, the resistance of the Vessel, and the straitness of the passage through which it is let out, is prodigiously agitated, divided, and rarified; and yet the Vapour received into a Vessel gives you always the very same Water that was put into it.

These Elements, therefore, ought by no means to be looked upon as a kind of little flexible Eels, moving about in sinuous convolutions, as the subtil *Descartes*, and the famous *Stairs*, have imagined: But on the contrary, the ultimate Particles of Water seem to be exceeding rigid, perfectly inflexible, and of an adamantine hardness. Are they therefore perfectly solid Spheres? This seems sufficiently probable. If the Air, therefore, that is intercepted betwixt these Elements should reside there in a spherical form too, then the Space taken up by the Water, would be to that taken up by the Air, as 100 to 7, nearly as 14 to 1, according to the computation of the ingenious *Cruquius*. Nor flexible.

But again, by various, and unexceptionable Experiments of the Academy *del Cimento*, it has been made evident, that the Elements of Water are not compressible by any force whatever. p. 197 to 207. *Du Hamel* likewise informs us, that a Sphere of Gold, when it was perfectly filled with Water, could not be compressed. That a Leaden Sphere, indeed, full of Water was compressible by the Hammer, *Colbertus* tells us, *Physic. General.* Part I. p. 4. Lord *Verulam* relates too, that a Tin Sphere, being filled with Water, and then strongly compressed, upon making a hole in it, made the Water fly out. *Boyle* asserts, that it threw it to the distance of three feet. Exper. 20. and *Stairs* affirms the same, p. 396. These last Experiments therefore seem to invalidate the Opinion of the Academy abovementioned: But here there are two things that ought to be carefully considered. In the first place, in the filling of these Vessels, the Air may easily insinuate itself, and lie concealed betwixt the Sides of the Vessel and the Surface of the contained Liquor; and if this is the Case, then when it afterwards comes to be compressed, it will press out the Water wherever there is a vent, till it is reduced to the common density of the Atmosphere. And secondly, as I hinted before, the Particles of the Metal being distended upon the Water, and endeavouring to contract themselves, must, upon any Hole being made in the Vessel, immediately force out the Water. These instances, therefore, are not sufficient to prove any compressibility, or elastic Spring, in the Water, which the *Florentine* Experiments seem intirely to destroy. Hence, then, Water, in respect to compression, and the density that arises from it, appears to suffer nothing at all from the different weight of the Atmosphere, let the variation be ever so great. And here certainly the Works of the Author of Nature appear very wonderful, whilst we see one Element, as Air, formed with almost an infinite Elasticity, whilst another, as Water, is not elastic at all. In making all these Experiments, however, what a prodigious deal of caution is necessary? For if there is but the Nor compressible.

least common Air, besides what is in the Water itself, intercepted and detained between the concave Surface of the Vessel and the convex one of the Water, which may easily be the case, as we see by the Bubbles formed upon the polish'd Surfaces of smooth Bodies immersed in Water; I say, if there are any such Bubbles as these, though they are first exceeding small, yet afterwards, by being united together, they may form there a considerable quantity of Air, which, upon being compressed, will exert a very great expansive force, which one may be easily led to ascribe to the Water itself. But we must be very careful, likewise, that, during the time that the Experiments are making, the Heat of the Water is neither increased nor diminished; for as the expansion of Water upon Heat, and its contraction upon Cold, is very considerable, by this means, likewise, the event may prove fallacious. But in the third place, we may here take notice farther, that though the Air which is lodged in the interstices left between the Elements of Water, has there no actual elasticity, yet, when it is expanded by a certain degree of Heat, is forced out thence by a hydrostatical force, and becomes united together, it then acquires an elastic power, in the same manner as it does in the Air-pump, when it is absolutely drawn out of it; if this then should happen to prove the case here, the Air which before being dispersed through the Water, did not appear elastic, now it is separated, and not immediately absorb'd again into the Water out of which it was express'd, will exert a true elastic force. Except therefore all these cautions are carefully attended to at once, an error may easily happen in these Experiments: For which reason it always ought nicely to be examined, whether there are any such Bubbles in these Vessels, or no.

Water ex-
ceeding sim-
ple.

The fourth property which the order of our Subject leads us to take notice of in Water, is its exceeding great simplicity: For if it is pure elementary Water, it does not discover the least diversity in its parts, so that it is every where found to be exactly the same; and by what has been already laid down, it appears to be immutable in its bulk, figure, density, weight, and other Properties. The Alchemists now observing this constant simplicity of Water, fell into an opinion, that all Bodies, in particular the more simple ones, were produced from Water alone, as their original Matter, by means of a seminal faculty in their Seed, and a quickening Fire. Hence *Paracelsus Archid.* x. c. 3. Water is the proper Element or Sea, that is, the true Mother of all Metals. And *Helmont* throughout his whole Works endeavours to advance and inculcate this Doctrine. And for this reason they asserted farther, that all Bodies, when they are perfectly and radically dissolved, by the universal Solvent, are at last reduced into a homogeneous, elementary Water, their particular, seminal power being quite destroyed. Consult *Helmont* in every part of his Writings. This Opinion, however, seems rather founded upon History and Disputation, than any Experiments which have been related in such a manner, that a sober man can fairly give credit to them. For after *Moses*, the most ancient Writer, had delivered a tradition, that the Spirit of God, brooding upon the face of the Waters, had communicated to them a prolific virtue, the wisest of the ancient *Persians* looked upon Water as the principle of Bodies. Hence the same doctrine came to be in vogue among the *Egyptians*, from whom *Thales* the *Milesian* carried it into *Greece*, by which means it at last came amongst the Chemists. Hence the followers of *Van Helmont* acknowledged only

only two simple, natural Bodies. *viz.* Water perfectly separated from every thing foreign, and heterogeneous, and Mercury freed too from every thing heterogeneous, and from the taint of its own inherent, original Sulphur, whose simplicity then would be greater than even that of Gold. Mercury, however, itself they asserted to be the offspring of Water, from which it originally has its rise, and into which it may at last be resolved. Hence they supposed Water to be the universal nutriment by which all Bodies are supported, which no Art whatever is capable of making any alteration in, but only the innate faculty of created Seeds.

As a fifth property of Water, we reckon its mildness. And this quality it is endued with to such a degree, that if it is reduced to the Heat of a healthy Body, and then applied to any of its parts, which have the quickest Sense, it not only don't excite any pain, but it don't so much as raise any other sensation than what is caused by the natural humours, and the parts feel when they are perfectly sound. If, for instance, it is applied to the *Cornea* of the Eye, than which there is scarce any part sooner affected with pain from any thing sharp, it does not cause the least uneasiness. To the Membrane of the Nose, which is made up of Nerves that lie almost bare, it is neither troublesome, nor affects it with any new smell; nay, if you apply it softly to the Nerves, when they are stretched with an inflammation, and from any very light cause grow so exceedingly painful, it produces no manner of inconvenience. In crude Ulcers, which can't bear the least touch of the softest thing without uneasiness, warm Water causes no irritation at all: Nay, foment even the bare and half-destroyed Nerves of an ulcerated Cancer with warm Water, and instead of increasing the sharpness of the Pain, you will assuage it; whereas if you apply any thing else to them, it will make it worse. The organs of smelling it does not affect with any smell, those of tasting with any taste, those of seeing with any colour, or the nerves with any sensation. Among all the humours of the human Body, it is found to be the mildest, even the Oil itself not excepted, which, let it be ever so soft, by its tenacity gives the Nerves a kind of uneasiness. And among those Elements which Art is capable of extracting from these humours, Water, when it is pure, is always observed to be the most mild. And lastly, it demonstrates its excellent mildness, by being able to dilute things acrid, in such a manner as to deprive them of their natural acrimony, and render them harmless, with respect to the human Body. A drachm of the Liquor drawn from Vitriol, for example, by the extreme force of Fire, called by the Artists the purest Oil of Vitriol, drank by a person with an empty stomach, would prove a violent poison, burning up his throat, *œsophagus*, and stomach; and yet if the same is diluted in six pints of Water, it will do no harm, though you drink it all. And in other instances the same thing nearly holds true.

In respect, therefore, of both these qualities, warm Water is esteemed one of the principal Anodynes, and Paregorics in Physic, and is hence recommended by *Hippocrates* as the softest Fomentation for the sharpest Pains.

The sixth property which we observe in Water, is its dissolving power, by which it is able to dissolve certain Bodies in such a manner, that when they are diluted in it, you will have a Fluid, in which the dissolved Bodies shall be so equably distributed, that in every part of the Water there shall be a proportional

proportional part of the solvend. As this speculation, now, is of considerable consequence, so it will be most readily understood, by examining in order those Bodies upon which Water is capable of acting in the manner described; and these are as follows.

First upon
simple Salts.

First, all true, simple, fossil Salts, whether existing in a liquid or solid form. Hence *Sal-Gem*, Fountain Salt, Sea Salt, Borax, Nitre, *Sal-Ammoniac*, and the alkaline Salt of Chalybeat Waters, as it is justly accounted by the famous *Hoffman*: As likewise the fossil, acid Salts, which are rarely found in a solid form, but being almost always liquid, are referred to the Acid of Sulphur, called the Oil or Spirit of Sulphur *per Campanam*; to the Acid of Alum forced out by an extreme Fire, called Oil of Alum; to a similar Liquor, drawn in the same manner, from Vitriol, called Spirit or Oil of Vitriol; all which three sorts of Acids, being perfectly depurated, and reduced to their greatest simplicity, seem hardly at all to differ from one another. It is exceeding difficult indeed to free them intirely from all their Water, and when you have done it, they immediately attract more into them out of the Air, as greedily as fixed, alkaline Salts do, when they are dried in the strongest Fire. When you have separated it from them, however, very nicely, they may be kept some time in the Cold, in form of solid Chrystals; but as soon as ever they attract any moisture out of the Air, they melt again, or if they are exposed to a somewhat greater degree of Heat, for then, like Ice, they perfectly become fluid. Hence, however, we see, that these acid Salts, when they are quite freed from their Water, are capable of acquiring a solid form, though they retain it with a great deal of difficulty. The other simple, fossil, acid Salts, are the acid Spirits of Nitre and Sea Salt; and these are always fluid; for they are of so volatile a nature, that they themselves fly off with that degree of Heat, that is necessary to separate their Water. All these fossil Salts, now, may be dissolved in Water, according to the Law abovementioned.

In a different
manner,

In the solution, however, effected in this manner, there is observed a very considerable and manifold diversity. For in the first place acid Salts, that are almost always liquid, and therefore are already diluted with such a quantity of Water, as to render them fluid in a certain degree of Heat, may be dissolved in any quantity of Water whatever, be it ever so small: If you take, for instance, a pound of the strongest Oil of Vitriol, and mix it with only one drachm of Water, you will so accurately divide the Elements of the Oil of Vitriol, that it shall be all perfectly dissolved in this one drachm of Water. And this is the case of all other acid Salts, that we are hitherto acquainted with. But on the contrary, those fossil Salts that are of a solid form, will not suffer themselves to be dissolved, except you apply to them a certain quantity of Water. If you make use of less than is necessary for this solution, then, such a part only of the Salt will be melted, as that quantity of Water will take up, the remainder still continuing solid. When these Salts, however, are once perfectly dissolved in a proper quantity of Water, they may afterwards be farther diluted in any quantity whatever. Take, for instance, an ounce of dry *Sal Gem*, and dissolve it in three ounces of Water, and you will have a simple *Lixivium*, to which, if you add only one scruple of Water, the *Lixivium* will be perfectly and equably diluted by it. And this property, certainly is very remarkable, inasmuch as there is no end to this dilution; for when a fossil Salt is once dissolved

dissolved in Water, it may afterwards be diluted in the smallest or greatest quantity of Water, in such a manner, that in every portion of the solvent Water there shall be a proportional part of the dissolved Salt. But in this dissolving power of Water it is observed, in the second place, that if the Water poured upon the Salt is shook about with it, the solution is sooner effected, and more Salt is dissolved; whereas, if it stands quiet, it is longer about, and the Water takes up less. In the third place, hot Water dissolves Salt in a great deal less time than Cold, and takes up, and retains a great deal more. Hence Water that has only 32 degrees of heat in it, performs its office slowest, and dissolves least Salt of all; whilst boiling Water, which has 212, does it quickest, and dissolves most. And this is always observed to happen in proportion to the degree of Heat and Cold. For if you dissolve Salt in boiling Water, 'till the Water is perfectly saturated, and then remove the Vessel from the Fire, you will observe, as the Water grows gradually colder and colder, it will continually precipitate more and more Salt to the bottom, 'till at last, when it is reduced to the 32d degree of Heat, it will have discharged a very large quantity of Salt in a solid form; and if then by a still greater degree of Cold, this salt Water begins to freeze, there will in that case be yet more Salt separated from it, so that in the sharpest Cold of all it will be nearly all expelled, and so long as that Cold continues, will remain with the Ice, of a solid consistence. But again, the salt Water, which when acted upon by so sharp a degree of Cold, discharg'd the greatest part of its Salt, will be much sooner thaw'd again upon the application of Salt to it, than common Water will without, in the same degree of Cold: For as Salt, on the one hand, by being mixed with Water, keeps it from freezing, 'till the Cold is increased a good deal below that point in which pure Water would have froze: So, on the other, if you apply Salt to Ice in that very same degree, precisely, in which if the Salt had been mixed with the Water, it would have been just upon freezing, it will reduce this Ice to Water, though without it, the Ice would have required several more degrees of Heat to dissolve it. By this surprising property, then, we see, that Salts have a power to prevent the association of the parts of Water, and their concretion into Ice, and that by the application and interposition of their own Particles. Hence the Water of the Sea is a good while longer before it freezes than fresh Water, and requires a much greater degree of Cold. In the fourth place, the concretion of Salt, before dissolved in Water, called chrySTALLIZATION, appears from what has been said to arise, first, from the want of a sufficient quantity of Water to dilute it; secondly, from the Liquor's being at rest, in which the Salt is dissolved; and, thirdly, from Cold: For these three are the instruments by which chrySTALLIZATION is brought about. But in the fifth place, we observe farther, that the dissolving power of Water operates much sooner upon one Salt than another; as we see *Sal Gem* is sooner dissolved, in the same Water, than Borax: and the same quantity of Water too will dissolve more of one Salt than another, as we see likewise in the same Salts. And sixthly and lastly, when Water is so perfectly saturated with one kind of Salt, that if you add any more it will fall undissolved to the bottom; yet even then it will be capable of dissolving a good deal of another sort, and that without letting go the former. Saturate, for instance, Water of a certain degree of Heat with *Sal Gem*, so that it won't dissolve the least grain more, and it will, nevertheless, take up a small quantity

quantity of Nitre; and yet the *Sal Gem* will remain perfectly dissolved in the Water as before. Nay, and when it is thus saturated with these two Salts, it will still be able to dissolve somewhat more of another. If the Philosophers and Chemists, therefore, would properly consider these *Phænomena*, it would open a way to farther inquiries into the nature of the Solution that Water exerts upon Salts, than have yet been made.

Secondly,
upon com-
pound Salts.

In the second place, pure Water dissolves those Salts that are called Metalline, or Terrestrial Salts; by which we mean the Chrystals or Vitriols produced from Metals corroded by Acids; and that, whether these Acids are Fossil ones, as in Vitriol and Alum; or Vegetable ones, as in Verdigrease. All these Vitriols, now, it appears by chemical Experiments, are compounded of a solvent Acid, a Water diluting this Acid, and a corroded Metal, united by a certain Law, and in a certain proportion into one Glebe. Whilst all these Bodies are thus dissolved in Water, the same six conditions just now mentioned, will hold good in these likewise.

And upon
those of A-
nimals and
Vegetables.

But in the third and last place, Water has a power also of dissolving the Salts, both of Animals and Vegetables, whether native, or produced by Art. Acid, Rough, Salt, Alcaline, Compound, Ammoniacal, Fix'd, Volatile, Semi-fix'd, and Simple ones, those arising from a Salt and Oil, combined together, and those produced by Fermentation, Putrefaction, and Combustion, are all dissoluble to Water. But here again, there is observed the same variety in the solution, as we observed above. And among all these different kinds of Salt, Tartar is dissolved with the greatest difficulty.

These things
confirmed by
Experi-
ments.

All these things, now, I'll demonstrate to you by various Experiments. First, then, in this Glass, I have an ounce of pure Water, into which I drop four drops of Oil of Vitriol, and upon shaking it together, the Liquor through the whole grows equally acid. 2. Here again, I have an ounce of Oil of Vitriol, into which I drop four drops of Water, and upon shaking the Vessel, the Liquor, as before, becomes uniformly acid. Hence then it appears, that acid Salts, whether mixed with Water in a greater or less quantity, are most equably divided by it, and most intimately dispersed through it. 3. With an ounce of Water, I mix half an ounce of dry Sea-Salt, part of which dissolves, and the remainder lies undissolved at the bottom. 4. To a very strong Brine of Sea-Salt, I add any quantity of Water whatever, and they very equably mix with one another. 5. If the same is performed with Nitre, *Sal Gem*, Borax, *Sal-Ammoniac*, Salt of Tartar, a dry alkaline Salt, a volatile alkaline *Sal-Ammoniac*, with Alum, or Vitriol, the effect will be perfectly the same, as in the third and fourth Experiments: All which I have here set before you. These Salts, therefore, in order to be perfectly dissolved, require always a certain determined quantity of Water, nor can Water dissolve solid Salts, but to a limited portion of them. All these Salts, now, that I here made use of, were first very carefully dried, and reduced to a very fine Powder. If we could, by any Art now, perfectly free acid Salts from all the Water that is mixed with them, it is very probable, that their Particles being then united and concreted into a solid form, would in a certain degree of Heat require a determined quantity of Water to reduce them again to a state of fluidity: For if the strongest Oil of Vitriol is exposed to a great degree of Cold, it requires a certain portion of Water to prevent its shooting into solid Chrystals; nor will that which is diluted

diluted with Water thus congeal in the Winter, but only that which is exceeding pure. It is not an easy matter, however, to give you an instance of exhibiting pure acid Salts in a solid form, without the concurring assistance of a very great degree of Cold; and hence Persons have generally imagined, that these acid Salts may be always diluted with the least quantity of Water; but this, you see, must be understood with some restriction, agreeable to what we have now observed. And thus much for the proof of the first propositions.

Into three ounces of the purest distill'd Water, I here put one ounce and one drachm of Sea-Salt, all which, if they stand at rest, will dissolve in time, tho' slowly; but if they are shook strongly together, it is all dissolved presently. To the same quantity of Water, in each of these Vessels, I add the same quantity of Salt, but one of them I keep here in the Cold, whilst I set the other upon the Fire; and the Salt in the warm Water dissolves much sooner than that in the Cold. With twelve ounces of distill'd Water, I here mix five ounces of Sea-Salt, and upon boiling them together, they are intirely dissolved: I add now as much boiling Water as was lost by boiling, and you see in this degree of Heat, there is a perfect Solution. I cover the Vessel that nothing may exhale, and set it by to cool, and the Salt concretes again in the Cold, and from the degree of ebullition, quite down to the degree 32, this *Lixivium* of Sea-Salt, which was as well saturated as it could be rendered by boiling, forms and deposits every moment more and more Salt. Hence then we learn, that the same quantity of Water in the Summer time, takes up more Salt than it does in the Winter; in a hotter Climate dissolves more than it does in a cold; and consequently, most of all in the Torrid Zone, and least about the Poles: But as putrefaction, *ceteris paribus*, prevails in proportion to the degree of Heat to which Bodies are exposed, we see it is wisely provided, that in hot Countries there should be so much more Salt dissolved than in cold ones, which best resists it. Boiling Water, then, will dissolve as much Salt, as Water can possibly take up: Water that is in the very next degree to freezing, least of all. But even Ice itself congealed from Salt-water in every increasing degree of Cold down to O in *Fahrenheit's* Thermometer, discharges continually more and more Salt, so as at last to retain but an exceeding small quantity, in the greatest observed natural Cold. All these Observations, then, make it evident, that in the Elements of Water there is a natural disposition, which, when they are acted upon by Fire, makes them liable to be so separated from one another, that the Particles of Salt may be disposed in the Interstices between them: And that on the other hand, when the Heat is withdrawn, and they are left to themselves, they then spontaneously attract one another in such a manner, as to lessen these intercepted spaces, so that the Particles of Salt can remain there no longer, but upon the nearer approach of the aqueous Elements are expelled from between them. The dissolving power of Water, therefore, with regard to Salt, depends partly upon the Salt and Water, and partly upon the quantity of Fire that is united with them both. And hence, tho' most of the Chemists, indeed, would have it otherwise, it is evident, that it is impossible to determine how much Salt may be dissolved in a given quantity of Water, unless the degree of Heat is first accurately adjusted in which the Solution is performed. And for this reason, it seems certain, farther, that Water, without the assistance of any Heat at all, is not able to dissolve the very least quantity of Salt, that is, that Salt will not be

The quantity of Water necessary to dilute Salts.

be diluted by the very coldest Ice. And here, again, it is very remarkable, that Salt, by being mixed with rasped Ice should make it thaw, and yet by the very same means should excite such a prodigious degree of Cold: This appears every where evident, but most of all so in those Experiments of *Fabrenheil's*, which we related to you, p. 99, which certainly evince, that Salt has a power of heating the coldest Bodies, and of expelling Cold from them into the neighbouring Bodies and Spaces; which again, is a wonderful Law of Nature. But as I am not treating professedly of this subject now, I must proceed, tho' I have a good many more things that I could add, which, perhaps, I may do hereafter: What I have offered, will in the mean time afford you matter of speculation and farther inquiry. Give me leave, however, to propose a few more Experiments which I have made relating to our present business. When the common Air was 38 degrees warm, I took of the purest driest Sea-Salt reduced to a fine powder 2 ounces, which suffered themselves to be dissolv'd in 6 ounces 3 drachms of pure distill'd Rain-water; so that here 4 parts of Salt required 13 parts of Water. One ounce of *Sal Gem*, prepar'd in the same manner, required 3 ounces 2 drachms of the same Water, the proportion here being the same as the former, viz. 4 to 13. One ounce of pure dry powdered *Sal-Ammoniac*, was dissolved in 3 ounces 2 drachms of the same Water. Nine drachms of pure dry Nitre, reduced to Powder, took up 6 ounces of the same distill'd Water; so that there were 3 parts of Nitre, to 16 of Water. Half an Ounce of very dry Borax, required more than 10 ounces of Water to dissolve it intirely; hence the proportion, as 1 to 20. One ounce of Alum was dissolved in 14 ounces of distill'd Water. One ounce of *Epsom Salt*, in 1 ounce 2 drachms: One ounce of Salt of Tartar, in 1 ounce and $\frac{1}{2}$. Three ounces of Water, shook strongly, and for a good while, with $\frac{1}{2}$ an ounce of the *Arcanum Duplicatum* of the Duke of *Holface*, dissolved it perfectly. And lastly, by shaking them together for some time, 3 ounces of Water dissolved intirely 1 drachm and $\frac{1}{2}$ of common green Vitriol. Hence, then, we infer, that different Salts require a very different quantity of Water to dissolve them: That some are dissolved sooner than others: That those which spontaneously melt in the Air, dissolve soonest, and in a very small quantity of Water; which too seem of a more active nature: And that these, when they are exposed to the Fire, part with the Water in which they are dissolved, with so much the more difficulty, so that Salt of Tartar, and Oil of Vitriol, cannot be freed from their Water without a very great degree of Heat. To these 3 ounces 2 drachms of Water, now, which has dissolved in it 1 ounce of Sea-Salt, nor is capable of taking up any more of this Salt, I add $\frac{1}{2}$ a drachm of Nitre, and this dissolves in it. Again, with these 6 $\frac{1}{3}$ ounces of Water, which contain 1 ounce of dissolved Nitre, and are perfectly saturated, I mix $\frac{1}{2}$ an ounce of Sea-Salt, and it dissolves intirely. Hence, therefore, Water, when it is saturated with one sort of Salt, so that it cannot take up any more of that, is nevertheless still capable of dissolving some more of another. Fountain-Salt, *Sal Gem*, Sea-Salt, *Sal-Ammoniac*, Nitre, and Borax, being reduced to their particular Brine, may be intirely and intimately mix'd with one another. In the Solution, however, of a metallic Vitriol by Water, it ought particularly to be taken notice of, that this cannot be perfectly dried before this Solution, but it will be altered in its Nature: Nay, and whilst it is dissolved in this manner, it always lets fall to the bottom a good deal

of indissoluble Ochre; and hence by repeated Solution and Chryftallization of Vitriol in Water, the whole substance is at last converted into Ochre, and a pinguious Liquid, that cannot be easily dried. The easier, therefore, the sooner, and with the less quantity of Water, Salts are dissolv'd, the more strongly they seem to retain their Water when they have once received it. But in the Solution of Metals, now, by Water, there are some *Phænomena* that are very singular, and well worth our consideration. Metals have some Salts, by which they may be dissolved; and when they are found dissolved by these into vitriolic Glebes, they then suffer themselves to be diluted in Water: And this Solution is always soonest effected, and is most perfect, when these Glebes abound with that Salt, which such a particular Metal is principally dissolved by; for then pure Water will so perfectly dilute such a Glebe, that the metallic Particles will be most equably distributed through the Water. But on the other hand, when in Vitriols, part of the solvent Salt is wanting, then Water poured upon them, will dissolve the Metal so much the less, so much slower, and more imperfectly, especially if you add too great a quantity; for then there is always some part of the Metal precipitated to the bottom. But when Metals are dissolved in a good quantity of their solvent Salts, and then diluted with Water, by a gentle exhalation they are reduced into solid vitriolic Glebes called Magesteries, Salts, Vitriols, Sugars, and Chrystals of Metals. In all these now, the Metal, its solvent, and pure Water, are always combined together in a certain proportion, and form pellucid, brittle Masses, dissoluble in Water, fusible in the Fire, and hence convertible into a fine Calx, which lose their transparency, as soon as ever the Water is drawn from them. By this Art, now, Metals are rendered potable, without much inconvenience, and with a medicinal effect that may be pretty certainly determined, as they are thus rendered dissoluble in Water. For in the first place, these Bodies will act by the Acid which dissolves the Metals, and then adheres to them. Secondly, by virtue of the metalline Mass dissolved by this Acid, and now in the Vitriol; for this metalline part will then act by the properties common to all Metals. And thirdly, in which their principal efficacy consists, these Vitriols will act by that singular virtue which is proper and peculiar to every particular Metal, and which is generally inimitable by any other. But fourthly, these Bodies likewise acquire a farther power, arising from the union of these three together, thus all united by the mediation of Water, in particular, into one Mass, which now acts by their whole joint efficacy. Of this kind now, thus produced by Water, are Vitriols of Gold, Mercury, Lead, Silver, Copper, Iron, and Tin.

This rule, however, must not be extended to all Semi-metals, as if Semi-metalline Particles, reduced by their solvent Acids into Masses appearing saline, might be afterwards diluted, and dissolved in Water like Salts, and true Metals. The purest metalline part of *Regulus* of Antimony, for instance, is perfectly dissolved in the strong Spirit of Sea-Salt that adheres to the corrosive sublimate of Mercury, in the distillation of Butter of Antimony; for what else is this Butter of Antimony, but a true vitriolic Salt of *Regulus* of Antimony, made by a combination of it with Spirit of Sea-Salt? Hence, therefore, from our History of metalline Salts, a Person would be apt to imagine, that this Butter, likewise, might be dissolved in Water; but how much would he be disappointed, when he came to make the Experiment? For as soon as ever the Water

Water don't
dissolve all
metalline
Salts.

comes to this icy Glebe, the solvent Acid immediately lets go the dissolved *Regulus*, mixes itself with the Water, and gives you again intirely the semi-metalline corroded *Calx* that lay conceal'd in the Butter. This rule, therefore, must not be carried beyond its proper limits.

Water dissolves Alcohol.

Water dissolves Alcohol, not spontaneously, but if they are shaken together; for if Water is gently poured upon Alcohol, it passes through it, and falls to the bottom, whilst the Alcohol swims at top. Nay, it will not readily so dissolve Alcohol, but that after you have shaken them, the Alcohol will still in some measure cohere together, and float about in the Water in pinguious *striae*: If the concussion, however, is continued for a good while, it will at last be perfectly diluted, and equably distributed through the whole Water. This tenacity, now, of the parts of the purest Alcohol, appears no where more elegantly than in an Experiment I formerly shewed you, p. 258, when I took a chemical Vial full of Water, and inverting it, immersed the mouth into Alcohol, for then you saw the Alcohol ascend through the Water without mixing with it, rise into the Belly of the Glass, and collect itself together at top. Since, therefore, pure Alcohol is a vegetable Oil reduced by the efficacy of a proper fermentation into these Spirits, which burn, and are miscible with Water;

Therefore fermented Oils.

Hence we learn, that even Oils themselves, after they have first been chang'd in this manner, may be intirely mixed with Water, let them be ever so pure, tho' sooner, indeed, and more easily, if they are diluted in some quantity of it already; for common Spirit of Wine mixes more readily with Water, than the purest Alcohol.

Water and Salt don't dissolve Alcohol.

In the mean time, however, it is particularly remarkable, that Water, when it is perfectly saturated with Salt, will by no means mix with Alcohol; nay, if you shake them together ever so strongly, and for ever so long a time, you will never reduce them to one uniform Fluid, but will find on the contrary, that they repel one another much more powerfully than any other two known Liquors in Nature. In this Vessel here, I have some Oil of Tartar *per deliquium*, in this other some Alcohol, both of them pure transparent Liquors: These, now, I mix together, and you see they continue perfectly distinct, the Oil of Tartar subsiding to the bottom, whilst all the Alcohol swims at top. But I'll shake these now with all the force I am able, and what is the consequence? Why the Oil again collects itself together, and the Alcohol rises united above it, nor so much as the least drop of either of them remains mixed with the other. Nay, farther, I put these two Liquors into a tall Bolthead, and made them boil, in order to try whether by this means I could not make them mix together, but I found it was to no purpose, for both of them continued perfectly separate from the beginning to the end, even in the act of ebullition, but the Alcohol being raised by the strength of the Fire, was separated from the Water, which remained at the bottom with its Salt.

Water sometimes attracts Alcohol, and deposits Salt.

But there is still something farther very extraordinary in this affair, and that is, that if Water is thoroughly saturated with a Salt that may be very easily separated from it, then if you mix the purest Alcohol with this *Lixivium*, the Alcohol will unite with the Water, and the Salt will be expelled and precipitated to the bottom in form of a dissolved Salt. In this Glass I have the strongest *Lixivium* that can be made with *Epsom* Salt and Water, which you see is quite

quite clear, nor has the least sign of any Salt in it. Into this, now, I pour some Alcohol, and it swims at top: But I shake them as you see together, and now the Liquor grows turbid, opake, and whitish, and lets fall some little Chrystals of Salt, by this means separated from its dissolvent Water, which is now united with the Alcohol. And in the *Offa Helmontiana*, where there is as much volatile alkaline Salt of *Sal-Ammoniac*, dissolved in Water, as it can possibly take up, and then an equal quantity of the purest cold Alcohol is poured upon it, the Liquors being shaken together, instantly coalesce into a white solid Glebe, from which in a little time there is separated some Water attracted into the Alcohol.

But another thing to be observed in this dissolving power of Water is this, that if it is mixed with Alcohol, that has a distilled Oil dissolved in it, then the Oil will be separated from the Alcohol. This you'll see, if you'll please to attend to the following Experiment. I have here some exceeding pure Alcohol, in which I have dissolved some choice Oil of Cinnamon, and you perceive how equably clear it is, without the least sign of any Oil swimming in it, or falling to the bottom. Into this mixture, I now gently drop some Water; and don't you observe how the Liquor immediately grows white, and from a transparent one, becomes opake? But you observe farther too, that the Oil, which before was so perfectly diluted, as to become imperceptible, discovers itself now, and collects itself together. Hence, then, it appears evident, that Water, being mixed with Alcohol, renders it unfit for the Solution of these Oils: That Alcohol unites more easily, and in a more kindly manner with Water than with these: And that these Oils, when they are diluted with Alcohol, do nevertheless continue real Oils, tho' they do not, during that time, appear in form of Oil, but of Spirits. Refins too, may be dissolved in Alcohol, so as not in the least to appear; but if you mix Water with this Liquor, it instantly becomes very white, discovers again the latent Refin in the Alcohol, and yields you the very same quantity of Refin that was dissolved: This is true in every kind of Refin whatsoever. These resinous Substances, therefore, may be dissolved in Alcohol, may be recovered from it again by the help of Water, may be dissolved again, and precipitated as before, and this may be repeated as long as you please. This I learned by a great number of repetitions of these Operations in Refin of Scammony. But let us take Camphire a little into consideration: What kind of Body do you look upon this to be? You'll be apt to answer, a Refin. Shew me then any other Refin in the World, that may be sublimed dry, without any *residuum*, or any alteration in its parts: In this particular, therefore, it is different from all Refins: This, however, may be perfectly dissolved in Alcohol, and upon the affusion of Water, exactly like other Refins, will be recovered into true solid Camphire, intirely the same as it was before. Upon the whole, then, it appears, that Water attracts Salt of Tartar more powerfully than it does Alcohol: Whilst on the other hand, it attracts Alcohol more strongly than that does Oils, Refins, and Camphire,

Water dissolves the Alcohol out of Oils, Refins, and Camphire.

But Water, again, dissolves every composition that is properly called a Soap, or a saponaceous Body, and that, whether it is artificial, or natural: Nor does it at all signify, whether it is fixed or volatile. For every *Sapo* is compounded of an Oil and an alkaline Salt, so united together, that they may be diluted in Water in such a manner, that there shan't be the least appearance, either of

It dissolves Sapo's, and saponaceous Substances, and by this its Power is increased.

the Oil or the Salt, but the whole mixture shall appear homogeneous. The particular property now of such a Substance is this, that if it is intimately mixed with Oils, oily Substances, Refins, resinous Substances, Gums, and gummy Substances, Gum-Refins, or any other tenacious Bodies formed from these, it will render them miscible, and dissoluble in Water, so that they may by this means be washed off from the Bodies to which they adhere. Water, therefore, not only dissolves true Soaps, but by being assisted by them, acquires a power of dissolving those Bodies, which otherwise would have been beyond its efficacy: The dissolving Power, therefore, of Water, by the help of Soap is vastly increased.

Water dissolves Air.

One would scarcely have believed, however, that Water had a power of dissolving Air, unless this had been absolutely demonstrated before in our History of Air. See p. 299, 300. But this in the mean time is effected only in a particular manner, and to a certain degree, but no farther; and indeed, with this circumstance, that the Air, whilst it continues thus dissolved, no longer retains that elastic quality which is proper to it. See the places just cited. In this respect, therefore, Water dissolves Air, as it does Salts, that is to say, in such a manner, that the small Particles of Air dispose themselves between the interstices left between the Elements of Water, as those of the Salts do; and whenever all this Air is perfectly separated from its dissolvent Water, by Frost, the removing the pressure of the Atmosphere, Fire, the Sun, or the Mixture of certain Bodies together, there is then immediately just so much Air imbibed by the Water as was disengaged from it.

And earthy Bodies, first prepared.

In the last place, Water is capable of dissolving many earthy Bodies, when they are first prepared; tho' whilst they were alone, they could never be diluted, and dissolved by it. Oyster-shells, the Claws, and other shelly parts of Lobsters, and Cray-fish, the Shells of Snails, and River and Sea-fish, Stones, the *Calculi*, and stoney concretions in Animals, their Horns, Hoofs, Bones, and the like, when they are first perfectly corroded by their proper solvent Acids, may be afterwards intirely dissolved in Water: Nay, and Chalk, Corals, Pearls, Mother of Pearl, calcined Stones and Flints too, have long been instances of the same thing.

Other Bodies it cannot dissolve.

Having thus then given an account of the Bodies that Water is capable of dissolving, it may be properly enough inquired, which then are those that are capable of standing out against this dissolving power? Why, to this question we shall then only be able to answer, when we are certain that we are masters of some Water that is absolutely pure, without the least Mixture of Salt; for Bodies are very often dissolved by the vertue of latent Salts, and the effect is falsely ascribed to the Water itself; whereas, was this Water quite pure, we might then be able to judge, whether this vertue belonged to the Water alone. In Metals, in particular, the thing is exceeding difficult, inasmuch as Iron, when wetted with the purest Rain-water, is converted into a Rust, and Copper into a Mould. The famous *Joel Langelotte*, indeed, has in his Writings asserted, that Gold may be dissolved by attrition alone: And the ingenious *Homberg* affirms, that simple Water, by being rubbed for a long time with Metals, nay, even Gold itself, is capable of perfectly dissolving their Substance into a potable, medicinal form. These Experiments I have read and examined; but as these have been made in the Laboratories of Chemists, where the Air is impregnated

nated with all kinds of volatile Salts, I have always doubted, whether these Solutions should not properly be attributed to these Salts; especially, considering that the rubbing in these cases was continued for the space of whole months, in which time, tho' but a very small quantity of Salt was applied at once, yet the aggregate of all together, must be pretty considerable. The most ancient, indeed, of the Alchemists, were of opinion, that all things are produced from Water, and at last are resolved into it; and tell us, that Bodies must be always resolved by principles consentaneous to their origin; and hence have acknowledged Water to be the universal *Menstruum*: But they have never let us into the method of practice that would confirm their Doctrine. Pure Earth, however, perfectly free from every kind of Salt and Sulphur, Water will not dissolve; nor will it attenuate and dilute Glafs, Gems, Chrystals, or Stones that are perfectly simple. Hence a great many Bodies of this kind, or compounded of these, it leaves intirely untouched. Hence, therefore, we infer, that Water is not a universal Solvent, but that it is limited to those Bodies which we have enumerated.

Having thus, then, carefully examined the properties of Water, we easily perceive, that it will readily insinuate itself into the invisible, nay, the smallest Pores of a great number of compound Bodies. For as it is very heavy, and consists of Particles that are exceeding subtil, its very great lubricity, and its easy separability into its Elements, will dispose them to penetrate with the greatest ease into the smallest interstices. But the very efficacious power that it has of dissolving such a vast number of Substances, very frequently effects too the resolution of the matter that stops up the Pores of Bodies, and by this means, likewise, it procures itself a passage into them; especially, as its ultimate Elements are exceeding firm and immutable, and hence have a true mechanical vertue, as well as that singular one, which depends upon their contractility.

When, therefore, by this power it has insinuated itself into the minute Pores of Bodies, and perfectly penetrated through their whole Substance, it is no wonder that by this addition of new matter, it should increase their weights. And this augmentation in many of them, which have a pretty great attractive power, with regard to Water, is very considerable; as in almost all Salts, the fixed alkaline ones in particular; most Soaps we are acquainted with; even pure fermented Spirits; and many Solids. Hence those Persons who sell by weight, find a considerable advantage in disposing of such kind of Goods in damp cold Weather, when they buy them in hot and dry. And by this means the Chemists have been sometimes deceived, who taking notice of these increments, and decrements of the weights of Bodies, have frequently ascribed them to fictitious causes, when in reality, they depended only upon this addition of Water.

But as it thus increases the weight of Bodies, so likewise it does frequently their Bulk. Hence, therefore, we perceive, that it does not only take possession of their vacuities, but that it exerts likewise a power by which it separates the solid Elements from one another. This appears to be true by numberless Experiments, but never more evidently than in one made and proposed by the *Academy Del Cimento*. Experiment 184. which because the Book is scarce, you'll give me leave to insert here.

A Cone

Pl. IX.
Fig. 2.And then
becomes
concreted
with saline
Bodies.And then
becomes
concreted
with saline
Bodies.And Sul-
phur.

A Cone AB was made of solid Steel, and formed as exactly as possible, and its altitude divided into some equal parts. There was then another Cone CD made of a piece of Wood cut longitudinally out of a Tree, which was hollowed in such a manner, that its internal conical Surface was fitted exactly to the Convex Steel Cone AB, when the wooden Cone CD was dry. This wooden hollow Cone was then made thoroughly wet, and upon this it was swelled so much inwards, that it would no longer admit the Cone AB into its Cavity, which it easily received before: But at the same time too the Cone CB, which when it was dry, went into another hollow Cone, was so swelled outwards, that it could not now be thrust into it. Thus then it appeared to ocular demonstration, that the substance of the Wood was expanded by the Water in all its dimensions. Hence, therefore, there are often produced very extraordinary and surprizing effects, by Water's insinuating itself into dry Bodies, which by this means become bigger, and by expanding themselves, are the causes of incredible alterations.

After Water now is thus intimately mixed with Bodies, that are of a vastly different nature from its own, it is then in a wonderful manner capable of being concreted with them into a Mass, in which one should secretly suspect there was any Water. This we see evidently to be the case, for instance, in common Sea-Salt, by the following method. Take three pound of this Salt, and cautiously decrepitate it with a gentle Fire, till it don't crackle any longer. Then put this decrepitated Salt into a clean earthen Vessel, and setting it upon a strong Fire, make it just ready to melt, and in this state reduce it to a Powder, mix with it three times its weight of Bole, and with a great degree of Heat, draw off an acid Spirit of Sea-Salt; of which you will have some ounces. Separate this Spirit, then, according to *Homburg's* method, into an Acid concentrated into a Chalk, and a Water; and by this means you will procure a true elementary Water, drawn from Salt, which having pass'd a calcining Fire, one would have supposed had parted with all its Water. But the Water which is very surprizing, is here so concreted with these saline Elements, that the dissolution of them is almost insuperable, nor to be effected without this extreme torture of the Fire. And the same is likewise true in *Sal-Gem*, *Fountain-Salt*, and *Nitre*: Not to mention *Alum* and *Vitriol*, which too, if they are first calcined with a gentle Fire, and then reduced to a very dry Powder, will, if they are urged with a strong Fire, yield an exceeding acid Spirit, which may be afterwards separated into an Acid, and a good deal of Water.

With regard to the driest Sulphur, too, I have often been in doubt, whether that likewise in its substance don't contain a large quantity of Water. Whilst it burns, certainly, it affords a Flame and an acid Spirit; but this Spirit, which is always in a fluid form, may by Art be separated into a pure Water, and an Acid equal to the most condensated Oil of Vitriol. That Acid, therefore, which united with the Vegetable Oil composed the Sulphur, at that very time contained Water in it, and consequently Sulphur, which is an exceeding dry Body, and perfectly combustible, is partly made up of Water, as a constituent Element. I am well appriz'd, indeed, that it may be imagined, and not without reason, that the Water which lies concealed in Oil of Sulphur *per Campanam*, and is procurable from it, may possibly arise from the Air, whilst the Sulphur is burning; for the moister, and more cloudy the Weather is, when this

this Oil is made, the more there is always of it. But supposing that this is true, yet Oil of Vitriol, and Sulphur, have always Water in them, whenever they exist; and hence, as Oil of Vitriol enters into the composition of Sulphur, Water must do so too. For this reason, therefore, we conclude, that Water is in reality a constituent part of all Sulphurs and Salts, and there lies concealed, tho' it may be extracted thence by Fire.

But it appears much more incredible, that soft fluid Water should enter into the composition of the hardest driest Bodies, and then adhere to them so tenaciously, as not to discover the least sign of its being there, nor to be separated from them without the extreme force of Fire. Nay, and even then, we are not absolutely sure that all their Water is expelled out of them. For the separate Elements of Water, which are exceeding solid, no ways compressible, immutable, and considerably heavy, when they are once very firmly united with Bodies, become at length concreted with them in such a manner, as scarcely to be separable from them afterwards by any Art, or violence. This singular property of Water, indeed, we have cursorily considered already in the beginning of this Chapter, whilst we were mentioning the universal concurrence of Water in almost all the works of Nature. We shall now, therefore, by undeniable instances make it appear, that the hardest, and heaviest Bodies, owe the cohesion of their parts, in particular, to Water alone, which like a kind of strong *Gluten*, consolidates them with so indissoluble a union, and binds the Elements with so firm a concretion, that no glutinous matter whatever is capable of doing it more efficaciously. And the Water itself being here concreted with these, and connecting them with one another, forms together with them one and the same simple cohering Body, appearing to us to be perfectly simple. This property of Water, now, should, I think, be particularly taken notice of by the Chemists, who upon Examination would find, that this conglutinating power of Water ought not to be less regarded than its dissolving one: And yet this last is very frequently taken under consideration, and discoursed of, the former very rarely: In the first place, then, let us examine *Gypsum*: This is a very soft fine *Calx* of burnt Alabaster, that may be blown away with a breath; and yet if you mix with this a proper quantity of Water, it becomes a ductile Paste, which presently acquires a stoney hardness, nor parts with its Water again without a great deal of difficulty. But consider, again, the fat Potter's Clay which we instanced in formerly: This, when it is perfectly dried, affords a Substance, that may be reduced to an impalpable Powder, that flies about upon the least breath of Wind; nor if it is kept dry, or burnt only with a moderate Fire, will ever become concreted together; but yet, if you work this with a proper quantity of Water, it will become a pliable Paste, which dried by a gentle Heat, and then burnt in a proper Kiln, yields us Vessels that vie with Stones in hardness, and are capable of holding Water. Lime-stones, or the boney Teguments of Fish, burnt to a *Calx*, produce a loose Powder, that by its volatility is troublesome to the Lungs, nor ever spontaneously grows hard; and yet work it well with a due portion of Water, you will have a Paste, which exposed to the Fire, burns into a Stone. If you mix Sand and Lime together, will these consolidate? Never. Add Water to them, and you have a Mortar, which will so fasten and cement Bricks together, that the union will continue for ages undissolved. And as for the Glues with which we

And earthy Bodies.

join Bodies together, made of Starch, Flower, and the glutinous Substances of Animals and Fish, these all are rendered fit for the purpose by the mediation of Water. If all these things, then, are properly considered, the opinion of these Chemists don't seem so absurd, who assert that Water is concreted with the very hardest Bodies. Who will venture to deny, that Water helps to produce the solid natural Bodies, who evidently perceives this to be the case in artificial ones? Or who will be obstinate enough to exclude Water from compound Bodies, who sees this necessary to the formation of some of the most firm ones?

And the
most solid
parts of Ani-
mals.

But lastly, let us take a view of the driest, hardest, and those that appear the most solid parts of Animals: I mean their Hair, Hoofs, Horns, Teeth, Bones, Ivory, and the Spines of Fish; shan't you be surprized, now, if I assert, that the terrestrial Elements of these several parts coalesce into a proper hardness, by means of the conglutination of Water? But this is certainly the case: For if any of these, after they have been laid by for years, and are become drier than a Pumice-Stone, are put into a glass Retort, and by a strong Fire separated into a volatile part, and a fixed one, the volatile part will be found far to exceed the other. And this volatile part, now, will be almost all liquid, except the Salt; and this liquid part will be resolvable into an Oil, Salt, and large proportion of Water. Hence therefore it appears, that Water is most intimately united with these hardest parts, and serves to consolidate them together; for when by the extreme force of the Fire the Water is all expelled, there remains nothing but loose Ashes, or brittle Fragments, that cohere so slightly, that they are very easily reduceable to Powder. If these Fragments now, which are always black, are afterwards exposed to an open Fire, they become white, and moulder away, and upon rubbing fall into Ashes. But if you calcine a Bone, till it is perfectly white, with heat quite through, and keep it whole, though exceeding brittle, and cohering very weakly, then, if you throw it into Water, you will hear the Water rush into it with a hissing noise, as if violently attracted into the dry Bone, and it will again restore it to its former weight and hardness, the cohesion being by this means recovered. Hence, therefore, we infer, that though Water does not supply the ultimate matter of which the solid parts of Animals consist, yet, as it performs the Office of a *Gluten* to unite the contiguous Particles together, it so long makes a part of the concrete, increases the bulk, and keeps the parts connected together with a proper union.

Nay in Oils,

But as for Oils, now, what person living could ever have imagined, that these are not only not free from Water, but that they are in a great measure made up of it? And yet the famous *Homborg* has proved by very exact Experiments, that distilled Oils may, by a chemical *Analysis*, be in a great measure resolved into the purest Water. *Hist. de l'Ac. roy. des Sc.* 1703. p. 37. *Du Hamel. Hist. de l'Ac. roy.* p. 372. Here, then, we see, that in a matter particularly inflammable, and looked upon as a true *Pabulum* of Fire, the greatest part of the composition in reality is Water.

And Alco-
hol.

Nay, and *Van Helmont* assures us, that the purest, simplest Alcohol itself is, by the attraction of Salt of Tartar, half converted into elementary Water. In burning it, certainly, there is a great deal of latent Water discovers itself, as we took notice before in our History of inflammable Matter p. 189. and following,

following. Whoever, then, is thoroughly apprized of these things, will make no doubt of the extensive distribution of Water, through vast numbers of *Species* of Bodies, and its most firm concretion with them.

But here again we must take care and keep within bounds, if we would not err from the truth: For what has been above delivered with some other considerations has given rise to an opinion among the Chemists, that Water alone is the Matter from which are produced all sensible Bodies. For some of the principal of them have laid it down in their writings, that Water being first rendered exceeding pure by a long continued Frost, and then never thawing again, but by an increasing Cold being condensed, and rendered heavier, would at length be converted into true mountain chrystal. And this they boldly assert to be confirmed by observation in the icy Mountains of *Helvetia*, which look northward, where the Ice never thawing for ages, is said to be thus transformed. Upon which head you may consult *Paracelsus*, and the *Academy del Cimento*. In the mean time, however, this is certain, that Water 40 degrees colder than the greatest observed natural Cold, thaw'd again immediately. Nor can the constriction effected by Cold ever so far condense Ice, as to make it come up in weight to Chrystal, much less to the solidity of a Diamond. It is not at all probable, therefore, that Gems are ever produced from frozen, condensed Water, but that these spring from their proper Seeds, as well as all other Bodies. The great *Verulam* says, indeed, that no nutrition is carried on without Water, p. 656, and that nothing grows without it: But this is true particularly of Animals and Vegetables. In Metals the case appears to be intirely otherwise, unless by Water you will understand Mercury; for the Adepts used to call Mercury the Water of Metals, nay and simply, Water, or their Sea. But who can ever believe, that Water can ever be rendered 14 times heavier than it is, in order to be converted into Mercury? Nay, and in Animals and Vegetables too, though its certainly true, indeed, that Water contributes vastly to the Matter of their Nourishment, and the intimate connexion of their constituent Elements, so that hence they partly consist of true transformed Water; yet it never has appeared, by any certain Experiments, that Water is capable of producing all the parts of these Bodies. I am well apprized of the Experiment of *Van Helmont* on the Willow supported by Water alone, which he so carefully describes, p. 88. 32; and the illustrious *Boyle's* account of the Gourd, and other Vegetables, sprung from Water alone, and increased to a very considerable weight. *Orig. Forms.* p. 165. Whence these great Men have been led to think it evident that the most simple elementary Water, being applied to the living Seeds of these Bodies, is, by their seminal power, transmuted into all the Elements both of Animals and Vegetables; so that hence their whole Substance has its rise from mere simple Water. But this doctrine *Van Helmont* advances and urges, because all Animals and Vegetables, when they are dissolved and cohobated with the Liquor *Alcabeſt*, are always changed at last into a mere simple Water, equal in weight to their former Body. As for this *Alcabeſt*, however, of *Van Helmont*, I confess I know nothing of the matter, nor have I heard of any person who since him has pretended to be Master of this wonderful Liquor, and to have performed the same Experiments. But be this as it will, by a more accurate inquiry into Nature, it is since evident, that Water, indeed, is the principal Vehicle to convey the Matter of Nourishment to the Bodies both of Ani-

Water how-
ever does not
produce eve-
ry thing.

imals and Vegetables, the Water at the same time not being the Matter itself, but being filled with various heterogeneous Particles that are: For the purest Rain-water always abounds with a great number of Corpuscles, very much resembling the nature of Vegetables: And the more any Water contains of a rich muddy Matter, the more weight it will give the same vegetable growing in it for the same time. But the greatest part of the Water that enters into plants soon exhales out of them again, which perhaps would not have been carried up into the Air, if it had not been received into them; and farther, the pinguious Matter that is mixed with the Water, is found to be consumed, whilst the Vegetation of the Plant is thus carried on in Water, Upon this head see the curious Experiments of the famous Dr. Woodward, *Phil. Trans.* No. 253. p. 193. which were afterwards repeated in the *Royal Academy of Sciences at Paris*. We cannot, however, deny, but that Water is sometimes intimately united with the solid parts of Bodies, so far as it becomes concreted with them into the same Mass; so that in reality it not only performs the office of a Vehicle, but likewise concurs in the composition of some parts both of Vegetables and Animals. And hence the ancient Chemists asserted, that Water is the universal Wine which all Plants, Animals, and Fossils drink. In this sense therefore we may venture to say, that Water is the Matter from whence all things arise, and from which, by the incubation of a pregnant Spirit, they are all produced.

A repulsive
force be-
tween Water
and some Li-
quids.

But there are some Bodies which refuse any conjunction with Water, and if it is brought in contact with them, repel it, but yet without any motion in their proper Substance. Oils, for instance, so strongly resist any union with Water, that if you forcibly mix them together, they will disengage themselves again, collect themselves into orbicular or spheroidal Bodies, and repel the Water from their Mass thus united under the smallest possible Surface. Balsams, Colophonies, and Resins melted with a gentle Heat, have likewise the same property. In these, as I remember at present, there is only this difference, that the more subtil Oils grow, the less they are averse to this union, the thicker they are, the more: And hence, when they come to be rendered exceeding thin, they at last become easily miscible with Water, and then will remain mixed with it for a long time, and that, though the Oils are exceeding pure. This, however, must be understood of Water that does not spontaneously lie concealed in Oils; for concerning this Water we have treated already.

And Solids.

But some solid Bodies, likewise, repel Water, those especially that are exceeding solid, or have a very smooth shining Surface. Thus we observe this property in the Furr of Beasts, the Feathers of Birds, Webbs of Spiders, and Bags, and Silk of Caterpillers, and Silk-worms; particularly if the Animals are in health. I confess, indeed, in all these there is an unctuous matter disposed all over their Surface, that has something of the nature of an Oil, and on this account repels the Water, for which reason, when they are boiled with a sharp Lye, and this is scour'd off, they repel it less than they did before: But still it is observed, that a very smooth surface will have the same effect. Examine plates of Metal, for instance, when they are perfectly polished, and you will find, that Water will not only not adhere to them, but that it will fly from them, whereas they would easily retain it if they were rough. Dry Ivory and Stones imbibe Water with their rough Surface, but when they are very nicely polish'd, they repel it. This, you'll say, perhaps, is owing to the Pores being stopped up.

up by the Polish, nor do I deny, but this may help, but even to the very external Surface it won't adhere, now it is polished, to which it would when it was scabrous. Is this, therefore, the reason that the Bodies of Fish, which are so soft, and dissolve so easily, are every where covered with smooth shining Scales, and a pinguious subcutaneous Membrane, that thus they may be able to withstand the effects of the Water, in which they are to live, and in which they so soon dissolve? And does it hence happen, that as soon as ever Fish are dead, their Scales are relaxed, and this oily Substance decays, the Water soon macerates their Bodies, which, had they lived, would have continued firm for a long time? *Act. Lips.* 87. p. 160. *Perault. Eff.* T. III. p. 297.

Having thus, then, examined the general properties of Water, we must now add a few things concerning the different sorts of it, for the service of the Chemist. In the first place, then, let us begin with Rain-water; and this certainly one may properly call the *Lixivium* of the Atmosphere, in which are contained all the *Species* of Corpuscles, that were floating about in it. Of what kind, now, these are, and what great variety there is of them, we have already treated particularly in our History of Air: Let these things, therefore, be consulted from p. 282 to 292. There it appears, that in this Air is dispersed every kind of volatile Bodies. But Bodies are either spontaneously volatile, or become so by Fire, Fermentation, Putrefaction, Mixture, Separation, or Effervescence: And hence Salts, Spirits, Oils, *Sapo's*, Earths, and even Metals themselves, are found there. These, however, will be distributed there in various manners, according to the diversity of the exciting cause, which for the most part is the Fire of the Sun, subterraneous, culinary Fires, or mechanical ones, made use of by Artificers. But this variety that is observed in Rain-water won't depend only upon the exciting cause, but upon the diversity of the Soil too, from which the Fire raises the Particles, and mixes them with it. Nor will the difference in the seasons of the year produce a less alteration in this Water: For we find, that the Vernal, Summer, Autumnal, and Winter Rains differ very much, both in the Matter they contain, and the Effects they produce. Vernal Rain-water, for instance, is particularly disposed to Fermentation: For this is replete with those Bodies which the Winter Cold had locked up in the Earth, and the succeeding warmth now resolves, dissipates into the Air, and mixes with the Rain. But the various alterations of the Weather, likewise, make a very considerable difference too in the Rain that falls at different times. Thus that which comes down after a very long Drought, appears by every character to be quite of another nature from that which falls after the weather has been rainy for a considerable while. To these causes add the Meteors that are frequently observed in the Heavens. The Water that falls with Thunder differs from the rest: Not to mention the Winds that carry the Water of the Air from one place to another; by which means it happens, that when Rain succeeds high Winds that have blown for a good while from one quarter, this is full of the Exhalations proper to places at a very great distance, and brought from thence by the Winds. These various Corpuscles, now, the Winds put in agitation, bring together from opposite places, mix with the Rain, and thus bring about a wonderful Mixture, greatly beneficial often to the Corn and Ground. And hence, as frequent observation teaches us, if the Rain that falls in very hot weather is caught in clean Vessels, and kept in them for some time, it will spontaneously putrify into a fetid, pu-

The nature
of Rain-water
various.

trid Liquor; though, as far as I remember, no body has ever observed Rain-water to grow acid. For my own part, at least, after a great number of trials made in the examination of Water, I have never, I confess, discovered any such thing. But when this Water has thus spontaneously grown putrid, it may be easily rendered wholesome again, and may be drank without being offensive; for if you give it only one boil on the Fire, the Animals that are in it will be destroyed, which, with the rest of the impurities, will subside to the bottom, and then if you make it moderately acid, by adding to it a small quantity of an Acid that is very strong, it will be fit for use. This is found to be of excellent Service under the Equator, and between the Tropics, where the Waters putrify so horribly, and breed such quantities of Insects, and yet must be drank. And for the same reason, a small quantity of Spirit of Vitriol mixed with Water will prevent its growing putrid, and breeding any Animals, and at the same time it will continue wholesome and good. But again, by all the Experiments I have made, I have never been able to raise Rain-water into a fermentation, and so convert it into inflammable Spirits. I have found, however, that in Rain-Water catched in a high, pure place, in clean Vessels, there swim about little pregnant Seeds of a very fine, green, river-weed; for upon keeping this Water in very pure Glasses, there first appeared some very small Corpuscles, discovering themselves by their green colour, which gradually increasing, at last extended themselves to a considerable breadth, and upon examining them with a Microscope, I found them to be perfect little Plants. If you rather believe, that in this case the Seeds fell out of the Air into this Water, the thing will be the same; for then as the Rain falls through the Air, they may come down with it. The invisible Seeds, likewise, of a great many kinds of Mosses being interspersed in the Rain, occasion abundance of little Plants too of this kind springing up in this Water. But much the most numerous, that thus grow in Rain-water, are the *Funguli*, which upon examination with a Microscope are found to be much the finest of all, and in the greatest abundance; but the collection of these to the naked Eye appears disagreeably, and looks like a Slime. These then are the principal Vegetables that properly belong to Rain-water, and which by no caution, hardly, can be kept out of it. In one part of the Year, however, they are in greater plenty than they are in others, and hence, in this respect, they produce some variety. But farther, Rain-water catched in the Spring and Summer Season, has been found tainted, likewise, with the impregnated little Eggs of Insects, and has discovered to the Microscope little Animals produced in it, especially when it has been cherished for a good while by the heat of the Sun, and being openly exposed to the Air. In a little drop of Water, thus circumstantiated, what numberless Animals have often appeared, as we learn from the industrious *Lewenboek*? You begin, therefore, to be sensible, with how little reason Rain-water is looked upon to be pure. But in Rain-water there is nothing more surprizing, than that if the very purest of it is perfectly shut up in a Vessel, it in a short time begins to form small, white Clouds, which increasing in number, and magnitude, grow continually more and more opake, and at last degenerate into a fine, tenacious *Mucus*, and change the Water into a slimy Fluid. Hence, therefore, it comes to pass, that when it stands quiet a good while, it is observed to form itself into numerous filaments, to deposite a seculent Matter, and alter in Colour, Smell, and Taste,
and

and after having passed these changes, to acquire at last the rancid smell, and nauseous, nay sometimes intolerable taste of a vapid, mucilaginous Water. This, then, O ye Chemists, is the true Nature of Rain-water, so far distant from a pure simplicity, and so tainted with various impurities! And yet this is the lightest sort of all that we have amongst us; whilst at the same time all others, in almost every place, are somewhat heavier. And, indeed, this is Water truly distilled by nature; for it is raised from the Surface of the Earth, by the gentle warmth of the Air, and carried to such a height as no chemical distillation can possibly imitate; and it returns out of the same Air, without being in the least rendered impure by any Vessel. On this account, therefore, the Chemists can scarcely by distillation prepare any Water purer than that which Nature thus yields us: This appears very evident, if we will but carefully consider the Water which the Chemist distills; the Vessel in which he performs his Operation; the Fire he makes use of; the small height to which he raises the Water; and the Air through which he carries on his distillation: I say, if we will but consider these things, and compare the natural distillation with this artificial chemical one, we shall not wonder, that distilled Rain-water is not lighter than the natural, but hydrostatically the same, as I have learned by undoubted Experiments. Among all the varieties, now, of Rain-water, that of Snow is found to be the lightest. *Boyl. Med. Hydrost.* p. 134. And this Snow-water, the higher the place it is caught in, as it comes down, the purer and freer it will be from the grosser and heavier Particles, inasmuch as it won't be mixed with these as it falls. And again, if after it has been for a long time very cold and dry, the Water aloft is formed into snowy Flakes by a sharp Frost, then this Snow will be the purest of all, especially if at the same time too the weather has been very calm, so that the purity of the Air has not been disturbed by the admixture of a variety of volatile Corpuscles. When the Snow, therefore, has fallen upon a sandy, barren Mountain, a great way distant from any commerce of mankind, and has perfectly covered the Surface, and is risen to a considerable height, then if you very gently take off only the upper part, this Snow will be as pure as it is possible, either artificially or naturally, to procure it: For in this there will be scarcely any Salt, Air, Oil, or other Bodies. Hence this Snow, when it is melted, yields a Water different from all other. The Water, indeed, of this Snow is the purest of all we are acquainted with, is exceeding immutable, capable of being kept for many years, and is a singular remedy for inflammations of the Eyes. From such pure Snow as this the Alchemists long ago asserted might be extracted, by a secret method, a very red Body, which lies buried and concealed, by an igneous power, in its inmost recesses. And that this Snow, when it falls upon the same place for some ages together, leaves every time a very fine Crust, which in a series of years rises to a considerable *Stratum*, and renders the Soil there extremely fruitful, the famous *Olaus Rudbekius* proves by abundance of arguments, in that infinitely laborious Work, his *Atalantis*. p. 128. Thus much, then, for the method of obtaining the very purest Rain-water. But farther, this Rain-water being digested for a considerable time, putrifies, stinks, and if it is then distilled, yields oily Spirits, that are in some measure inflammable. And being digested, putrified, distilled, and concentrated, it has afforded a very fragrant Spirit, which very gently dissolves the Body of Gold, without any effervescence. *Aët. Lips. An. 90.* p. 86. When it is put into Casks,
and

and by the heat of the weather has putrified between the Tropics, it afterwards loses its stink and putridness, settles, and grows very clear. *Phil. Transf. Abr.* Vol. II. p. 326. The most impure Rain-water, now, of all, is that which falls in very hot and windy weather, and is caught in places about cities that are low and fetid, where Animals, Vegetables, and other Substances, by the vast number of people are perpetually dissipated into the Air; especially if at the same time that Air is foggy, thick, and stinking, so as to affect the Nose with a very disagreeable Smell, and the Lungs with a noxious Vapour; which Stink, as it often comes without any visible cause, so it disappears again in the same manner, without leaving the least mark behind it, and perhaps afterwards returns again as it went. We have likewise observed, that when it has been exceeding hot and dry for a long time, and there succeeds great Thunders, with large showers of Rain, the Water that then falls, if it is collected in pure Vessels, produces a Froth, which seems truly to contain something of a very fine kind of nitrous Salt. And Rain that has come down with terrible Whirlwinds, has been sometimes found to be fetid, and if it fell upon any garment, in the space of four and twenty hours, filled it full of Animals *Phil. Transf.* No. 127. p. 652. Abrid. V. p. 171. Hence, then, we may easily see the reason why this Water is so greatly conducive to the fertility of the Earth, both as it contains a very subtil Matter, which furnishes Particles both for the solid and liquid *Pabulum* of Plants, and at the same time is the most proper Vehicle to carry to them all those Substances which are necessary to their nourishment. If the Water, now, collected from melted Snow, and mentioned before as the purest, is distilled once with a gentle, clear Fire, in tall, clean Vessels, this may be looked upon as the very purest of all, especially if this distillation is performed in a place that is free from Smells and Vapours. After having tried a great many different methods, I have not found any one by which I could render Water more pure than by this. I know, indeed, that some chemists, when they wanted Water exceeding pure, have distilled it very gently off of fixed alkaline Salts; and by this means, it is true, they have fixed all the Acids in the Alkali, and easily retained in it both the oily and the terrestrial Particles, but then, at the same time, there is somewhat of a lixivious quality communicated to the Water. Others, therefore, have distilled these Waters off of *Sal Gem*, Sea Salt, Nitre, and the like; but the Water they obtained by this means was always more impregnated with heterogeneous Particles. Nay, though you distill it successively with different sorts, you won't make it at all purer, as I learned by performing the distillation alternately, with alkalious, acid, and compound Salts. This purest Water, now, when it boils on the Fire, has that fulminating quality which we formerly described, and concerning which we took notice, that it did not depend upon the Air, nor does it ever lose it, though it be ever so pure, and has been distilled some number of times. But it remains farther, that we lay before you those Marks, which in such a manner belong to this purest Rain-water, that they serve to distinguish it from every other sort. In the first place then, if this pure distilled Water is mixed with other Waters less pure, there immediately appears a whiteness upon the mixture, though they both were very clear before. If the best common, or Venice Soap is dissolved in this Water, the solution is perfectly equable, without any small soapy Fragments; whereas,

if you dissolve it in Water less pure, you will observe such little Masses appearing half dissolved, like Milk that is half curdled. If it is poured upon wax, that is to be exposed to the Sun, or thrown upon Linnen that is to be whiten'd, it gives them an exquisite whiteness, whereas that which is impurer leaves them not so clear. Of all Waters, this grows hot and cold again the soonest: But by boiling, it never becomes better. If into this Water, when it is cold, you throw the purest Gold or Silver, when they are perfectly melted, either separately, or together, they pass quietly through it, and fall to the bottom, divided into little grains: This the Assayers call Granulation, and it is of excellent service in a great many chemical Operations. Iron, Tin, and Lead, in fusion thrown into this Water, in the same manner, fly from it with a very violent motion, and a great noise, so that the mixing these with it is much more dangerous. But what a surprizing quality has Water, with respect to melted Copper? Certainly, if you throw this into Water, the Copper, Water and Vessel will be agitated with an incredible noise and fury not to be restrained, to the imminent danger of all around it. Nay, it has been confirmed by very fatal instances, that upon a small quantity of Water's being poured upon this metal, when it was in fusion, every thing about it has been torn to pieces, with an *impetus* almost quicker than that of Gun-powder. This surprizing property, now, I am of Opinion, cannot be understood, or explained, from any common principle of Bodies. In the last place, Rain-water, when it is simple and pure, may be looked upon as the Mercury of Animals, and Vegetables; for then in point of simplicity it is not inferior to the Mercury of Metals. Then, according to *Van Helmont*, it is the first Element, out of which all things are produced, and the last into which they are all resolved. But this doctrine, as we took notice before, must be allowed only with proper restrictions.

All Spring-water owes its origin intirely to Rain-water. For the Heat raises the Water from the Surface of the Earth, and the Waters, into the Air; and then the Air, when it is thus replete with watery Vapours, being stopt against the cold, broad tops of high mountains, applies it to them, by which means it is there collected into drops, exactly in the same manner as in our distillations. These drops afterwards uniting together, run down the sides of the mountains, either in little streams on the surface of the ground, or else sinking down into some subterraneous passage, there form a kind of reservoir, and descend from thence. When these places, now, are higher than those where these Waters find an out-let, there the Fountain plays up so much higher in proportion, as these collections of Water are higher than the mouths where they burst out. Hence, then, we see the reasons why there are no Springs, except in the neighbourhood of mountains? Why there are most Springs where the Mountains are most in number, highest, and most solid: And why in Vallies situated between Mountains, Springs are most frequent, and rise highest. Hence, likewise, we understand, that Spring-water can never be more pure than Rain-water, since the purity of the former depends intirely upon the latter. And how, indeed, is it possible it should be more limpid than that Vapour from which, when it was aloft, it took its origin? For, certainly, Water can by no method be purified more than by being carried to such a height in the Air. This Rain-water, however, thus collected into
Spring-

Spring-water, if it happens to fall into places that are full of Flints, then, being detained in their Interstices, and running through them, it there deposits all the heterogeneous Particles it was before tainted with, and at last, having been purified through these Meanders, it becomes pure Water, clearer than Amber. This then is the method which Nature makes use of to bring Water to its greatest clearness, and simplicity; and this is the Water mentioned by *Virgil* as *exercitata cursu*, and described by him as purer than Amber: Nor do I know any other contrivance whatever, by which it can be rendered more pure. But we know, likewise, that our common Sand or Gravel is nothing but a collection of very pure Chrystals, or little Flints. And the figure of these, now, is so vastly irregular, that it is scarce possible to find any two that are perfectly alike. Hence they can never be so placed among one another, as not to leave some empty Spaces between them; and for this reason, if the Water that distills from the Mountains happens to light upon these sandy Gravels, it then running through the small Interstices of the Sand, becomes a good deal more pure than it was before. And hence, too, even Rain itself, falling upon the Surface of sandy Mountains, and then strained through very clear Sand, runs down in form of very pure Water. This Spring-water, however, when it runs through such places as contain Substances that are easily dissoluble in Water, it then in its passage dissolves such Bodies, and carries them along with it. Nor does it at all signify, then, whether it runs through Rocks, Sand, Hills, or Mountains, for it will still retain these dissolved Particles. And hence it comes to pass, that Brooks, Rivers, and Springs acquire the Nature of that Matter, which lies in the Channels through which the Waters pass. For this reason, therefore, nothing can be asserted concerning the particular disposition of Spring-water, till we are acquainted with the nature of the subterraneous Passages through which it runs. A reflexion upon Alums, Salts, *Sapo's*, and Vitriols, makes this sufficiently evident. Thus sometimes it comes out under the name of Chalybeate Waters, called the *Acidulae*, though the egregious *Hoffman* has made it plainly appear, that these are of an alkaliescent, volatile Nature, and are replete with an embryonated Spirit. And often, you see, it appears in sulphureous Baths, vastly different from the former, though they both owe their origin to the same Spring-water. Some Springs again are wholesome, and have a medicinal vertue; whilst others are pernicious and poisonous. Nay, there are some which are endued with a petrifying quality, as is observed in the petrifying Cave in *Burgundy*, about a mile distant from *Quingey*, where the Water, as it drops down, petrifies into statues of all kinds of figures, *Journal des Scav.* 1688. p. 432. And yet what is particularly surprizing, these petrifying Waters don't generate Stones in the human Body. *Mem. de l'Ac. roy. des Sc.* 91, 92. From all these instances, then, it evidently appears, that nothing can be asserted of the clearness, weight, and vertues of Spring-water, that will hold universally true; but we must examine every one particularly, if we would rightly understand its nature. And indeed there is no consideration makes this plainer, than this, that if you boil any sort of Spring-water whatever, for some time, and then let it stand to cool, it will always deposite some *Fæces*. But whilst we are thus examining all the circumstances of Spring-water, there is nothing more particular and extraordinary than that you shall have none of this Water in some places, though you dig to a prodigious depth.

A surprizing instance of this we have given us by the famous Dr. *Plot*, in his description of *Staffordshire*, where he tells us of a Well that appeared by letting down a Line to be 2600 feet deep, tho' it did not then touch the bottom; and yet in all that depth, there was no Water to be met with. How prodigious solid must the bottom of that Well be, to prevent any Water's bubbling up through it? And how very strong and solid must the sides of this Well be from the Surface of the Earth to the depth of two thousand six hundred feet? Consult the famous Author, and *Journ. des Scav.* 1680. p. 14.

River-water should come next under our consideration: But as all Rivers that run with a constant course, owe their origin intirely to Water collected from the Air by Mountains, as we have just now mentioned to be the case of Springs, hence the matter of them both originally will be perfectly the same. In this respect, therefore, every thing that has been said of Spring-water, may be applied to River-water. And the principal difference, indeed, that there is between them, is this, that Spring-water almost always runs underground, whereas River-water being generated on the Mountains, trickles down the sides of them, collects itself into little streams, which gradually uniting together, form Rivulets, and at last terminate in large rapid Rivers, always exposed to the open Air. Hence, therefore, whatever falls from above, whatever is brought by the Wind, whatever is added by Vegetables that fall into them, whatever is brought thither by Animals, or deposited there by Fishes, or amphibious Animals, all these things are collected in Rivers, mixed with their Water, and lodged in them, and there may be macerated, putrified, and at last dissolved. River-water, therefore, besides containing every thing which we mentioned before of Spring-water, may have all these Bodies mixed with it likewise. If you please now to consider, that these Rivers thus coming from the Mountains, let them run ever so far, at last discharge themselves into a Sea that is lower than those Mountains, then you will easily perceive the reason why they never stand still, but constantly keep on their course towards the Sea. Hence, likewise, we understand, that Rivers, whilst they are continually running through so many different places, as Woods, populous Cities, &c. their Water must in every one of these become perpetually of a different nature. For this reason, then, again, we must not pretend to pronounce absolutely concerning the particular nature of River-water, but consider here, likewise, what alteration it continually receives by this addition of new Bodies. The Rain-water, certainly, that comes down from the Clouds, mixes itself with this River-water: As we see likewise Animals, Vegetables, and Fossils, in different places, and times, are dispersed through it likewise. What wonder, therefore, is it, that some Water taken in by the *English* at *St. Iago*, and put into Hogsheds, should be so altered, that when they were about the Island *Borneo*, it should, by the Heat of the Weather, emit a Vapour, which upon a Candle's being apply'd to it, catch'd into a bright Flame? The Water at that time was exceeding fetid, but after it came to settle, it grew very sweet again. *Philos. Transf. Abridgm.* T. V. p. 271. *Thames* Water, put into Casks, stinks, and comes to itself again. And *New London* Water stank prodigiously in eight days time, but being carried to *Virginia*, it again became sweet. *Phil. Transf.* N. 127. p. 652. And again, the same *Thames* Water being put up into Hogsheds, and carried into hot Countries, within the space of 8 Months, was changed into a Liquor abounding

with inflammable Spirits, so that the Vapour of it took Fire like Spirit of Wine. At that time too it stank; but upon the admission of the fresh Air to it on opening the Vessels, the stink was all gone in four and twenty hours; but if the Vessels with their Water were well shook about, it went off in five hours in such a manner, that it was not at all troublesome: And yet this stinking Water when it is drank, is born by the human Body without any inconvenience. *Transf. N.* 268. p. 838. *Transf. Abridg.* T. III. p. 547. *Mem. de l'Ac. Roy. des Scav.* T. I. p. 404. If Sea-water, now, is drawn off by distillation, and is then mixed with River-water, it uses to prevent this putrefaction, as appears by the Experiments of *Du Hamel* upon *Menstruums*, p. 412. But again, in the Kingdom of *Congo*, there is found a Water, the froth of which, if it lights upon Straw, and is then exposed upon the Shore, concretes into a tenacious matter, which when it comes to the Fire, grows hard like Iron. *Æt. Lips.* 1687. p. 650. And the Water of the *Rhone*, if it is first suffered to stand and settle, and is then put up into earthen Vessels, will not putrefy by Heat, tho' it will very much if it is put into wooden ones. *Æt. Lips.* 1683. But farther, upon a careful Examination by Experiments, it has been observed, that Rain, Snow, Spring, and River-water, hydrostatically compared, scarce differ one thousandth part of their weight; and that, tho' some Water from the *Ganges* was tried among the rest. *Boyl. Med. Hydr.* p. 104. Hence we can scarcely understand, or think credible, what is told us by another Author, viz. that there is a Water in some part of *Africa*, which upon an accurate hydrostatical Examination, appeared in the Bulk of one pound to be four ounces lighter than the Water in *England*. *Boyl. Useful. of Phil. Experim.* Part II. p. 114. I wish this surprizing Experiment had been more exactly described, and confirmed by proper authority: The thing certainly is of consequence enough to deserve it: For if this was found to be always the case, then what *Herodotus* tells us of the Water of the long-lived *Ethiopians*, would appear to be perfectly true. But not to grow too prolix, I think what I have said sufficient to let us into the nature of River-water: For it appears to me very evident, that the impurities of such a vast number of Bodies as are mixed with this Water, supply that matter which causes it, when exposed to a great Heat in wooden Vessels, to suffer and undergo all those alterations of Fermentation, and Putrefaction, which we have just now mentioned; which, therefore, are to be ascribed to the contents of those Waters, and not to the Waters themselves.

Standing-
water.

But we must still add a few things concerning the Waters which stagnate in Lakes, Ponds, and Ditches about Towns; for these likewise are frequently made use of by the Chemists. If we consider this sort about our City of *Leyden*, we find it to be a *Lixivium* of all the Privies and Common-shores that are continually discharging themselves into these publick Ditches. At the same time too, vast quantities of materials made use of in dying our Wool, Hair, and Silk, are here dissolved likewise; by which means what a surprizing and confused Mixture must hence arise? Certainly, Alum, Tartar, Vitriols, the Substances that give the Colours, and *Aqua Fortis*, are perpetually running in great abundance from the Dyer's Coppers into this Water. And yet all this Water, now, is either discharged into *Harlemer Meer*, or only gently flows backwards and forwards. Why, therefore, should it seem at all strange, that a good many Articles in dying should be brought to greater perfection here by the help of these Waters,

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than in other places, where they are attempted in the same manner without them? That this is the case, abundance of Experiments confirm. This stagnating Water, now, is a good deal heavier than pure natural Water: For 12 ounces of this Water being put into a glass Bason, and exposed to a gentle Heat, when the Water was exhale'd, discover'd at the bottom a great many little Insects of various kinds, and besides, a large quantity of earthy Matter, yellowish, and of a limy nature, together with Mud; which being mixed with *Aqua Fortis*, produced a very strong Effervescence. Various kinds of these Waters, now, being examined hydrostatically by a glass *Index* immersed into them, there appeared to be a considerable difference in their weights, which reduced to a Table was as follows. First, pure Rain-water, caught as it fell, was found by this Instrument to be lightest of all, and therefore this was made use of as a standard for the rest. Secondly, Water taken out of the river *Salé*, was one Line heavier than the former. Thirdly, the medicinal Waters at *Hall*, were two Lines heavier. Fourthly, the Spring-water there was four Lines heavier. Fifthly, the Spring-water in the Houses was six Lines heavier. Sixthly, that Water being put into an open Vessel, and let stand a good while in a Cellar, was six Lines and a half heavier. And Seventhly, the Water that stagnated thereabouts in the Ditches and Lakes, was found to be heaviest of all, viz. to be seven Lines heavier than the first Rain-water. All these Experiments made with a great deal of caution, and accuracy, are faithfully related by the egregious *Hoffman*, in his *Exercitationes Physico-Chemicæ*, which can be never sufficiently recommended. How careful, therefore, ought we to be in making Experiments with Water, which appears to be so various; since every sort of it, in regard of its different contents, must so far constantly produce different effects? We ought, therefore, to be acquainted with the methods by which its purity may be discovered, before we make use of it for these purposes. One of the best ways then of trying whether Water is pure, is by a Solution of Silver made in *Aqua Fortis*, and then diluted with the purest Water we can procure: For if you then drop some of this Solution of Silver into any Water you want to examine, if it don't thereupon grow turbid, opaque, or white, you may safely enough depend upon its being very pure, except, that it may contain some Spirit of Nitre, or *Aqua Fortis* in it. In the same manner the best Oil of Tartar *per deliquium*, diluted in a good deal of pure Water, sufficiently demonstrates the purity of the Water under Examination, if upon being mixed with it, it produces no alteration in it; for if there is any thing else in it besides alkaline Bodies, it immediately discovers it by a sudden change of its Colour. But there is nothing in this case more easily affected than a Solution of Sugar of Lead in the purest Water you can get; for if any heterogeneous Water is dropped into this, its impurity appears in an instant. Consult the *Acad. del Cimento*, p. 237, where you will find various valuable Experiments. Such Marks, now, as these, that thus serve for the Examination of Waters, are of infinite service in chemical Inquiries, where there is an incredible nicety required, since the very least admixture of any foreign Matter will often render the whole Operation ineffectual. How often have the Chemists, to their great disappointment, experienced the truth of this, when they have been engaged in raising the *Arbor Dianæ*, or in the chemical Production, and variation of Colours?

Ice, the natural state of Water.

Upon an Examination, now, of what has been said, we are obliged to conceive of Water as a kind of *Species* of Glass which melts in a Heat of 33 degrees, and grows hard in a Cold that is a small matter greater: For it then becomes a hard, elastic, brittle, pellucid, inodorous, and insipid Mass, that may be polished into durable *Lens's* and *Menisci*, for Microscopes, and Burning-glasses. This Glass, it's true, is volatile; but in other respects, is the same as the common. And if we regard it now with proper attention, it is pretty surprizing, that from so soft and fluid a Body as Water, there should in a short time be produced so hard and solid a one as Ice: And that from Corpuscles, which whilst they were in a state of Fluidity, had no signs of elasticity, there should, now they are constringed together, arise a Mass that is exceeding elastic, and which being formed into a Ball, rebounds like Glass, or an elastic Metal. And this hardness, now, and elasticity, thus produced in Ice, increases continually in the same proportion as the Cold increases, so that when at last that comes to be very intense, Water becomes hard like true Glass, and acquires a prodigious elasticity. But this Glass arising from Water, dissolves again in 33 degrees of Heat, and then becomes immediately volatile. Some ingenious Men, indeed, have asserted, that by a strong and lasting Cold, the Particles of Water may be so united together, as to be converted into Chrystals and Gems, that would not melt in a common Glass-house Furnace: But that this opinion is not sufficiently confirmed by proper Experiments, we have taken notice already. If you suppose, however, that this may be true, then Water, by this transformation, would be capable of receiving such a quantity of Fire into it, as to make it red hot, and shine in the dark like Metals, Stones, and other solid Bodies. But so far as we are hitherto acquainted with Water, it is found impossible, by any assistance of Art or Nature, to increase the Heat of it to more than 214 degrees, unless at the same time you compress it with a greater power than common. If, indeed, we could compress Air a thousand times more than it is compressed by a common Atmosphere, in this case, possibly, one might heat it nine thousand degrees farther; which Heat would then be much greater than that of melted Iron. But in the last place, as soon as ever frozen Water is dissolved by the warmth of the Air, all its hardness, elasticity, and brittleness, are at once perfectly destroy'd.

When it thaws, it becomes a Solvent.

And no sooner is Ice acted upon by the very least degree of a Heat that is able to thaw it, but it immediately becomes a *Menstruum*, a moving cause, and the most universal Vehicle, which dissolves, in particular, the more active Bodies, mixes them together, applies them to one another, by uniting itself with many Bodies that are too acrid, renders them more mild, puts all Bodies in agitation, and so produces the most remarkable physical changes, and operations.

In Animals the Vehicle of Aliments.

In Animals, certainly, all Nutrition is carried on intirely by the help of Water. Not, indeed, that the Elements of Water are converted into the very Elements of the animal Body, for this is not so universally agreed on, but without the assistance of Water, the true nutritious Particles can scarcely be convey'd to those parts of the Body that want a supply of Nourishment from them. As Water, therefore, alone, is a proper Vehicle for this purpose, hence, of consequence, Nutrition cannot be brought about without it.

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But neither is there any such thing as Life itself in Animals, without the concurrence of Water ; for this is the softest, most fluid, and finest part of all our Humours, and penetrates most effectually into all, even the minutest Vessels of the Body. If this is too much diminished, Life itself is soon at an end, the Blood and other Fluids being by no means capable of carrying on the Circulation : Nor is there any known Liquor in Nature that will by any means be able to supply its defect. Hence, therefore, every vital action depends upon Water, as it is this that renders the other Humours fit to circulate through their proper Vessels. Whoever by a very gentle Heat has separated the Water from any animal Juices, either the thickest, or the most diluted, has always found, that this constituted much the greatest part, and disposed the remainder to pass through the Vessels designed for them. And again, if you examine any solid part of the Body, you will find, that likewise owes almost all its aptitude to the actions of Life, to Water alone, which being once removed, it becomes incapable of them immediately.

The Instru-
ment of Life,

Nay, and Health itself, which is the greatest perfection of Life, and the exercise of all the actions necessary to it, depend upon, and are effected by Water, more than any thing else. The increase of the Body is brought about principally by Water. Water is the cause of a great many diseases, and a great many are removed by it. Death itself is often occasioned by an excess of Water, but much more frequently by the defect of it. And lastly, Water performs the most happy Cures.

And Health,

And that Water is equally serviceable to the Life, Health, Nutrition, Increase, and other Actions of Vegetables themselves, is very evident from what the famous Dr. Woodward has given us upon this subject, in the *Philosophical Transactions* ; which has been since confirmed by the ingenious Dr. Hales in his *Vegetable Statics*. The whole fruitfulness, certainly, of the Earth, arises from Rain and Snow, by which a fertile Crust is gradually spread over the most barren Sands, and there produces a very black and fruitful Earth: This we learn from the elegant Observations of Olaus Rubekius, whom we have mention'd already. But in *Egypt*, and *Lybia*, where the ground is not much moistened by Dew, or Rain, nor any Rivers arising from Mountains, there, when the Sands are once barren, they always continue so ; particularly, because the Storms of Wind there raise up the Sands in vast Clouds, and thus destroy the first Rudiments of this fruitful Crust. *Verulam. p. 655, 656.*

As also in
Vegetables,

And lastly, Fossils themselves, so long as they remain in the metallic Veins, in appearance of a liquid Juice ; nay, and Metals, whilst they continue in form of a thick, pinguious, ponderous Fluid, and go by the name of a metallic *Gur*, so long they exist in form of a saline unctuous Fluid, and they may then be dissolved in Water, nay, and actually contain in them a diluent Water. Upon this head you may consult the Writers upon Metals, and particularly *Agri-cola*, who is far the chief of them. Certainly, all saline, vitriolic, metallic, concreted Juices confirm the truth of this ; for all these make it evident, that Water is the principal Agent among them, that dilutes, moves, changes, and increases them, and mixes them one amongst another.

And in Fossils.

From what has been said, then, it evidently appears, how surprizingly and universally Water is useful. The most tender, and beautiful Colours of Bodies, certainly, are formed by the concurrence of Water, witness the finest Colours

The uses of
Water for
other purposes.

lours of Flowers, not to mention numberless other instances. The particular scents of Bodies are chiefly mixed, preserved, and perfected by the admixture and temperament of Water: For in this Vehicle, which is much the properest for this purpose, they are most gratefully distributed. And as for the elegant variety of Tastes, what does this depend upon but Water, which by a due interposition, applies them to the Tongue, and the Palate? The singular, the nutritive, medicinal, medicated, and poisonous qualities of Bodies too, by the concurrence of Water, are rendered active, tho' they were not so before. But again, that the very great hardness and firmness of Bodies depends often upon the interposition of an aqueous *Gluten*, we have already demonstrated. Certainly, Bricks, Tiles, Stones, Bones, Horn, Hair, and Hoofs, were it not for the Water that is in them, would soon be dispersed into a very soft Powder. Nay, and most of the physical actions that Bodies exert one amongst another, are performed by means of Water, and would cease without it. And as this is true of Operations that are excellent in themselves, and are the origins of a great many other actions; hence those of course must depend principally upon Water. An instance will make this plain: The Effervescences produced between Salts and Salts, Salts and Oils, and Salts and solid Bodies, happen then only, when these Salts are so diluted with Water, as to be reduced to a state of fluidity, and so brought into action: For when they are perfectly freed from all their Water, and left quite solid, they then generally are but little active. But we know what a vast many changes and operations arise purely from Effervescences; which therefore all necessarily require the concurrence of Water, in order to their being effected. But if we consider Fermentation, too, the fruitful Spring of so many, and so great physical productions, this certainly, can by no means be brought about without Water. Nay, on the contrary, if Vegetables are deprived of their own Water, they can never possibly be raised to a Fermentation, but will continue unaltered for a long time: But as soon as ever a proper quantity of Water is added to them, and they are exposed to a suitable degree of Heat, and the Air has free admission to them, a fermentation spontaneously succeeds and produces all its effects, which are so very considerable. The putrefaction of Animals, Fish, and Vegetables, never happens neither in Bodies that are dry: For these likewise, if they are intirely freed from their Water, and thus rendered perfectly dry, may be kept for a vast while in a dry Air without corrupting, whereas, if they are moistened with Water, they are soon converted into an intolerable putrid Matter. There are numberless other separations of various Bodies, which are brought about by Water very easily, but can be no ways effected without it: Thus the separation of Salts from Earth and Oils, and the extraction of Alcohol from Resins, and resinous Substances are performed by Water. And on the other hand, the union of a great many Bodies too, depends intirely upon Water, and cannot be obtained without it; of which we have given you a great number of evident instances already. Precipitation, again, which among the chemical Operations is so considerable a one, is performed principally by the mediation of Water. The Sublimation, too, of the precious Oil, procured by distillation from Aromatics, Balsams, Barks, Flowers, Leaves, and Seeds, depends intirely upon the assistance of Water alone: For take away this, and there is no physical or chemical Contrivance by which this beautiful Oil can be obtained pure, and
without

without an empyreumatical Taint. But again, Water is the *medium* by which we can certainly distinguish and direct the degrees of Heat from the degree 32, to the degree 212, which it is very difficult to do by any other method. I don't deny, indeed, but that Oil will do the same, nay, and farther too, quite to 600; but in these cases, Water continues always the same, whereas Oil growing continually thicker and thicker, does not afterwards retain the equable increments of the ascending Heat. This now is of vast use in the chemical Art, nor was this known to the ancient Chemists; if it had, they would not have taken such a vast deal of Pains to find a method of raising and keeping up an equable degree of Heat, equal to the vivifying Warmth of a brooding Hen; for this now-a-days may be easily come at, directed, and continued by the help of Water, and a Thermometer. Concerning all these effects of Water, however, that have been mentioned, this is to be remarked, that they will be very different, according to the various degrees of Heat that are applied to it, so that upon every increase of Heat, the effect of Water will constantly vary: But as this is sufficiently evident, I shall not take up your time in explaining it.

But Water now is never observed to be more active, than when by boiling, it is raised into Vapours in a close place; for if Bodies are exposed to such a floating Vapour, and are perfectly moistened by it, they are thence surprizingly penetrated, altered, corrupted, and dissolved. By Experiments, however, that have been made on purpose in this affair, it is certain, that Vapours exhaling from Water by means of a gentle Heat, have this different effect upon Bodies exposed to them, that those that rise from Salt-water make them putrify less, than those from fresh, which destroy them a vast deal sooner; so that hence the putrifying power of the Vapour of fresh Water, by the assistance of Heat, was very evident. The ancient Physicians, therefore, very justly remarked, that a moist and hot Air has a pestilential Quality, and soon dissolves human Bodies. And by the Moderns it has been observed, that the *Europeans* who first settled in *America*, almost all died of a malignant distemper, which in form of a putrid Fever, very soon resolved their Bodies. And this happened particularly to those Persons who lived in the places which were woody; for there the Air is always exceeding moist, and abounds with warm Vapours exhaled by the Trees, and other Vegetables, in incredible quantities. For if you compute, according to the calculation of the ingenious Dr. *Hales*, in his *Vegetable Statics*, the Surface that all the Leaves of a pretty large Tree make up in the Summer time, it will be evident, that there must be a prodigious deal of Water continually exhaling from the Woods in so hot a Climate. And hence, when these Woods were set on fire and destroy'd, and the Country was laid open to the Air, the same places became very healthy. See upon this head the curious Observations of that famous Physician *Ludovic. Testi*, concerning the wholsomeness of the Air of *Venice*. *Act. Lips. Sup. Pl. III. p. 167.*

That Water rarifies when it is by Frost congealed into Ice, was first observ'd by the famous *Galilæo*, and consequently, that Ice is rarer and lighter than the same quantity of fluid Water. Hence it comes to pass, that Ice always swims upon Water, the specific gravity of Water being to that of Ice, as 9 to 8. *Experim. of the Acad. del Cimento. 25. 28.*

The Vapour
of hot Wa-
ter active.

Ice rarer
than Water.

From aerial
Bubbles.

This rarity, however, of Ice, is owing to Spaces full of Air-Bubbles, which, whilst the Water is freezing, are formed in it, and being considerably large in comparison of the Water, are the cause that the Body of the Ice appears lighter. For in our History of Air and Water it has been abundantly demonstrated, that in cold Water there is a pretty large quantity of Air lodg'd in the Vacuities left between its Elements; which Air, however, not coming at any other aerial Particles, is not collected and united together, nor has any elastic force. But when the Water comes to be constringed by the Cold, by reducing itself into a narrower compass, and lessening its Interstices, it presses out the Elements of Air, unites them together, and hence forms elastic Bubbles, that expand themselves, and become lighter. And as the strength of the Cold grows gradually greater and greater by the association of new ones, these Bubbles grow continually bigger and bigger, and thus increase the proportion of Air, to the bulk of the Ice.

Hence
breaks Vessels.

These now at last being rendered very great, the Air acquires such a prodigious expansive power, that it bursts almost all Vessels, let them be ever so strong in which it is confined; even such as it could scarcely have broken, if it had been dilated by the Heat of boiling Water. Some of the most ingenious among the Philosophers, indeed, have imagined, that this accident happens from the solid parts of the Metal's contracting themselves upon the Ice that is formed within, and consequently, not from the expansion of the Ice outwards, but from this contraction inwards, the Vessel, and the Ice, being in the mean time both condensed by the Cold. But to this ingenious conjecture, the Gentlemen of the learned Academy *del Cimento*, oppose the following evident Experiment. They took a new hollow Sphere of pure Gold, and filled it perfectly full of Water, and having closed it, exposed it to a freezing Cold. At the same time too, having fixed the Sphere, they fitted upon it an exact metal Ring, a little less than a great Circle of the Sphere; which being placed loose upon the Sphere, encompassed it round almost at its center. They then mark'd the place exactly in the Sphere where the edge of the Ring rested; and afterwards, when the Water was frozen, they found, upon examination, that the Surface of the Sphere was so remov'd from the center, and grown so much larger, that the Ring was considerably raised from the great horizontal Circle of the Sphere towards its *Vertex*, the expansion of the Sphere being much greater than the contraction of the Ring, as appeared by comparing it with another Ring that was of the same size, and was not exposed to the Cold.

Ice formed
of Water,
deprived of
Air.

But Water, now, from melted Snow, or that which has been a good while boil'd, freezes more slowly, and at the same time becomes much more solid, rarifies less, and forms much fewer Bubbles whilst it is freezing. *Acad. del Cimento*, p. 163. And very pure Water, kept a good while in the Air-pump, and exposed to a freezing Cold in *Vacuo*, freezes there much sooner than it would have done with its Air in it, and standing in the open Air in the same degree of Cold. The Ice too from Water thus deprived of its Air, has been found to be much harder, heavier, more equable, and more pellucid, than common Ice: So that hence it is certainly evident, that it is the Air which is lodged in the Water, and is collected by the freezing Cold, that produces this rarity and lightness. Nay, upon making some Experiments very carefully in this manner, there was Ice produced, that would not swim upon Water.

Ibid.

Ibid. 171. If in exceeding cold Weather, you pour a fine Powder of Sea-Salt, *Sal-Gem*, Fountain-Salt, or *Sal-Ammoniac*, that is equally cold, upon rasped Ice or Snow, and then rub them together, the very moment they are mix'd, the Salt will begin to dissolve, and at the same time there will arise a greater Cold than was in either of them before, and that always to a certain degree, let the degree of Cold in them before they are mixed be what it will: At least, as far as we have been hitherto able to discover. And this artificial Cold, by a repetition of the same Experiment, may be increased at pleasure. Alcohol of Wine, in the same manner, being poured upon, and mix'd with Ice, increases the Cold. If the pure saline acid Spirits of Sea-Salt, Nitre, *Aqua Fortis*, or *Aqua Regia*, are rubb'd too with Ice, they generate Cold likewise, which will be always so much the intenser, as they are stronger. But of this we treated largely in our History of Fire, whilst we were relating *Fabrenheit's* Experiments for producing the greatest Cold that has hitherto been known.

If a Person, therefore, should in the coldest Weather take the most pure Water, and in the carefulest manner deprive it of all its Air in the most perfect *Vacuum*, and let it freeze there, and afterwards by this contrivance of *Fabrenheit's* cool the Ice as much as possible; then one might procure the hardest, densest, purest, most pellucid, and heaviest Ice, and by this means the physical character of Ice might be determined evidently to the Senses. In the mean time, however, as far as we can judge from what has been experienced, such Ice would dissolve again with a Heat of 32 degrees. The most perfect Ice.

Hence it evidently follows, that the greatest degree of known Cold does not convert pure Water into any kind of Stone, Chrystal, or Gem, tho' this artificial Cold is 40 degrees more intense than the natural one in those places, where it is asserted, that frozen Water is changed into mountain Chrystal. With us, certainly, no increase of Cold in Ice has made it melt with more difficulty, when it has been exposed again to the usual degree of Heat that dissolves it. Not changed by Cold into a Body that remains hard in the Fire.

The purest Water, now, being poured into a very clean Vessel, and hermetically sealed up in such a manner, that it had not the least communication with the external Air, continued a whole age without any sensible alteration: So that in all that time, it neither hardened into a solid form, nor generated Earth, or any thing else in it, tho' this was tried in the Air at *Rome*, which is pretty warm. *Boyl.* V. I. p. 62. *Du Hamel.* T. IV. p. 109. Water not changed by time.

Again, if by the help of the Air-pump, you deprive Water as much as possible of its Air, and then whilst it remains so, shake it about in a Vessel, it will emit an infinite number of very small Bubbles, that spring up like sparks of Fire, and have not much the appearance of Air rising out of the Water. Do these very small Bubbles, therefore, when they are united together, form those fulminating non-aerial Bubbles, which appear in Water whilst it boils upon the Fire, after all the Air by long boiling has been expelled out of it? *Du Hamel. Demonstr.* p. 395. Contains something more subtil than Air.

But there is nothing now that is more apt to impose upon us, than the quantity of Water in the Air: For the Particles of Water being ranged in a certain position, with regard to one another, are capable of producing very thick black Clouds; and yet the same Water, in greater quantity, and more dense, but disposed in a different manner, shall be so pellucid, that there shall not be Lies often wonderfully concealed where there is a great deal of it.

the least appearance of it. Thus, if we shut our lips pretty close, and blow our breath out very strong, it will scarcely appear; but if with an open mouth we breath it out gently, it forms a very visible little Cloud, if it meets with the cold Air. In the same manner, ones moist Breath, in the Summer-time, is not discernible, though you see it very plainly in the Winter. But of this we treated fully in our History of Fogs and Clouds. Here, therefore, we only give this hint to the Chemists, that, since it so much concerns them, they would learn to make the most accurate Hydrosopes possible, and study, by the help of them, to find out a method of discovering the quantity of Water in the Air, whenever they have a mind. The usefulness of such a knowledge, not to mention any thing else, appears evident from the necessity of knowing what temperature of the Air is most convenient, if you would prepare Oil of Sulphur *per Campanam*, or Oil of Tartar *per Deliquium*, in the best manner.

A Wave of
Water.

If standing Water is not at all ruffled with Wind, it forms a Surface, that disposes it parallel to that of the Earth. If you then throw a heavy Body upon the Surface of this Water, whether it be a great one, or a small one, or whether it falls upon it gently, or with force, this Body, by thus falling into the Water, will with some *impetus* drive out so much of it upon its stagnating Surface, as is equal to the bulk of the Body. This expulsion, therefore, of the Water will successively continue so long as any part of the Body continues above the Surface of the Water, but when once it is quite covered, it then descends equably, nor is afterwards taken notice of. The Water, now, that was raised by the Body immediately returns back again into the place that is left by it as it subsides, by which means there is formed an undulatory Circle upon the Surface of the Water. And this, from the point where the Body falls as a Center, is propagated in greater and greater Waves, always concentric to one another, to a considerable distance. And these Waves are always formed by this Law, that in the space of $8\frac{1}{2}$ seconds, they run through a *radius* of 12 feet from the Centre of their motion; whereas sound runs 1080 feet in one second in the Air; so that a Wave of Air is to a Wave of Water formed in the same time, as 765 is to 1, which is pretty near the proportion of their specific gravities, according to the computation of the famous *De la Hire*. Though such circular Waves, now, arising from different causes and centers, happen to intersect one another, yet each of them still continues on concentric to its proper center; nor are they confounded with one another. And if they happen to meet with a resisting and reflecting obstacle, after their reflexion they proceed on with the same celerity as if they had met with no resistance at all. And, which is still a much greater Paradox, and really surprising, whether the Wind is with or against them, it makes no difference at all in the propagation of the Waves. See by all means on this head the *Memoirs de Physique*, &c. Ann. 1693, p. 133. These things I thought worth while to take notice of, that they might afford matter of speculation to our Chemists, who are continually forming notions about the harmony of the universe.

Can Water
be converted
into Earth?

If you distill the purest Water with a gentle Fire, and in a very clean Vessel, to a perfect dryness, it will leave a slight spot at the bottom of the Glass. And this will always happen, repeat the Operation ever so often, with the

the same Water, but in fresh Vessels. 'Nay, and if you pour it back again into the same Vessel, and then distill it again, upon every such distillation the Crust will grow a small matter bigger, till at last it becomes pretty considerable. This Experiment, by the indefatigable industry of the great *Robert Boyle*, was carried on to the two hundredth time, and he tells us in his laborious Treatise of *Original Forms*, that when Water had been thus cautiously distilled 200 times in a glass Vessel with an Alembic, an ounce of it at last produced six drachms of a white, light, insipid Earth, that was fixed, heavy, and insoluble in Water. *Orig. Forms*, p. 259. to 273. Upon the authority of this account, the greatest Philosophers have laid it down as certain, that Water, by simple repeated distillation, may be absolutely transmuted into true Earth. And hence the illustrious *Newton* deduced, that Water thus converted into Earth, might at last be made red hot. *Opt. Lat.* p. 319. Q. 22. With proper deference, however, to these great Men, give me leave to tell you, what I have been able to discover upon a careful examination into this matter. I took some Rain-water that was caught upon our observatory, in Vessels that were very clean, and so placed, that no Rain could be beat into them that first fell any where else: A great quantity of this I put into a large Cucurbit, and with a very gentle Fire of an Athanor, to avoid any Smoke, I distilled it into a very clean Receiver to a perfect dryness. There remained then a white spot at the bottom of the Glass, but incredibly small in proportion to the quantity of Water: And at the same time, though I had with the utmost care luted the Vessels together with a Lute made of Linseed-flower and Water, I found that in this distillation there was a good deal of the Water lost. Hence I confess I can no ways possibly understand how those famous Gentlemen could by any means prevent all the Water's perspiring through the luting of the Vessels, before the same could be distilled two hundred times. But supposing this, whilst we are repeating these distillations, at the same time that the Water passes in form of Vapour out of the Cucurbit through the Alembic into the Receiver, the empty part of the Cucurbit, the Alembic, and the Receiver are full of the common Air of the Elaboratory where this Experiment is made: But this Air is always full of Dust floating about in it, occasioned by the Fires, the draughts of Air, Wind, and people's moving backwards and forwards. That this is the case appears plain from any glass Vessel disposed in the very uppermost parts of such a place, which will be soon covered with Dust. If we consider this carefully, therefore, it will be very evident, that in every distillation there must by this means be a small quantity of Dust added to what was collected before. And if this Operation is repeated too hundred times, there must, on account of the Water's being poured back again, be four hundred such collections of Dust. I don't at all deny, therefore, but that some of the powder so produced is owing to the feculent Corpuseles themselves in the Water, though the greatest part of it I think ought to be ascribed to the Dust in the Air. And when, upon a just calculation, founded on experiment, I compute the quantity both of the Dust arising from the impurity of the Water, and that collected from the Air, I confess I cannot certainly see that any Earth was really generated from the simple Body of the elementary Water in these Operations. And, indeed, there is still so much the more reason to doubt of it, as *Mr. Boyle* repeated the Operation himself but three times, and afterwards took it upon the

authority of a Chemist, that by two hundred distillations, an ounce of Water had yielded six drachms of Earth. I don't at all question, therefore, but every body that is pleased with this kind of inquiries will think that there is somewhat of consequence in the opinion, which I here candidly submit to the examination and correction of the publick. That Water may be concreted with other Substances into a solid Body, arising from this union, I am obliged to believe, for reasons I have given already: But that the Elements of Water, by mere distillation, have ever, without the interposition of a third Body, been so united as to be converted into mere Earth, I have not yet seen sufficiently demonstrated by Experiment, and have learnt by frequent inconveniencies, that we are too apt to neglect in our chemical processes, those heterogeneous Bodies that secretly insinuate themselves, during the Operation. Thus then, Gentlemen, I have laid before you all those things which the modern doctrine furnishes, with certainty, concerning the third universal, chemical instrument, Water. Whether, now, that Water into which the *Alcabeſt* is said ultimately to resolve all Bodies, is the very same with that which we have been treating of, I am not yet, I confess frankly, able to determine. This doubt those persons only are capable of resolving, who are so happy as to be let into such mysteries, the admiration of which is all that is left for us.

Of EARTH.

Definition of
Earth.

Both the Philosophers and Chemists have made use of the term Earth, in treating of the Principles or Elements of which compound Bodies consist. For by this word they designed to express one of those Elements, which in conjunction with the rest makes up these compounds, and qualifies them in a good measure for performing the Operations both of Nature and Art. And if we examine very nicely into the proper signification of the term, as made use of by them, we shall find, that by Earth they meant a simple, hard, friable, fossil Body, fixed in the Fire, but not melting in it, nor dissoluble in Water, Alcohol, Oil, or Air.

Explained.

That the Idea of Body is included in that of Earth, no body, to be sure, will deny, as its Mass is extended into the three dimensions of Body, is perfectly impenetrable, and always gravitates with its own proper weight. But it seemed a more difficult matter to determine, whether or no it ought to be ranked in the class of Fossils: Upon a careful examination, however, of the characters we formerly laid down of the three natural Kingdoms, I should think it ought principally to be referr'd to fossil ones; for more or less Earth is always intermixed with almost every Fossil that we are acquainted with. This I confess in Metals is demonstrated with more difficulty; but in the rest it is discovered very easily, and that in such quantity, that it can scarcely be separated from them, and then, not without a great deal of trouble. The weight of it, besides, is so great, that it exceeds that of Water, Salts, Oils, and vegetable and animal Spirits; and by this means it insinuates itself into the innermost parts of the Earth, so that it is found, and may be dug out of its deepest recesses. And lastly, pure Earth never discovers in its Mass the intermixture of any other Elements, or scarcely any variety. Hence, therefore, it appears, that Earth could hardly be reduced more properly to any kind of Bodies, than that of Fossils. Supposing, then, Earth to be a fossil Matter,
what

what an exceeding simplicity do we discover in it? Certainly, so great a one, that you'll scarcely, in the whole compass of Nature, find a Body that is more simple. For pure Earth, or, as it is called, Virgin Earth, appears so uniform, and homogeneous, that even Metals themselves don't seem to be more so. And when it is perfectly separated from every thing else, then, notwithstanding its exceeding fineness, it is hard and consistent. I confess, indeed, there are harder Bodies; but this, nevertheless, possesses a considerable degree of hardness. The Matter of Earth, in the mean time, appears friable, so long as it continues under the observation of our Senses; as it always readily suffers it self to be reduced to a finer Powder, in which respect it differs widely from true Metals and Gems. In this particular, however, consists its greatest difference, that it remains so fixed and immutable in the most intense Fire, that when it is intirely alone it is not possible to put it in fusion.

If a person catches pure Rain-water, and distills it carefully, he will find some *Fæces* left at the bottom, as we took notice just now in our last article upon Water. If the fæculent Matter thus collected is perfectly dried, and then thoroughly burnt, it will yield some Ashes, which being very accurately freed from all the Salt that is in them, produce a fine pure Earth, which goes by the name of Virgin Earth. For whether this Matter is generated from the Water itself, which is supposed to be changed in this manner; or whether, which is more probable, it is collected from the Air, it produces this very subtil Powder. For the Air, as we observed before, though it is quiet, and contained in a close place, abounds even then with a large quantity of an earthy, and kind of ashy Dust. This appeared evidently in our History of Air, by the consideration of looking obliquely upon the Rays of Light, in a dark Room, and is confirmed by laying a piece of black Silk open there, which will soon be covered with a kind of dusty Crust; which consists chiefly of a fine Earth, which was floating about in the Air. A very considerable part, therefore, of this Powder is Earth, which, by an infinite number of Causes, being rendered exceeding fine, and put into motion, becomes capable of being carried aloft in the Air, particularly, if it happened to be exposed to Wind. There, afterwards, it intimately mixes itself with the falling Dews, Fogs, flying Clouds, Water, Rain, Snow, Hail, Hoar-Frost, and other things, to which it is applied, and with which it becomes closely united. Nor does the fixed nature of the Earth, generated in the distillation of Rain-water, which, as Mr. Boyle observed, would bear the intensest Fire in a crucible, without being changed, or flying off, make at all against what we have asserted, though a person, indeed, might be apt to think with himself, how can such a quality as this be consistent with a Powder's floating about in the Air: But it is one thing, certainly, for a Body to be at rest in a Fire, tho' a very intense one, that is equably applied to it, on all sides; another to be taken away with an unequable motion of the Air, though without a Wind. When a very fine Powder of Earth is placed in a Test, and urged upwards, downwards, and on all sides, and from the center, by the very same Force, it stagnates, if I may so express myself, in a homogeneous Liquid, and by this means continues at rest; but if the puff of a Bellows happens to fall upon this same Powder, it instantly disperses it about: And as Clouds replete with Water are driven about, and the very Waves of the Sea are carried up, and hurried along by the Winds, so we know likewise, that the Sands of *Egypt* and

The most perfect procured by distillation.

and *Lybia* are raised into the Air in such a manner, that they were sufficient to overwhelm *Cambyfes's* whole Army. Gold-Leaf, and very thin Plates of other Metals, bear the greatest force of the Fire, for a considerable time, in the Cupel; and yet are blown away by the Breath, or a very gentle Wind, and dissipated into the Air. We ought to consider, likewise, at the same time, that Bodies that are perfectly terrestrial, so long as they are intirely simple, and unmixed, often continue fixed and unmoved by the Fire, though upon their being mixed with other Substances, they become so volatile, as to suffer themselves to be carried up into the Air, by a moderate Heat. There is nothing, you know more fixed in the Fire than Gold; and yet if you mix it with *Regulus* of Antimony, and then carefully rub it for a considerable time with the best Sublimate of Mercury, you make such an Alteration in it, that it will fly off with a gentle Fire. And so pure Earth, if it is perfectly separated from every thing else, will remain fixed in a Crucible, in the strongest Fire; though if you mix it with other Bodies, you may dissipate it into its ultimate Particles. This we need no other proof of, than the burning of Wood under a high Chimney. Does not the Smoke of this fix a black Soot to the very uppermost part of the Chimney, which, being chemically examined by Fire, yields a large quantity of Earth, which was carried up so high by the Oil and Salt that were mixed with it? And yet this Earth, now, when it is purified, and by itself, you may burn with the strongest Fire, and it will in the midst of the Flames remain perfectly fixed. Thus then you understand where and by what method one may procure the most simple Earth, *viz.* by distillation of the purest Rain-water. But yet even in this case, the *Fæces* that are thus produced, will contain in them every thing that was, together with this Earth, floating about in the Air, and at the same time is not volatile enough to ascend in that degree of Heat with which the distillation is performed.

And by combustion, from the Ashes of Vegetables.

If Vegetables are burnt in an open Fire, they moulder away into white, fixed, fine Ashes, which with the least puff may be blown into a volatile Powder, and be carried by the Wind to a very great distance. Nor has there ever yet been discovered any one Plant that upon burning would not produce such Ashes. If you take, now, these Ashes, and wash them a good many times, and very carefully, with the purest Rain-water, you may by this means perfectly free them from all the fixed Salt that remained in them: And as the Fire before had carried off all the Oil, and volatile Salt, the Earth will at last remain in the Water by itself. These Ashes, then, which will not have the least Saltiness in them, must be shook well together, with some very pure Water, and when this is become turbid, it must be poured off into a clean Vessel, and then more Water must be put upon the *Residuum*, and stirr'd together, and decanted as before, and this must be repeated till all the Ashes are thus washed from the little Stones, Sand, bits of Glafs, and other little, solid, heavy Particles, which are not capable of being diluted in the Water. All this turbid, decanted Water, then, must be put into one Vessel, and suffered to stand till all the Ashes have subsided to the bottom; and then you must very carefully pour off the Water, leaving at the bottom a very fine Mud, which if the Salt is perfectly separated, by being dried with a gentle Fire, will give the true elementary Earth, produced from Vegetables by the Chemical Art. This Earth, now, is found to be perfectly inodorous; quite insipid; of a white colour; very soft,

and scarcely sonorous ; hardly dissoluble by any means, in Air, Water, Fire, Alcohol, or Oil ; so fixed in the Fire, that if it is pure, it can scarcely be converted into Glass ; capable, like Flower, of being work'd with Water into a Past that is so ductile, that with care it may be formed into a Vessel, which is able to bear almost the very greatest Torture of the Fire without any damage, will not vitrify in any degree of common Fire but remains unchanged, and will contain in it all kinds of Metals, whilst they are in fusion. This is that Earth which the Assayers make their Tests with, for trying their Metals, when they want to discover what quantity of Gold or Silver is mixed with other fossil Bodies. Of this are formed the Cupels, in which the Fossil Glebes are mixed with melted Lead, by which means they leave their Gold and Silver fus'd into a globular Figure, whilst every thing else is dispersed and carried off. Of this too are made the Mufflers under which these Cupels are placed, to prevent any Dirt's falling into them, and through which there passes a pure and very strong Fire. This is that Earth which being kept ever so long with melted Lead in an intense Fire, is never fused itself, or made to vitrify with it. And lastly, this is the Earth of which is formed that *Mystica Vannus* of *Vulcain*, not of *Bacchus*, through the Pores of which the crude and imperfect Bodies, that vitrify with Lead, are strained, as it were, and run out, whilst not the least Particle of Gold or Silver is admitted through them, which collect themselves, and unite into a globular Mass, in the center as it were of the Test, though its whole Concave Surface and Body are every where, and equally porous. This Earth, therefore, when it is formed into such a Vessel, is the true Sieve of Metals, when they are fused with Lead. All these Characters, then, belong properly to that very pure Earth, which is procured from the Ashes of burnt Vegetables, by the Chemical Art.

The very same sort of Earth, likewise, may be obtained from that part of Vegetables, which in burning ascends from the Fire, in form of Flame, Sparks, Smoke, and Soot : Nor does it at all signify of what kind they are, or whether they are green or dry, acrid or mild. For if the Smoke that fixes upon the very uppermost cold parts of the Chimney, and there forms itself into sooty Flakes, is collected, and exposed to a very strong Fire, in a clean iron Frying-pan, it will fume, take fire, flame, and at last consume into white Ashes, which being freed from their Salt, if they contain any, by the method aforementioned, yield an Earth, which in every property exactly resembles the former, nor can by any means be distinguished from it. Hence therefore we learn how volatile Earth may become, when it is mixed with other Bodies, and rapidly agitated by Flame ; to what a great degree of volatility it may by this means arrive ; to what a height it may be carried, and so be dispersed and scattered through the Air. When the black Smoke arises from Vegetables, and floats along in form of Clouds, the Earth likewise being there rendered volatile, moves together under the same appearance. But lastly, when Soot is collected, and distilled in a clean glass Retort, with various degrees of Heat, and at different times of the distillation, it yields a Phlegm, Spirits, a volatile Salt, and another Salt, that rises only with the last degree of Fire, and various sorts of Oils ; and in the end there remains at the bottom some black *Fæces*, which being burnt in an open Fire, produce Ashes, which when by the help of Water they are perfectly depurated from their Salt, give exactly the

As likewise
from Smoke
and Soot.

very

very same Earth as was procured by the foregoing Methods. These last Experiments, therefore, evidently demonstrate, that the force of Fire agitates the very Earth with the Water, Oil, and Salt, and carries it aloft; and that this is perfectly of the same Nature with that which remains in the fix'd Ashes of burnt Vegetables. This indeed is very surprizing, and at first may seem hardly credible, but yet it is absolutely certain, and discovers to us a quality of Earth which before we were not acquainted with. If this Earth, now, which in burning is so volatile in the Soot, as it was first in the Smoke, by distillation, or combustion, is perfectly separated from all the watery, oily, and saline parts that are united with it, it then becomes equally fixed with that which is procured from the Ashes of the same Vegetable when it is burnt. Earth, therefore, when it is perfectly pure, and alone, is exceedingly fixed in the Fire, tho' by being intimately combined with Oils and Salts, it may be very easily rendered volatile. How full therefore must the Air be of a true terrestrial Matter, especially about those places where great quantities of Vegetables are continually burning?

And by Distillation.

But again, take any kind of Vegetable that we are hitherto acquainted with, put it, as Nature produces it, into a clean glass Retort, make a very gentle Fire under it at first, gradually increase it to the greatest degree, so that every thing may come over successively into the Receiver that will rise by those different degrees of Heat, and then this Vegetable will be divided into two distinct parts; one, which will suffer itself to be carried up into the Receiver in form of a distilling Substance, whilst the other remains in the bottom of the Retort, and will bear the utmost force of the Fire without ascending, being a fix'd black Coal, which will continue so for a long time, as *Van Helmont* very justly observed formerly, and *Dr. Hook* has since confirmed by Experiment. The Chemists, indeed, commonly tell us, that the Water, Spirits, Oil, and volatile Salts, come over into the Receiver in form of Liquids, as the volatile parts, whilst the Earth, fix'd Salt, and a small quantity of fix'd Oil remain at the bottom of the Retort. But how far this is true, we must here examine. The volatile, first part, therefore, is always of various sorts, viz. Water, Spirits, an Acid Salt, an Alcaline one, and different kinds of Oils. These all now being mixed and united together, produce a Matter very much resembling the Smoke of Vegetables, and the Soot that arises from it; with this difference, however, that when these are raised by an open Fire, then many more and grosser parts are carried up, than when the same Substance is exposed to the Fire in a close Vessel. And hence it comes to pass, that the very same quantity of vegetable Matter yields a good deal less Ashes, when it is burnt openly, than it leaves Coal and Ashes procurable from it, in the bottom of the Retort, when it has undergone the utmost force of the Fire. If you take now all the parts together that were raised by distillation into the Receiver, and distill them again in a clean Vessel, 'till the *residuum* at the bottom is perfectly dry, there will then always remain a black Coal; for tho' you urge it every so long with the strongest Fire, you will never be able to render it volatile: Fumes, indeed, you may constantly force out of it; but the Coal itself will always continue fix'd in the Vessel, and exceeding black. When you have attempted this, therefore, a good while in vain, take it out, and you will find it light and fungous: Then put it in a clean open Vessel upon a common Fire, and

it will burn, and flame, and by this means will have all its blackness consumed, and will then leave a white Earth, which being perfectly freed from its Salt by the methods before mentioned, will be the very same virgin Earth, as was procured by the former Operations. Hence, therefore, it appears evidently, again, that in the distillation of Vegetables, the Earth rises with the Water, Spirits, Salts, and Oils. If you take now the Oil distilled in this manner, and in a clean Retort, urge it through all the successive degrees of Heat, gradually increased, you will have an Oil in the Receiver purer than the former, and much more penetrating. If you then repeat this Operation for a great number of times, the Oil at length will become so fine, that it will come near to the subtilty of Alcohol; but in every distillation, a great part of it will be dissipated into the Air, and its proper Spirit, which gave it its peculiar smell and taste, will intirely disappear. In the mean time, likewise, in every distillation, there will, at the bottom of the Retort, be generated a black Coal, which never yields any Salt, or can be rendered volatile: And when this again is burnt in an open Fire, it produces white Ashes, and a considerable portion of Earth, always of the same nature. Nor is there any end of this, repeat the distillation ever so often, 'till at length you may collect so large a quantity of it, that the greatest part of the Oil will be converted into a pure simple Earth; as you may see in Mr. Boyle, *Of the Mutability of Principles*.

Hence, therefore, it is certain, that this Earth may be procur'd from any part of Vegetables whatsoever; and that amongst all the sorts thus produc'd, there is not the least difference that our senses are capable of discovering. Hence too, we learn, that all this Earth, when it is absolutely pure, is so fix'd in the Fire, that it can bear its utmost efforts almost without any alteration; but that, nevertheless, when it is mix'd with other volatile parts of Vegetables, it is together with them carried up by the Fire, and is in that respect so long volatile: This we see, both in the Soot that is generated by burning them in an open Fire, and the parts that rise in distillation in a close Vessel. And again, we observe farther, that there is not any volatile part of Vegetables that renders Earth more volatile, and more easily so, than the Oil: And that among the different sorts of Oil, procurable either by Art or Nature, there is not any one that carries up more Earth with it in distillation, than that last thick pitchy one, that is forced out by the ultimate action of the Fire. And to this, indeed, it seems owing, that these Oils are so very heavy, the large quantity of Earth which they contain, thus increasing their weight: And hence arises likewise their very great tenacity. This is particularly confirmed by this Observation, that these Oils, when the Earth is separated from them by distillation, grow immediately very thin, lighter, and exceeding volatile.

But we shall again discover a wonderful origin of pure Earth, if we now take carefully into consideration, the other part of the Ashes ^{produced} Vegetables, namely, that fix'd alkaline Salt, which in the Water was washed away from the Earth that we just now examined. Any body, indeed, would be apt to imagine here, that there was no Earth at all remaining in this Salt; for the Earth we saw in the preceding Operation, was left undissolved, whilst the Salt was dissolved in the Water, and passed pure through very thick filtering Papers in form of a *Lixivium*: Upon inquiry, however, we shall find to the contrary. To this purpose then, take this *Lixivium*, and first of all,

Corollaries
from these
observations

Earth in fix'd
alkaline
Salts.

by suffering it to stand quiet for a long time, let all the terrestrial *faces* subside to the bottom; and by this means, it will be so depurated, as to become as limpid as Water: Let it then be filtered through *Hippocrates's* Sleeve, and let this be repeated till it is grown as clear as Chrystal. This Liquor then, if you examine it with a Microscope ever so nicely, will not discover the least sign of any terrestrial matter. Take then this very pure *Lixivium*, and put it into a clean Vessel, and in a quiet place as free as possible from dust, reduce it to the consistence of a thick Oil; and then in a clean iron Pot, evaporate this thick Liquor to a dryness, keeping it continually stirring with an iron Spatula; and by this means you will procure an exceeding pure fixed alkaline Salt. When this is done, put this Salt into a good clean Crucible, and with a Tile cover it over as close as possible, and in this condition commit it to a very strong Fire till it is melted: Then pour it out into a warm brass Mortar, and with a hot Pestil rub it immediately into a fixed alkaline salt Powder. Let this Powder then be put into a large glass Basin, and be thus exposed to the Air in a place free from dust, and the Salt in a very short time will be intirely dissolved into a Liquor perfectly fluid, whilst to the bottom there will fall a white terrestrial Powder, which being thoroughly washed from the Salt that adheres to it, will appear to be nothing but mere Earth, such exactly as the other, which remained in the Ashes. If you take now this Oil of Tartar *per deliquium*, and dry it, calcine it, and expose it to the Air as before, it will dissolve again, and you will have a new Oil *per deliquium*, and always some Earth remaining; and if you repeat the Operation a vast number of times, at length the greatest part of the fixed alkaline Salt will be reduced to a mere simple Earth, that in burning was united with that other Principle, which in conjunction with it, formed the alkaline Salt; which saline Principle being now by many calcinations and solutions separated from its Earth, and set at liberty, flies off, and is dissipated into the Air, and leaves the Earth alone. If you collect, however, all this Earth together, and weigh it, you will find it a good deal lighter than the Salt was at first; this decrease in its weight, evidently evincing, that a great part of the Salt was rendered volatile, and thus carried off. As this Experiment, therefore, constantly succeeds in this manner, we cannot but conclude, that this Earth, thus discovered, did really exist before in the fixed alkaline Salt from which it is by this means procured, and that in so latent a form, that it suffered itself, during that time, to be perfectly dissolved in Water, which otherwise is so repugnant to the nature of Earth. And hence, therefore, it likewise appears, that the purest Earth, when it is united with some other Principle, is totally dissoluble in Water, tho' it is by no means so when it is alone: Unless, perhaps, you will rather believe, that the very Salt itself, not terrestrial before, may, whilst it undergoes these calcinations or solutions, by an actual transmutation, be converted into true Earth. This opinion, however, is not founded upon any Argument or Experiment that I am acquainted with, and therefore seems intirely precarious: And besides, it seems to me to be inconsistent with the settled constancy of Nature, which for so many ages has always been observed to act in the same manner, and by the same means; inasmuch, it has never yet appeared, that any one Element has prevailed upon another, but that being properly adjusted together, they have all constantly remained in the very same proportion.

And

And as for the other Opinion, that Earth, by being united with saline Principles, may be rendered capable of being dissolved by Water into a Liquor, in which nothing at all earthy shall appear, this is every where warranted by the chemical Art. In Glass, is not Earth intimately concreted with an alkaline Salt, and thus produces with it a perfect transparent Mass? Which nevertheless, according to *Van Helmont*, may be again resolved into an Alkali, and an Earth precipitated from it. Do not all Metals, when united with their proper dissolvent Acids, appear in Water in the form of a very pellucid Salt? Which, notwithstanding, may be thence again procured opaque, intire, and without alteration: 'Tis needless to mention Chalk, Stones, Oyster-shells, Earths, and other Bodies; all which, by being combined with Salts, seem to be converted themselves into very pure Salts, which yet by various methods, may be again resolved into their solvent Liquors, and an Earth which is separated from them. How evidently is this evinced by chemical Precipitations? From the abovementioned Experiments, therefore, it is certain, 1. That the common fix'd alkaline Salts, procured from the Ashes of burnt Vegetables, do consist in a great measure of true, simple, elementary Earth, which whilst they are forming, enters into their composition. 2. That this Earth is so concealed, intermixed, and dissolved in these Salts, so long as they exist in a fixed alkaline form, that it does not give the least indication of itself by any sign whatever, and therefore so long cannot be discovered; as it will by Water, or the moisture of the Air, be so dissolv'd, as to be converted into an exceeding simple limpid Liquor. 3. That this Earth of Vegetables can only be subtiliz'd to this degree, by the most violent action of an open Fire, which whilst it is thus consuming Vegetables, so intimately unites this Earth, attenuated at the same time with another alkaline saline Principle, that from both of them thus conjoined, there is generated an Alkali, which is a proper creature of the Fire. And this, now, as we just mentioned, will only happen in the open Air; for a Coal, made from green Wood, being included in an iron Box, was in this manner exposed for several hours to a very strong Fire, and nevertheless continued a very black Coal, nor would yield any fix'd alkaline Salt, tho' upon being afterwards taken out, and burnt to Ashes in an open Fire, its Ashes then afforded some. Hence, therefore, it appears evident, that this Salt does not in reality pre-exist in Vegetables, but is then only introduced into Nature, when the Fire has united Earth to that other Principle, which may be thus combined with it in the open Air, but not in a close Vessel. And that this fix'd alkaline Salt is generated only in the open Air, and by the power of the Fire alone, is not less certainly confirmed by this consideration, that if any Vegetable whatever, is only so far burnt, either in the open Air, or a close Vessel, as to be converted into a black Coal; then, if you reduce this black Coal to Powder, and boil it in Water, it will not, in the *Lixivium*, afford any fixed alkaline Salt: And yet if afterwards you take either this Coal, or its Powder, and burn it in an open Fire, by boiling its Ashes, you will be able from them to procure it. The Earth of Vegetables, therefore, being vastly attenuated by the extreme force of an open Fire, is after the consumption of the Oil, intimately united with the other saline part, and thus produces a fixed Alkali. Nor has this Salt ever any other origin that we are acquainted with.

4. Fixed alkaline Salts, therefore, are not simple Bodies, but are compounded

of two perfectly distinct Principles, intimately united together. 5. And it is likewise exceeding probable, that this burning of Vegetables, after it has attenuated the Earth, combines it with that native Salt, which was naturally in the Plant, and existed there in form of a *Sapo*, made up of this Salt and an Oil united together. And hence we suppose the action of the Fire consumes the greatest part of this Oil, and then converts the Salt, the Earth, and a tenacious black Oil, into a black Coal, in which the saline part lies so concealed under the Oil and Earth, that it does not appear there as a Salt dissolvable in Water, but remains secure from the action of this *Menstruum*, till by a longer continuance, and greater strength of Fire, the black Oil of the Coal is destroy'd, and thus this Oil, which served as a *vinculum* to bind together the Earth and Salt, is removed: And thus we imagine, that at length this saline part, which before was of itself considerably volatile, becomes fixed and united with this ultimate, subtil Earth, being now perfectly freed from its principle Oil. And hence it seems to come to pass, that this fixed alkaline Salt itself, if it is kept for a long time in a very intense Heat, will at last become volatile, and perish in the Fire, tho' if it is mixed in a certain proportion with Ashes or Earth, it will be converted into Glafs, which is considerably fixed there, and is very durable. 6. Hence, therefore, we never find any simple Salt in Vegetables, which of itself is naturally fixed, that which is so, owing its fixity intirely to the Earth, with which the Fire has combined it; for if Vegetables are exposed for a great length of time to the alternate vicissitudes of moisture and dryness in the Air, or if they first perfectly putrify, then, if they are afterwards burnt, they won't produce any fixed alkaline Salt in their Ashes. 7. And hence these fixed alkaline Salts, generated in the manner just explained, may, by the contrivance abovementioned, be again resolved into those two Principles, from which they were first formed by the action of the Fire, namely, into a pure, simple, imperceptible, volatile Salt, and a very subtil, pure, inactive, fixed Earth. 8. From this History, therefore, of Earth, it appears vastly more probable, that these Salts are thus generated from this Earth, and a saline Principle, than that Water, by being intimately united with the Earth, should be converted into an Alkali; for tho' all the contrivances within the compass of the chemical Art, are made use of to combine Earth and Water together, it never has appeared, that a fixed alkaline Salt has been thence produced, let the Fire be ever so intense. 9. This Earth, therefore, which is always, and every where the very same, is extracted from Plants in great quantities with the Water, Spirits, volatile and fixed Salts, and Oils, when they come under the management of the Chemist. And as for all the other Principles, the Water excepted, when they come once to be perfectly freed from their Earth, they are so attenuated, and become so active and volatile, that through this vast subtilty, they intirely escape all farther cognizance of our senses, and are scarcely afterwards to be confined in any Vessels, but return into their former aerial Chaos. The Water only, and solid Earth at last remain behind; all the rest quite disappear. The most ancient of the Chemists, therefore, were absolutely in the right, when they asserted, that the Spirits are held fast, that they may not fly off, by Oils, or Sulphur; that it is Earth alone that retains the Sulphur and Salts; and that, therefore, their fixity is to be attributed to the Earth. Thus, then, Gentlemen, from what has been said, we are come to a sufficient certainty about the nature of that Earth, which is found in the class of Vegetables;

tables; which, as it evidently appears to be perfectly the same in every kind of Vegetable, constitutes, perhaps, an immutable Element.

Let us now, therefore, proceed to examine this Earth in the Animal Kingdom. It has always been observed then, that all Animals, of what kind soever, whether they fly in the Air, swim in the Water, or live upon the Earth, or within it, if they are exposed to a warm moist Air, presently putrify after they are dead, in a Heat less than that of a Man in Health. And by this putrefaction, they are in a short time so much altered, that their whole Bodies are resolved into a most fetid putrid matter, which is so volatile, that it is dissipated into the Air, there remaining only a small portion of a firm solid substance behind. Whole Elephants left dead on the ground in hot Countries, and vast Whales thrown up upon the Shore, are soon consumed, their bare Bones only being left behind, whilst all the other parts are carried aloft. As for Camels too, Dromedaries, Horses, and human Bodies left unburied, after the carnage of Battles, it's surprizing how soon there appears nothing of them at all but their Bones. Certainly, the Water, Spirits, Oil, and Salt, are dispersed in such a manner, that there is nothing but a little simple unactive terrestrial Matter left behind: And then this Earth is exceedingly like that which we have just now been examining in Rain-water, and Vegetables. But why should we insist upon this any further, when we see it so evidently in the burying places of very populous Cities, where the Bodies that are buried are resolved into so small a quantity of Earth, that they hardly raise the ground at all? All the parts, therefore, both solid and fluid, of which Animals consist, and into which they may be again resolved by the action of the Air alone, are of so volatile a nature, that they intirely exhale, the Earth being the only part that remains fix'd, and is not dissipated with the rest. And this terrestrial part, if we examine it more nearly, presents to us only mere Bones, or a little Ashes, which are dispersed with a slight Wind and disappear.

Earth in putrified Animals.

But the nature of our design leads us to examine this Earth in Animals still more nicely. Let us first, therefore, take into consideration any of the Humours of any kind of Animal whatever, after, by a due circulation, they have been quite changed from the crude disposition they had when they were taken into the Body, and by the natural powers of the Animal, are assimilated to its peculiar Nature. These then, under this Limitation, being put into a clean Retort accurately fitted, and luted to a Receiver, and exposed to a Fire very gradually increased from a very gentle one to the greatest, will in a Heat raised to 212 degrees yield, first, an incredible quantity of Water; such a one as no-body could ever imagine should enter into the composition of the animal Fluids. If you continue this degree of Heat for a considerable time, all the Water that is thus distill'd from these Humours, seems in most of its properties to be almost the same with that which is drawn from Vegetables, and was before considered; indeed, to such a degree, that we find but little difference. There is, it's true, in this Water from Animals, somewhat of a subtil rancid Smell, and a disagreeable Taste; but these, as they don't discover the least sign of any Earth, have nothing to do with our present Enquiry. If you proceed then to urge the *residuum* with a stronger Fire, when all the aqueous part has been drawn off by the Heat of boiling Water, then this Mass, which is always dry, and in some measure slightly burnt, will yield a light, yellow, Li-

And in their humours distilled.

quor,

quor, less volatile than the first Water, which has been called the Spirit of these animal Humours. This now is fetid, and of so saline a nature, that upon mixing with Acids, it will cause an Effervescence. If you collect then, this Spirit carefully by itself, and distill it in a clean Vessel, it will produce some *feces*, which being burnt, and depurated, as before, yield a small quantity of Earth, perfectly of the same nature with the former; so that this Earth rises with this Fluid, and may be procured from it. If the Mass, then, of these Humours, thus deprived of their Spirit by its proper degree of Heat, is still exposed to a greater Heat, you will have from it distilled animal Oils in great abundance. But if you distill these again in a clean Vessel, they likewise will leave at the bottom of the Retort a large quantity of fixed Earth, as we took notice in the distill'd Oils of Vegetables. And thus, likewise, will these Oils, by a reiterated distillation, be converted into Earth, till at last there will remain only an exceeding subtil Oil thus freed from its Earth, which is almost of a spirituous nature: So that the thickness, tenacity, and fixity of these Oils too, ought to be attributed, as before in Vegetables, to this very same Earth. And as for the volatile Salt of Animals, which partly is forced out of them by the Fire together with these Oils, and partly rises afterwards, and is separated by itself, this always in the beginning of its production has a large quantity of Oil united with it, which by its viscosity, holds down, fixes, and retains it; for as soon as ever you have, by the chemical Art, perfectly freed this Salt from its Oil, it immediately becomes perfectly volatile, and in distillation leaves no *feces* behind it. After the sublimation, indeed, is made with a very moderate Fire, there remains at the bottom an unactive Water, which, let the Salt appear ever so dry, adheres to it so closely, that in a gentle Sublimation, it always discovers itself in this manner, nor can scarcely be perfectly separated from by any contrivance whatsoever. All the fixity, therefore, of the native animal Salts, seems to be owing intirely to an Oil which is naturally in them, and serves to retain the saline parts; but this very Oil owes all its fixity and tenacity to the Earth with which it is united; and consequently, the Earth is, in reality, the *Vinculum* by which the volatile Salt is secured, and held down, which would otherwise be of too volatile a nature: When the former Oils are thus drawn off, if you still proceed to increase your Fire, you will then have a very black, thick, pitchy, tenacious Oil, which will often puff up, and fill the whole neck of the Retort, and thus in form of an inflated Pitch, pass into the Receiver, being heavier than any of the Liquors that were drawn from the Vegetable in the former distillations. If you take now this last Oil, and distill it carefully, and according to Art, the greatest part of it will remain an Earth at the bottom of the Retort, tho' you urge it with ever so strong a Fire. And if you repeat this distillation again, and again, the Oil will every time become more and more limpid, and there will always a large quantity of Earth be left behind. By such a tedious rectification of this, I reduc'd, formerly, some pounds of a thick Oil of Hartshorn, into a very thin, pellucid, volatile Oil, and a large quantity of a black oily Earth, which being burnt in an open Fire, yielded the very same Earth, which we have already so often mentioned. By this means, then, I became certain, that when this last Oil, very tenaciously adhering to the Earth, was raised by the most violent action of the Fire, it carried likewise this Earth along with it; and consequently,

consequently, that though we call this Substance Oil, yet, in reality, a great part of it is only mere Earth. Hence, then, we learn, that Fire, when it is applied to Oils united with Earth, is so far capable of rendering the Earth volatile: And again, that the properties peculiar to this Oil that rises only with this intense degree of Heat, almost all depend upon the Earth, and not upon the Oil itself. Hence, for instance, arises its very great degree of fixity, thickness, tenacity, and weight; all which it loses, as soon as ever it is perfectly separated from its large quantity of Earth. And hence, likewise, we discover farther, the intimate, and almost inseparable union of this Earth, with all the animal Oils, and the constant effect produced by this union, *viz.* the prevention of their being volatile; for as on the one hand, the Oils, by being united with the Earth, render it, in some measure, volatile in the Fire; so this, on the other, by this same union, prevents their being rendered too volatile, by a small degree of Heat. And as the very volatile Spirits are intangled, and held down by the Oils; so the Oils, which would otherwise rise too easily, are retained by the fixity of the Earth. But lastly, if the fixed, black *Fæces*, that remain at the bottom, after all the Oil is expelled by the former degree of Fire, applied for a good while, are urged with the greatest degree of Heat, and this is kept up for a long time, they will at length emit some blue, shining, dense Fumes, and throw out, at the same time, some sparkling Corpuscles, which, being received into pure cold Water, will be condensed, and by their weight sink to the bottom, where being collected in little Masses, they produce the Phosphorus, now called the Solid, as the former, whilst it floated about in the form of a Fume, may be called the Fluid. This Phosphorus, now, if it is exposed to the Air, takes fire, consumes in appearance of a little lucid Flame, and flies off with a fetid Smell; but even then it leaves behind it a very acid, thick Water, in which there is always something of terrestrial *Fæces*. Of this wonderful Substance, now, we may very reasonably inquire, whether it is, in reality, of the animal or vegetable kind? Or whether it is properly a Creature of the Fire? Or whether it don't owe its origin to all three together? This is certain, it burns perfectly, it will keep for years in Water without being dissolved, and at the bottom of Water it will by Heat be melted like Wax. It rather, therefore, seems to be of an oily nature, than a saline, or terrestrial one; and yet it is perfectly different from every thing that has hitherto been ranked among the Oils or oily Substances, and contains but a small quantity of Earth.

If we examine, now, the ultimate *Fæces* that remain after all the different parts above-mentioned are drawn off, we find them still to continue black; but if the Mass is taken out gently, and burnt in an open Fire, it becomes white, of an earthy nature, retaining its former figure.† This History, then, of Animals and Vegetables, given with a view particularly of coming at the true nature of Earth, lets us see, at the same time, that these two kinds of Bodies appear to be vastly near a-kin in all their properties, and in a great many of them to agree intirely. Hence, therefore, it is no wonder, that Animals, by means of their concoctive faculties, can subsist intirely upon Vegetables, with the simple addition of Water. And as this appears to be every where the case, the bodies of Animals seem almost, in many instances,

The likeness
between
Animals and
Vegetables.

stances, to be nothing but transmuted Vegetables. The chief difference, indeed, between them seems to lie in their Salts; for these, when thoroughly concocted, and so become proper to particular Vegetables, are in many of them acid, or austere; whereas I have never been able to discover any acid ones, much less austere ones, in the native humours of Animals. Let me caution you, however, that this must not be understood of crude Juices, just taken into the Body, and still retaining their own proper qualities; but of such as by the natural vertue of the animal Body, have been truly assimilated to the animal Nature. But again, the Salts of most Vegetables, procured from them by burning, are found to be fixed; whereas there was never any fixed alkaline Salt discovered in Animals, when treated after the same manner; though, as I shall demonstrate hereafter, there are Vegetables that have a volatile, alkaline Salt, like that of Animals, as appears in the Scurvy-grass, Mustard, and others. But the Earth itself, or the Oils, as they contain a large quantity of Earth in them, seem, by their admixture, to cause the chief difference that there is in the fixity of the animal and vegetable Salts: And hence it seems likewise to follow, that the Earth in Animals exists in less quantity, and is less intimately united with their Oils and Salts, than it is in Vegetables.

The putrefaction of Vegetables separates their Earth from them.

Let us, however, consider, in the mean time, that the perfect putrefaction of Vegetables makes such an alteration in their proper disposition, that the Earth being, by this means, more disengaged, recedes, both from their oily and saline parts, and thus effects, that Vegetables, which before putrefaction yielded, in burning, a large quantity of a fixed, alkaline Salt, being burnt afterwards, afford none at all, but then give out all their Salt, of a volatile nature, as Animals do. The union, therefore, of elementary Earth, with all the other Elements of Vegetables, is dissolved by no action more easily than it is by means of putrefaction, which very powerfully divides and separates their Elements from one another, and thus destroys their former particular form, by which means, those both of Animals and Vegetables become nearly the same. And hence it comes to pass, that this very putrefaction renders the Bodies of Animals and Vegetables exceeding fit to produce such a matter in the Air, Water, and Earth, as shall be rightly disposed to yield a kindly nourishment to new Vegetables, and so again, through their means, to Animals. On this account, therefore, all putrefied Substances are particularly serviceable in fructifying the Earth; and for this reason, all Animals whatever, are, by the grand Law of Nature, subject to putrefaction, sooner or later, and thus afford fresh matter for impregnating their Mother Earth, and replenishing it with new fruitfulness.

Fermentation does not separate this earth.

Since, therefore, the putrefaction of Animals and Vegetables thus separates the Earth from the other Elements, and by this means renders them so volatile; hence, perhaps, some persons may be ready to infer, that fermentation, likewise, will do the same. But this happens quite otherwise: For though fermentation agitates Vegetables so powerfully, and for so long a time, yet it is never able thus to free the elementary Earth from its Salt and Oil. And for this reason it does not so assimilate Vegetables to Animals as purefaction does; nor prevents their yielding a fixed Salt in their Ashes, if they are afterwards burnt; as evidently appears in Tartar. One sort, indeed, of the vegetable Oils it converts into a volatile Alkali, but is not able to change all the oily parts

parts of it in the same manner. From such a number of Experiments, then, we understand the nature of that elementary Earth which enters into the composition of Animals and Vegetables, as a true principle. And in both these, this Earth seems to be perfectly of the same nature, there being very little difference observed in it. This no where appears more evident than in the Cupels, which are made equally good from the Ashes of Vegetables, or the pure Earth of Animals; and that, whether it is procured from Fishes, Birds, Beasts, their Bones, Hoofs, Flesh, or Juices, provided the Earth is but pure. See *Laz. Esker*, where he treats of this subject. This Earth, therefore, serves in the same capacity, both in Animals and Vegetables, gives a firm make to their Bodies, and affords a solid *Basis* for the rest of the Elements; for these must all be united with this Earth, that by this means they may be fixed, and held together, and thus reduced into the shape of any particular solid Body. This Earth alone gives to them all their proper form; and when this is separated from them, they all sink down into an irregular Mass, or being resolved, and set at liberty, become volatile, and are dispersed from one another. This Earth, by its fixity and tenacity, proves a proper *Vinculum* to bind, associate, and properly dispose all the other parts with one another, and so hardens the Body that arises from this conjunction, that by this means it becomes capable of resisting the Air, Water, Sun, and some degree of Fire itself, without suffering any inconvenience. But then, likewise, on the other hand, pure, dry, elementary Earth stands in need of the assistance of Water, or Oil, as a kind of Cement, to hold together its separate Elements, and thus to form them into one Mass.

If whole Animals are burnt in an open Fire, till they are intirely consumed, there then remains nothing but white Ashes, which being pounded, exhibit again an Earth exceedingly like the former, and free from all Oil or Salt. This can no ways be distinguished from the Earth procured from Animals, by the former operations, and serves absolutely for the very same purpose in every kind of Experiment.

The Earth of Animals by combustion.

But it is time, now, that we take a view of the fossil Kingdom, and see what Earth we are capable of discovering there. And here the native Salts, Nitre, *Sal-Gem*, Fountain Salt, and Sea Salt, first offer themselves to our observation. Take these, then, as pure as they can possibly be procured, dissolve them in very clean Water, and digest them for a long space of time in Vessels accurately closed, and they will yield an Earth at the bottom, precipitated from them, which will not be dissolved in the Water. When the Liquor is thus depurated, and grown exceeding clear, let it exhale in a place free from Dust, till you observe a Pellicle on its Surface; then remove it into a low, cool, quiet place, and it will shoot into little saline Glebes, of a particular figure, pellucid, and pure, which the Artists call Chrystals, and these, if they are thus carefully prepared, produce a particular *Species* of Salt perfectly distinct from every other. If the Liquor then that remains after the Salts are thus formed, is gently poured from them, it may be again inspissated to a pellicle, and by the same method as above it will generate fresh saline Chrystals, but not so transparent, or pure, as the former. If you, then, as before, separate the remaining Liquor, and proceed in the same manner, after the last chrystallization, there will be left a fat saline Liquor, that will not be dried

Earth in Fossils; first in Salts by solution.

without a great deal of difficulty, but then will produce some Earth: And this Mass, when you have rendered it dry by the Fire, will again spontaneously dissolve in the Air, and be of an acrid austere nature. If you take then the Chrystals thus procur'd, and dissolve them, and proceed as before, you will every Operation have some more pure Earth, which being collected together, will produce a large quantity thus generated from the pure fossil Salt. And at last, after this Chrystallization and Solution has been repeated a great number of times, all the Salt will become volatile, be dissipated into the Air, and escape any farther notice of our Senses; and of the whole Mass of Salt, which has thus passed under Examination, the Operator will have nothing left but mere Earth; for all the other parts, which in conjunction with this Earth, made up before the Body of the Salt, being by these Operations separated from it, grow so subtil, as not to fall under our Observation, and so volatile, that they cannot remain at rest, but fly away. These Experiments concerning the nature of Earth in Fossils, were known and describ'd by the ancient Chemists, and have been since performed and confirmed by the Moderns. See *Du Hamel Hist. de l'Ac. Roy. des Sc.* 1701. p. 16, 17.

By Distillation.

But again, if you take any one of the abovementioned Salts pure, and very dry, reduce it to Powder, and accurately mix it with three times its weight of very dry Clay, Bole, Brick-dust, or pure Earth, and then urge it with the greatest degree of Fire, it will by this means be resolved into a liquid part, which will be volatile, acid, and corrosive, and a fixed one, which will remain at the bottom of the Vessel in the Earth with which it was mixed. This fixed part, now, if, by boiling it in Water, and letting the Water settle, and afterwards filtering it, you perfectly depurate it, and then reduce it to Chrystals, will yield a Salt pretty much resembling that which was made use of in the distillation, except, that that from the Nitre will be in some measure alcalinescent. And if the Salt thus generated, is again dissolved, inspissated, and chrystalliz'd according to Art, it will likewise produce a great deal of Earth of the same nature with that which was procured from the original Salt. The acid Liquor, too, thus drawn from the Salt by distillation, being again distilled in a clean Vessel, will leave some yellow *feces* at the bottom, which when they are dried, are found likewise to contain something of Earth. And these acid Salts, now, thus prepared, are so volatile, when they are accurately freed from all their Earth, that being impatient of rest, they are continually dispersed into volatile Fumes, which can scarcely be contained within their Vessels, and fly off as soon as ever they come to have a free communication with the Air; as appears evidently in the distillation of *Aqua Fortis*, Spirit of Nitre, *Glauber's* Spirit of Salt, and Spirit of Sea-Salt; for in these the pure Volatile acid Salt spontaneously resolves itself into white or red Fumes, and without the assistance of any external cause, immediately flies off into the Air. If you thoroughly now consider these *Phænomena*, perhaps you will think it not very absurd to suppose, that all these acid Salts hitherto described, would not of themselves be at rest in our Air, but that they owe this rest, or as the Artists call it, fixity, principally to the latent elementary Earth, which secretly uniting with them, fixes their volatility, and thus holds them down: And on the other hand, that whenever they are disengaged from their confinement, and get free, they then spontaneously regain their former and proper volatility. Supposing, therefore, this

this to be the case, then both the simple Acid, and alkaline Salts, would, as has appeared by the former Experiments, from the purity of their simplicity, be always volatile, and then only become fixed when they were intimately united with Earth. In this Doctrine, however, there are two things that ought to be taken notice of; first, that the Acid of Vitriol, and burnt Sulphur, remains fixed in a Fire of 560 degrees, tho' it is purified by repeated distillation, and has deposited its *faeces* at the bottom of the Vessel. This, I confess, indeed, may possibly be owing to some non-acid that is intimately mix'd with it, whether you suppose it of a metalline or terrestrial Nature, that cannot easily be separated from it; for during the distillation, the Receiver is filled with very volatile Fumes, which, if there unfortunately happens to be any crack through which they can make their way, burst out in a deadly Vapour: Secondly, that the most volatile acid Salts, by being united with a very volatile alkaline one, are converted, without the assistance of any Earth to fix them, into a compound *Sal-Ammoniac*, which is semi-fixed. But to proceed, if Fossil Alum is dissolved, chrystallized, and treated in the same manner as the Salts abovementioned, from this likewise may be procured a great quantity of Earth, which being perfectly separated, this Salt too becomes volatile. This likewise in distillation sends forth a very volatile and pernicious Vapour, and leaves a great deal of a kind of Lime-Earth at the bottom of the Retort. But prosecuting these inquiries still farther, I dissolved some Vitriol in Water, and digested it, and by this means procured from it a large quantity of Earth, called Ochre: And whilst I patiently repeated the former work of solution, and chrystallization, and in the same manner removed the *faeces*, all the Vitriol was converted into a yellowish *Calx*, which was the greatest part of it, a volatile part that was dissipated into the Air, and a thick Liquid, which was pinguious, and very austere. These *Faeces*, now, I am very well apprized, indeed, cannot properly be referred to elementary Earth, but are rather the *Calx* of the corroded Iron: In the other particulars, however, this *Analysis* of Vitriol resembles the former Operations. The *Calx* now thus procured, may, by a very strong Fire, be converted either into Copper or Iron, according to the different sort of Vitriol you make use of; and hence we evidently see what judgment we ought to make of that opinion, which some Persons have fallen into, who upon seeing the separation of such a *Calx* from a metalline Vitriol, have hence inferred, that Earth itself enters into the composition of Metals. For my own part, I confess, I don't remember, that by any one Experiment I have ever discovered a true Earth in Metals: As for that which is offered for it, it is capable of being melted into Glass, and by this very property shews, that it is not of a terrestrial nature, and gives strong suspicion that it is of a metalline one.

If we examine farther, the fossil liquid Sulphurs, and the substances produced from them, as the *Asphaltus*, Bitumens, *Naptha*, *Petroleum*, and *Oleum Terræ*, these, if they are exposed to an open Fire, burn in Flames, produce Soot, emit black acid Fumes, and when they are quite consumed, have something of Earth at the bottom; and from this, if by farther burning you reduce it to a *Calx*, you will always be able to obtain a pure Earth, exceedingly like that from Animals, Vegetables, and Fossil-Salts.

And in sulphureous Liquids.

And Solids.

And as for true Sulphur, if you sublime it into flowers in a close Vessel, it will always the first time leave some Earth at the bottom; tho' the Flowers, indeed, thus produc'd, in a second sublimation scarcely yield any. But if with the purest Sulphur, you intimately mix over the Fire an equal quantity of a very pure alkaline fixed Salt; then the compound that arises hence, being put into a clean glass Basin, and exposed to the Air in a place free from Dust, will very soon dissolve into a Liquor, to the bottom of which will subside a great deal of Earth. This Earth you may possibly attribute to the Alkali; nor do I deny but this may be concerned in it. Give me leave, however, to assure you, upon undoubted evidence, that the Oil, which, in conjunction with the fossil Acid, produces Sulphur, contains likewise, and will yield a good deal of Earth. Hence, therefore, you will be apt to be of opinion with me, that this Earth may in this case be regenerated in the resolution of the Sulphur, and thus discover itself to the Operator.

Is there any
likewise in
Metals?

The most ancient of the Chemists who got a knowledge of the Laws of Nature purely by the assistance of Experiments, were of opinion, that all Metals consist of Mercury exceedingly homogeneous, and another principle, which gives it fixity and ductility under the Hammer: That these two Principles alone enter into the composition of Gold and Silver; but that in the other Metals, besides these two, there is likewise another matter that won't bear the Fire, is subpinguious, and in some measure inflammable, which being intimately mixed with them in their original formation, becomes very firmly concentered with them: As for any other Principles, they scarcely make mention of them in their natural History of Metals. The Moderns, however, relying upon the evidence of their Experiments, every where in the *Analysis*, and composition of Metals, tell us of an Earth, and that too, one that will vitrify, which enters into their composition, and is the firm *Basis* of them all: But this Earth, which they thus tell us may be procured from Metals, does not, in reality, answer to the character of Earth, and therefore in a strict sense does not deserve the name of it. For my part, I have taken a great deal of pains in that affair, but have never yet, I confess, been able to discover in them any true Earth.

Scarcely in
Mercury.

Mercury, when it is fresh brought out of the Mines, if it is strongly pressed through a thick Leather, seems to leave a little Earth behind it, whilst it thus passes through its Pores. If you then, after it is depurated in this manner, distill it in a clean glass Vessel, it will leave a small quantity of *Fæces*, of no weight hardly, or scarce worth taking notice of. Nor can I, indeed, venture to call this, Earth, which is thus separated from the Mercury by distillation, since the distinguishing marks, by which we before defined Earth, are not found to belong to these *Fæces*. Take then this Mercury, now rendered exceeding pure by distillation, and put it into a strong glass Bottle, made of deep green Glass, and so thick, that it may bear the concussion of the Mercury without any danger of being broke: Then stop the mouth of the Bottle exceeding close with a Cork covered with a Hog's-bladder, which drive in tight, and then secure it all round with Pitch, that let the agitation be ever so great, none of the Mercury may be able to escape out of the Bottle. This being done, let the Bottle with the included Mercury be mov'd very strongly about, and for a great while together; which will be best effected by fastening

tening it to the Sails of a Wind mill, or fixing it in some swift carriage that is every day driving about: And by this means, the Mercury being thus continually agitated within this narrow compass, the greatest part of it, without the addition of any thing else, will be converted into a dry, black, heavy, fine Powder, which is exceedingly efficacious in curing stubborn Ulcers, and as it is imagined, is scarce dissoluble in any *Menstruum*. This very extraordinary Experiment, which has been tried by the egregious *Homberg*, and which few people are acquainted with, has given occasion to its being asserted, that true Earth may be produced from the very Body of the Mercury by this simple mechanic motion; whilst on the other hand, others have rather been of opinion, that the pure Mercury, by being agitated by this continued concussion, disengages itself from the terrestrial part, which nature had united with it in its formation; and that, therefore, that part of the Mercury, which remains after this separation, being purified, and freed from its unactive Earth, become agile and pure, and by this means grows fit for the profound Operations of Alchemy, and is, in reality, the so much wish'd for *Mercurius Sopororum*. Perhaps you may desire to know what is my Opinion of this Affair: In short then, I take the liberty to assert, that the Powder thus described is not elementary Earth, much less an Earth, that as a constituent Principle, enters into the composition of native Mercury. And if any Person will but take the pains to examine this Earth by calcination, and nicely observe the various and wonderful Colours that successively appear in it, and will in particular, at the same time consider its wonderful virtues in curing carcinomatous Ulcers, I am persuaded he will hardly be of opinion, that this is the mere simple Earth of Mercury. Nay, but should I assert farther, that this Powder may be dissolved in various *Menstruums*; and that afterwards it may be reduced again into pure Mercury, it would not be without foundation. Believe me, Gentlemen, who have had long experience in these things, minds that are always ready to run into hasty conclusions, are not properly suited to the prosecution of the chemical Art, which discloses its secrets to those only who are patient of labour, and carefully compare together the events of various Experiments, whom it rewards with proper discoveries. As it is exceeding difficult, therefore, truly to demonstrate any Earth in Mercury, so on the other hand it is easy enough to come at the knowledge of many various forms of this changeable Body, which from its own nature is capable of being converted into a thousand odd and different appearances, and thus imposes upon the unwary, tho' at the same time it remains always one and the same at the bottom.

And let a Man, now, examine the rest of the Metals ever so accurately, where will he be able to discover any Earth in them? In the *Calx* of them? These certainly all continue true Metals: For altho' the *Calx* be insipid, inodorous, fine, and sometimes too pulverizable, yet, by the addition of some reducing Powders, as they call them, and other contrivances, they may be brought back again to their original form. Whoever, therefore, looks upon these *Calx's* as true elementary Earth, may suppose with equal reason, that by these slight methods, too, he is able to transmute Earth into Metals whenever he pleases. But besides, the Metals calcined in this manner, may, by the efficacy of the Fire alone, or by admixture of some other substances with them, be converted into true Glass, which every one, who is acquainted with these things, knows

Nor from
other Me-
tals.

knows very well, can scarcely be affirmed of pure simple Earth. In the mean time, however, I must caution you, that the baser Metals, Iron in particular, when they are analyz'd according to Art, do yield something that comes very near to the nature of Earth; tho' this, indeed, is but in small quantity, and even here does not appear to be perfect Earth. But whilst we are upon this head, give me leave to lay before you, what I myself, after a great deal of pains in examination of Metals, have been able, with certainty, to discover. If Gold, Silver, Copper, Tin, and Lead, are first prepared in a certain simple manner, and then accurately mixed with the purest Mercury, and by this means intimately dissolved, and are afterwards digested for a long space of time, and then either very patiently rubb'd or shook about, there will at last be produced from this Mixture, a great deal of insipid, inodorous, fine black Powder, which in all of them, will be of the same kind, and which being perfectly separated by Water and Motion, will leave a pure metallic Mass. This being agitated by farther shaking, or rubbing, will generate as before a large quantity of the like Powder; and this will be always the event, tho' this Operation should tediously be continued for years together, as I myself have often experienced. If those Gentlemen, therefore, who in their Writings suppose Earth to enter into the composition of Metals, had prosecuted these inquiries in the same manner, they would not certainly, in order to confirm their opinion, have too hastily referr'd us to this Powder. For my part, who have hitherto laboured in vain to bring these Experiments to the desired issue, I am obliged ingenuously to confess, that the Powder procured by this Art, is by no means Earth, but a wonderful metalline Production, whose properties I have found to be very surprizing. Upon this head, therefore, I may be excused at present saying any thing farther, as I think, to the wise, what I have offered is sufficient. If any Person goes about to seek for a true Earth in this metalline Powder, he will hardly accomplish his end; tho', at the same time, he will discover a great many things that he never dreamt of. And, indeed, upon the evidence of what I have seen, whilst I have been closely engag'd in these pursuits, I may almost venture to affirm, that neither Gold, Silver, or Mercury, contain any thing of Earth in their natural Composition; but that they are formed of such a nature, that tho' they are divided into their least possible parts, yet they will still retain such a disposition, as will render them fusible in the Fire, or ductile under the Hammer. Concerning Gold, I can testify myself, that I have reduced it into a Liquor by the assistance of fossil Acids, I have formed it into soft Pastes, and procured *Calx's* from it in different manners; it may easily, likewise, be converted in a volatile scarlet Oil; it may be chang'd into a Substance like Butter; it may be turned into Glass; and it will sometimes most exactly resemble Earth: But still, notwithstanding its appearing under all these different forms, it may always be again reduced to Gold, perfectly the same in all respects, its weight not in the least, either increased or diminished. And after an incredible number of distillations of it with Mercury, I have always at last procured my Gold again. With Silver too, I have performed the same tedious Operations, and the event has been constantly the same. Upon the evidence, therefore, of these Observations, I could not help again admiring the ancient Alchemists, who have openly told us, that Gold and Silver are generated from pure Mercury alone,

fixed by a condensing Sulphur; and that the rest of the Metals too, owe their origin to the various combinations of a Mercury less pure, and a Sulphur less defæcated.

From the Doctrine, now, that we have thus delivered, we may deduce the following Corollaries. Hence then it appears in the first place, that the very same simple elementary Earth, concurs, as a constituent Principle in the formation of the particular corporeal fabrick of Animals, Vegetables, and some Fossils, that are less durable, and less simple: That in all these it serves as a firm *Basis* to give them their proper form, and unites all the other Principles, both with itself, and with one another, into one single particular Body: That by this means, it fixes, retains, and keeps from dissipation the other parts, that are of themselves too volatile, and thus disposes and qualifies every Body to continue what it is for some time, and that, both with regard to the whole Body, and every part of it: That this is the principal natural cause, that the whole frame is not too easily, or too quickly dissolved, either by the Air, Water, its own proper juices, or even Fire itself: And that to the efficacious concurrence of the Earth, therefore, in giving to every single Body its proper and peculiar structure, must be ascribed in an especial manner, the power of assimilating foreign substances into the nature of the Body that is nourished, and consequently, in some measure, the seminal virtue that Bodies have of generating their like; for this always perishes in every particular Body, as soon as ever its structure, which depends principally upon the Earth, is destroyed. 2. These Bodies, therefore, that owe their origin to the very same Earth, must in this respect, wonderfully agree with one another. Nor, indeed, do they resemble one another only in respect of their Earth, but generally likewise, in the very great affinity there is between their other concurring Principles. If you consider all the different kinds of Animals, in what a vast number of circumstances are they like one another? As Vegetables, we see all agree in many surprizing Properties. The Elements of Animals, we observe, are continually changing into the Matter of Vegetables; whilst on the other hand, the Bodies of Animals are perpetually supported and nourished by the Vegetables which they take in, and assimilate to their nature, and which afterwards actually enter their very make. The same thing likewise holds true in most kind of Salts, which are partly composed too of this Earth. Who will pretend to assert, that Salt of Nitre, or Sea-Salt, are so very remote from the disposition of the animal Body? But in these we discover the same Earth. And hence, by the way, it comes to pass, that alcalious fixed Salts, when they are taken in a moderate dose, are so easily assimilated to the animal Nature: For if a strong healthy Man takes small quantities of these, at suitable distances of time, they will lose their proper qualities in his Body, nor will there any fixed Salt appear in his Urine. 3. Bodies, therefore, that owe their origin to the same Earth, are easily transmuted into one another. 4. Iron, which of all the Metals seems to come nearest to the Earth of Animals and Vegetables, must be allowed likewise to come nearest to Animals and Vegetables in nature, and seems as if it might in some measure be dissolved in them: And hence it yields a noble, and very safe remedy for Diseases of the human Body, whilst the rest of the Metals act with more violence. 5. For these, as they do not acknowledge Earth, but Mercury for their *Basis*, seem to remain
immutable

immutable in all Bodies, nor appear to be capable of being digested by our concoctive faculties. For this reason, therefore, they always continue foreign to our nature, and contrary to it; and tho' sometimes in certain exceeding stubborn diseases they are of service, yet if you regard them in another view, they seem intirely superiour to the animal powers. 6. If there was no such thing, therefore, as Earth or Mercury, would all the Bodies that we are acquainted with be active, volatile, and so subtil as not to fall under the cognizance of our senses, and consequently be floating Atoms? Even the Sulphur of Metals itself, before it fixes, and is fixed by Mercury, the Alchemists tell us, is of all Bodies the most subtil and volatile. Concerning the rest, the doctrine we have above delivered leaves us no room to doubt. 7. Earth, therefore, principally furnishes the Chemists with their Instruments and Vessels. All kind of Glass has a great quantity of terrestrial matter united with its fixed alkaline Salt; and therefore, in this respect, owes its origin to Earth. As for the Potter's Vessels, these consist chiefly of pure Earth, compacted into a solid Mass, by the intervention of Water. China-vessels too must be referred hither, tho' they are of a particular kind. And Chalk, on account of its great likeness, may be reduced hither also. 8. But again, pure Earth being mixed in a proper quantity with pure fixed Salt, prevents their running into a Mass, if they are exposed to a strong Fire, which would certainly have been the case, had the Earth been away. And as by this simple intermixture it thus hinders their fluxing, so likewise, at the same time, it renders them volatile, tho' they were ever so fixed. Salt of Tartar may serve as an instance of this, which, if it is very good, and has nothing else mixed with it, will melt in a strong Heat, and if it don't insinuate itself through the Pores of the Vessel, will continue fixed there a great while; and yet, if you accurately mix it with three times as much pure Earth, calcin'd Bones, for instance, and then expose it to the same Fire, it will in a short time almost totally fly off, nor will it run as before. In the same manner, Nitre and Sea Salt, more particularly, if they are alone, and urged with a strong Fire, will flux, and remain fixed; if you mix Earth with them, they will not melt, but will be converted into Acids, and become volatile. Pure Earth is, likewise, of excellent service to the Chemists, when they want to purify animal or vegetable Salts from the Oil which tenaciously adheres to them, and renders them very impure; for when these are exceeding foul from the empyreumatical Oil that is united with them, by the mixture of very pure Earth, they will be disposed to rise in a proper Heat of an exceeding white colour, depositing all their Oil in the bibulous Earth, and being by this means intirely freed from it, which, without the addition of such Earth, would be very difficult to accomplish. And here the purer and dryer your Earth is, and the greater quantity you make use of for this purpose, the finer and more perfect will you obtain your Salt, especially, if you make use of a tall Vessel, and expose it but to a gentle Heat: With these circumstances the operation is always performed most to advantage, which was formerly very cautiously concealed among the *Arcana*. 10. This same Earth, again, by being mixed with a great many Substances disposes them to discharge a flatulent Vapour, which otherwise, upon the application of Fire to them, would make them puff up to such a degree, that not being able to bear the Heat necessary for the distillation, they would swell
and

and rise in the Retort in such a manner as to run over into the Receiver, and thus confound every thing together, and prevent the hop'd for effects of the operation. If a person has a mind to distill Honey, for instance, or Wax, for any valuable purposes, he will lose his labour, if he makes use of these for this operation by themselves: For by a gentle Heat you won't be able to bring about the separation of these tenacious particles; and if you apply a strong one, these Substances will swell and puff up, like a sponge, and by this means, in a liquid form will rise through the neck of the Retort, altered, indeed, but not separated, according to art: But when by practice the Operator has learn'd to mix a proper proportion of Earth with them, then the effect of the tenacity of the Particles being prevented by the interposition of the Earth, they will bear a considerable Fire, without any danger of this inconvenience, and the flatulent expansion being thus restrained, the separation of the parts by the action of the Fire will be equable and regular. Nor is this observed to be the case only in such kind of viscid Bodies, but it is found to hold true, likewise, in others. Take, for instance, Blood, Eggs, or Urine, and by very patiently and cautiously distilling them, proceed till you have drawn off all the volatile parts, and there remains a fixed Substance at the bottom of the Retort: If then you increase your Fire to the last degree, the whole Mass being now grown tenacious, like pitch, will be wonderfully expanded, will cohere together, and in this manner will rise into the narrow part of the neck of the Retort, will fill and stop it up, and thus inclosing the Matter, which is under it, and which too is equally expanded, has been often the occasion of the Vessel's being burst in ten thousand pieces, in a very dangerous, and sometimes fatal manner. All this violent effect, now, may be prevented, by throwing only a terrestrial Powder upon the Matter that you are about to urge in this manner; and hence the addition of Earth is of vast service in the production of Phosphorus from inspissated Urine, by the extreme force of the Fire. 11. All that I have hitherto laid down concerning the nature of elementary Earth, must by no means be applied to our common Sand, which many persons very wrongly imagine to be true Earth: For this, if it is very pure, upon examination with a microscope, discovers itself to be nothing but a heap of small, pellucid, multangular chrystals, every one of which is of a different size and figure: These, in conjunction with a fix'd Alkali, will easily run into Glass, as has long ago been discovered: These the wise Author of Nature has disposed about the World, that the fructifying Water might be always able to insinuate itself through the pores of the Earth, which would otherwise very easily unite and coalesce into one Mass, and by this means in a short time acquire a perfect stony hardness, to the infinite detriment of Mankind. Nor must we refer the Boles, or medicated Earths, commonly called the scal'd Earths, to this natural class of elementary Earth: For who don't know, that these are compound Bodies? That somewhat pinguious predominates in them, the Writers of Natural History have long ago taken notice; and hence they have called some of them, the *Axungia* of the Earth: In others of them there is somewhat of a saline astringency, sometimes of the aluminous, or vitriolick kind, to which their particular virtues are owing; not to mention any more of them. When Water, however, and Fire have exerted their utmost force upon these Boles, then, I confess,

fels, they come nearer to true Earth, but then too they lose at the same time their medicinal virtues. But least of all, must we, in a chemical sense, look upon the earth, as it is commonly called, which we tread upon, and which furnishes us with supplies both of health and life, as such an Earth as we have been describing. For this our Earth evidently contains fat Clays, medicated Boles, sterile Sands, little Stones, Water, Air, Oils, Salts, all the Elements of Animals resolved into their Principles, and all the Principles of dissolved Vegetables, blended, and confounded together. This, therefore, appears to be so far from a pure Element, that if we would consider it in a proper view, we must regard it as a Chaos of all the natural Elements, and the Bodies compounded of them. Many things more, Gentlemen, I could offer upon this Head, but by the length of my discourse, I am sensible I have already grown tedious. What things I have delivered, however, I think I could not length omit, as they are every where of service, nay, indeed, and necessary to be rightly understood. You'll be so good, therefore, to excuse my entering so minutely into these inquiries, if it was for no other reason than this, that you have by this means had a faithful account, at least, if not a compleat one, of those four Elements, by the concurrence of which the most ancient of the Philosophers supposed every kind of Bodies to be formed. The particular opinion too of the Alchemists, upon these subjects, you have here had likewise laid before you. And lastly, I may almost venture to doubt, whether you have not here met with some things which were never published before. You have seen, that what are generally looked upon as Elements, are, in reality, mixed with an incredible quantity of various Bodies, and by this means are of an exceeding compound nature: That these, however, when they are artfully separated from every thing else, and thus obtained perfectly pure, and by themselves, far excel all other Bodies in their individual simplicity. What is there in Nature more simple than pure Fire, Air, Water and Earth? And again, in another sense, what is there that is more compounded? I have endeavoured to offer nothing concerning these Elements that is not sound, and will bear the test; and therefore always caution'd you where I was at a loss myself, nor have ever been too hasty to come to conclusions, where the thing was doubtful. What I have interspersed concerning Metals, I formerly did not think to have added; but the diligent attendance with which you have honoured me has drawn it from me.

Of CHEMICAL MENSTRUUMS.

Having thus, Gentlemen, dispatched those four Instruments both of Nature and Art, Fire, Air, Water, and Earth, let us now pass on to a fifth kind, which is look'd upon as almost proper to Chemistry, and to which the Masters of this Art assign the principal place, valuing themselves particularly upon it, and chiefly ascribing to it the surprizing effects of their Art; and this they have called a *Menstruum*.

Definition
of a Men-
struum.

By this barbarous term, now, they designed to express a Body, which being applied to another, according to the rules of art, would so minutely divide it, that the Particles of the Solvent should be perfectly intermixed with those of the Solvend, or Body to be dissolved. This definition I chuse particularly for this reason, because it accurately distinguishes the action of a *Menstruum*

struum from the other solutions of Bodies, which are performed chiefly by the mechanical powers: For in these cases, the Solvent recedes from the Solvend, nor is reciprocally dissolved by it, but as soon as ever the solution is over, they separate from one another, according to the disposition of their specific gravities.

The reason of a Solvent's obtaining this name, was this; as the application of the *Menstruum* to its Solvend was promoted particularly by the help of a moderate Fire, which was constantly kept up for forty days, or a philosophical month, hence the Solvent came to be called the Solvent *Menstruum*, and at last by the simple name *Menstruum*. The reason of the term.

From the nature of a *Menstruum*, then, it will follow, that this itself must be equally dissolved by the Solvend, as the Solvend is divided into its parts by the *Menstruum*. And this circumstance obtains in every kind of solution whatsoever, that is effected by the help of a *Menstruum*, though, at the same time, it is true, it may happen, that when the Solution is perfectly compleated, the Solvent and Solvend may be separated from one another. And, indeed, in the Solutions that are performed by the Liquor, Alcahest, *Van Helmont* tells us, the Solvent and Solvend are distinguished into two different *Strata*, lying upon one another; but setting aside this, this separation is rarely observed in these solutions. The proper faculty, therefore, of the Solvent consists in this, that it on every side applies its own particles to those of the Body to be dissolved. The divided Particles, therefore, of the Solvent must insinuate themselves between those of the Solvend, and so interpose themselves between their Surfaces, and thus divide the Body to be dissolved. And at the same time that this happens, you see, likewise, that the *Menstruum* must be separated into its minutest parts by the divided Particles of the Solvend, as well as that is separated into its Particles by the *Menstruum*. And hence, likewise, appears the truth of our former assertion, that this action of a *Menstruum* is absolutely different from any common mechanical separation; for in this case, the dividing Body remains whole and intire, both whilst the division is effecting, and when it is compleated. This you see evidently in the action of a Knife, Wedge, Sword, Ax, Hatchet, Saw, Dagger, Augre, and Hanger; for these all, whilst they divide, are not divided, but remain nearly the same they were before. In the mean time, however, if we examine into this Affair more nicely, there will be room to doubt, whether every single Particle of the *Menstruum*, separately considered, does not, whilst it is dissolving, act in reality, in the same manner as the Instruments just mentioned. Certainly, one such dissolving Element will have its proper size, figure, hardness, and weight, and will act by these Powers, which so far may be called mechanical. At the same time too it is constantly true, that every *Menstruum*, whilst it is dissolving, and even in this respect, that it does dissolve, as it is then divided into Particles that, on account of their subtilty, become insensible, must for this very reason be a Fluid, and in the very point of time that the Solution is perfected, the Solvend too itself, as such, must likewise be dissolved into a fluid Body. Hence therefore, at last, it follows, that at the time of solution, the Solvent with its Solvend will be converted into one Fluid. Property of a Menstruum.

But here it is necessary we take notice, that many *Menstruums*, before they perform their office of dissolving Bodies, are themselves solid, hard and dense; Division of Menstruums.

though indeed so long as they continue in this solid form, they by no means act as such. By use, however, it has obtained, that these should be called *Menstruums*. And hence the Chemists have always laid down, that some *Menstruums* are hard or solid; others fluid. And this division may be allowed of, if the distinction just mentioned is first properly understood.

1. Into those
that are dry
before the so-
lution.

To the hard, dry, and solid *Menstruums* then may be referr'd the following Bodies, which we have reduced into their proper classes. 1. The fix solid Metals, Gold, Lead, Silver, Copper, Iron, Tin. These, now, when they are cold, hard, and solid, have no effect at all upon one another, but when they are put in fusion, may be so intimately mixed together, that to the senses the Mass will appear homogeneous, nay, and will have this surprizing property, that in every single Particle of the compound, there will be found the very same proportion of the different Metals, as there is in the whole Mass. For if in a strong Fire you melt ten ounces of Silver with one ounce of Gold, and thus form a Body of eleven ounces; then if you give but one grain of this mixture to a person well skill'd in the docimastic art, he will return you $\frac{1}{11}$ of a grain of Gold, and $\frac{10}{11}$ of Silver. But another thing here still more remarkable is this, that it is possible to divide Gold in this manner as long as ever you please, without any limitation hitherto observed; for if with a hundred thousand parts of Silver I thus mix one part of Gold in the Fire, and then examine but one small Particle of this whole Mass, according to the rules of the metallurgic art, the event will be exactly the same as the former. This surprizing *Phænomenon* then evidently demonstrates the very extraordinary power that Metals have of dividing one another by the sole help of fusion. Consider, I beseech you, to what an expansion this small Particle of Gold must be distended in so great a Mass, to effect, that there shall not be the least Particle of Silver assignable in the whole, in which there will not be always a proportionable part of Gold; which nevertheless continues still immutable among other immutable Particles, exceeding dense among other dense ones, and perfectly simple among other simple ones. Think of these things, Gentlemen, attentively, for it is well worth your while, and learn hence how wonderfully the Great Creator has formed these Metals: Certainly you will discover here somewhat infinitely mysterious, and that surpasses all human comprehension. Upon the contemplation, possibly, of this property, the Chemists have so often asserted, that Metals are opened by Metals alone; that nothing is intimately admitted, or enters into Metals, but Metals themselves; and that the Mercury of Metals is of infinite subtilty, and continues always the same. 2. Solid semi-metals, to which may be referr'd Antimony, Cinnabar, Bismuth, Merchasite, Zincq. These too, like Metals, when they are melted in the Fire, may be mixed together, and will divide one another no body can tell how far; and these, likewise, may be mixed and blended with Metals with the same success: Cinnabar, indeed, with more difficulty; the rest easy enough. But with this admixture with Metals, they constantly destroy their malleability, and render them so brittle, that they will suffer themselves to be reduced to powder, though before they were ever so tough: And this again holds true in every the least Particle of the Metal. Here, therefore, likewise you have a wonderful *Phænomenon* that deserves your consideration. 3. To dry *Menstruums* again must be referred all perfectly dry Salts, Alum, Borax, Nitre, *Sal-Ammoniac*, Fountain Salt, *Sal-Gem*, Sea Salt, Vitriols,

Vitriols, dry, fixed alcalious Salts, and corrosive Sublimate of Mercury. All these, now, when they are acted upon by the Fire, or melted, bring about by their dissolving powers, very extraordinary effects, scarcely imitable in any other manner; and they suffer themselves, likewise, to be very minutely divided by the Fire, and by this means may be intimately mixed, not only with one another, but also with Metals, Semi-metals, and other Bodies. 4. Among these must be reckoned all hard, fossil Sulphurs, quick Sulphur itself, common Sulphur, Arsenic, Orpiment, and Cobalt. In these, likewise, when they are assisted by the Fire, or melted, and so mixed with one another, or other Bodies, there is a wonderful dissolving power, by which they produce such effects, as we can scarcely accomplish by any other causes. 5. And lastly, under this head I reduce all those kinds of Fossils, which the Metallurgists commonly call Cements; for these consist of Salts, Sulphurs, and Bricks, reduced to a dry powder, which is then disposed between plates of Metals, either to heighten their colour, or to separate them from one another.

But among the various *Menstruums*, we find some, likewise, that, after they have performed their solution, and are left to themselves, coalesce into one hard Mass, which to our senses appears simple, and every where of one uniform nature. And the apparent simplicity is here often so great, that though the Mass is compounded in this manner of different Substances, yet still it appears simple. To Lead, whilst it is in fusion in the Fire, pour melted Tin, and they will run and mix together, like Water with Water, or Mercury with Mercury; and this will always be the case, let the proportion of one to the other be what it will. Look at these Metals thus melted in the Test, and you won't discover the least sign of any different Substance; and if you suffer them to grow cold together, they will form one solid homogeneous Mass, that appears simple to the sight, and will afterwards continue so. The same holds true in all Metals, and in some Semi-metals beforementioned. If to a pound of melted Tin, in the Fire, you add a scruple of *Regulus* of Antimony, when the Mass is cold, it will appear homogeneous, and be so brittle through the whole, that take ever so small a particle of it you will not find the malleability in it that is natural to Tin; but on the contrary, you will always find a proportionable part of the Antimony mixed with it. Does not a fixed Alkali run, likewise, with Sand or Flints into one simple Mass? But there are an infinite number of like instances, as you yourselves very well know, and therefore these we have mentioned are sufficient. In all these cases, now, the Particles both of the Solvent and Solvend are so minutely divided, intermixed, and concreted together, that they form a new Body, in which it is not possible for any person that don't know the composition to discover the concurring Substances, except by some other contrivance he again resolves the Body into its component parts. Sulphur too and Mercury are by rubbing converted into a black, dry powder, and this being sublimed with a strong Fire, produces a Cinnabar, of a beautiful red colour, and to all appearance, exceeding simple. But in the second place, it is likewise observed, that a great many solvent Fluids perfectly dissolve solid Bodies into their ultimate parts, but when the solution is completed, unite again in one hard, and often dry Mass. Not to mention again Sulphur and Mercury; if we examine almost all the *Menstruums* of Metals, don't we find, that these

2. Into dry ones after solution.

unite.

unite with their Metals into Vitriolick Masses that are considerably firm, and durable? The very strong Acid of Wine, Vinegar, after it has corroded Oyfter-shells, Stones, or Chalk, separates from its aqueous part, and with these dissolved Substances hardens into a dry Mass.

3. Fluids before solution.

But a great many, and perhaps the greatest number of *Menstruums*, do really exist in a liquid form, before they perform the office of solution; of which sort, indeed, are almost all what the Chemists usually call *Menstruums*. Vinegars, Water, fermented Spirits, saline, acid Spirits, alkaline and compound, alcalious Oils, as they are called, *per Deliquium*, and many other Liquids, are referred hither: And as all these appear in a fluid form, the action of them is much more evident, and easy to be understood; and that the more so, because they are continually in use in the Elaboratories of the Chemists.

4. Fluids after solution.

And last of all, there are some *Menstruums*, or Solvents, which before solution are liquid, and when that is completed, still continue together with their dissolved Body, in the same form. This no where appears more evident, than in the Solution of the five Metals by simple Mercury; for when these are thoroughly mix'd together, according to art, there arises hence a soft Paste, which, by the affusion of more Mercury, you may dilute at pleasure, without any limitation: But scarcely any body has ever been able to render this Substance hard by the chemical contrivances that are vulgarly known. Whoever can make himself Master of this secret, will be a good, and perhaps a rich Operator; but whoever attempts it, will find in it plague enough. But again, any acid Liquids, when they have dissolved their proper Metals, if they are mixed with them in a large quantity, will, together with their Solvents, continue moist, nor will afterwards be dried very easily. Hence a great many persons have looked upon these dissolved Bodies, with their Solvents, as fixed, metalline Oils, and idly expected from them wonderful secrets; whereas in reality these are nothing more than a large quantity of acid Salts, collected about Metals. There are besides vast numbers of other *Menstruums*, which with the Bodies dissolved still continue in a liquid form, so that we need not detain you any longer upon this head.

The action of *Menstruums*.

From the consideration, now, of the several kinds of *Menstruums* just mentioned, we easily perceive, that many of them unite Bodies together, as well as separate them into their minutest parts. For it is a common observation, that when the Particles of some *Menstruums* have by their proper action dissolved their Solvents, they then so unite themselves to the Particles of the Body dissolved, that by this concretion they become together formed into a new compound Body, oftentimes very different in nature from the simple, dissolved one. And here it is likewise certainly true, that the Particles of the Solvent do not any longer continue in mutual contact, but are separated from one another, by means of the Particles of the dissolved Body that are now interposed between them: And again, that the Particles which before, by their union, composed the Solvent, are now kept too at a distance from each other, by the interposition of the Particles of the Solvent. From this division, separation, and concretion, therefore, of heterogeneous Particles thus brought about by the help of *Menstruums*, there arises a vast variety of new Bodies. But this now becomes particularly remarkable, when only some of the Particles of the Solvent and Solvend are united together into one Mass, whilst,

at

at the same time, others are not admitted to this new concretion, but appear in a different form.

Hence, therefore, it evidently follows, that the Particles of the *Menstruum* Considered more nicely. apply themselves to those of the Body to be dissolved, and become chiefly united with them, at the very instant of time that the solution is effecting. Here, therefore, some certain cause is necessary to occasion the Particles of the *Menstruum*'s receding from one another, and applying themselves rather to those of the Solvend, than remaining in the situation they were in before. And when the Particles of the Body dissolved are by the power of the *Menstruum* separated from one another, is there not a similar cause requisite, that these Particles should continue united with those of the *Menstruum*, and not rather, that after the solution is compleated, the Particles of both of them should, by an affinity of nature, collect themselves into homogeneous Bodies? This, Gentlemen, I would desire you to take particular notice of; for it highly deserves your observation.

But again, please to consider, that this cause, be it what it will, must for the very same reason be sought for in the Solvent, as in the Solvend: And hence it will be common and reciprocal in both. For when Gold is dissolved in three times its weight of *Aqua Regia* into a yellow Liquor, the Particles of Gold remain so united with those of the *Aqua Regia*, that, though those of the former are eighteen times heavier than the latter, yet they keep suspended in this Fluid, nor sink to the bottom. Is it not plain, therefore, that between every Particle of the Gold and *Aqua Regia* there is some reciprocal vertue, by which they attract, and come into a close union with one another? If this was not the case, the Particles of the dissolved Gold would certainly subside to the bottom; the saline parts in a different *Stratum* would lie next above them; whilst the Water would swim separately and distinctly at top; whereas, on the contrary, we see that all these three, though so very different in their natures, appear in the form of one simple, uniform Liquor. Both in the Solvent and Solvend.

If we may be allowed, therefore, to reason from analogy, the action of dissolving, so far as we are hitherto acquainted with it, seems rather to be performed by a certain power, by which the Particles of the *Menstruum* endeavour to associate to themselves those of the Body to be dissolved, than by one which makes them fly from, or repel one another. Here, therefore, we are not to conceive of any mechanical actions, violent propulsions, or natural disagreement, but there seems, on the contrary, to be a sociable attraction and tendency towards an intimate union. This I confess, indeed, appears a paradox: But consider, if you please, what you yourselves have observed in any violent solution; certainly, the agitation, noise, and confusion continue no longer than till all the Particles of the Solvent have united themselves with all those of the Solvend, and the very moment that this is compleated, there appears among them but an intire and perfect rest. As an instance of this, please to take notice of this Vessel, which contains some diluted Spirit of Nitre. The Liquor, you perceive, at present does not discover the least sign of motion. In this now I immerse this piece of Iron, and what a multitude of Bubbles are by this means produced spreading themselves even to the brims of this large Vessel? What a violent agitation, ebullition, noise, and almost fiery Smoak! But how long do all these last? Certainly no longer than whilst there are still left some saline Particles of the Nitre, which are not come into contact with those of the Iron, for as soon as ever this adunation is totally More from attraction than repulsion.

tally and perfectly completed, then the whole mixture is immediately quiet, and all the Acid becomes so closely united with the Iron, that it can scarcely afterwards be separated from it.

Is performed
always suc-
cessively.

Nor must we here neglect to take notice, that the whole Solvent never acts at once upon the whole Body of the Solvend; for this, as I know of, has been never known to happen: But on the contrary, the Particles of the Solvent act only upon those of the Solvend, which they first come into contact with, and having dissolved these, and separated them from the whole Mass, then other fresh Particles of the *Menstruum* apply themselves to those of the Solvend that still cohere together, and so proceed, till the solution is quite completed.

Exciting
itself.

Part of the *Menstruum*, therefore, acts upon that part of the Body which it actually dissolves and separates from it. But whilst this separation happens among these parts, from the conflict that arises between them, there necessarily follows an agitation through the whole, by which means the other Particles of the *Menstruum* which were at a distance are put in motion, and thus in their turn are brought more easily to the remaining part of the Body that is not dissolved.

And increas-
ed by Fire.

But as the agitation thus excited proves an efficacious cause in these solutions, so there is another that promotes them likewise, and that is Fire. What the consequence would be, should this be totally absent, it is not possible for any mortal to determine, as it has formerly appeared, that it is impossible intirely to exclude it from any part of space. This, however, in the mean time, we are absolutely certain of, that if Fire is applied to a *Menstruum*, it excites, supports, and increases the vigour of its action. And on the other hand, when the Fire that is every where distributed, in extreme Cold becomes less efficacious, we find that these solutions will not be effected, or at least will proceed more slowly, though they will immediately be promoted again if this is augmented.

Various in
various Bo-
dies.

But here again some *Menstruums* stand in need of a great degree of Heat, to make them capable of dissolving Bodies, as appears evidently in the solution of Metals by *Mercury*; whilst others require a very gentle one, as we see *Sal-Ammoniac*, *Sal-Gem*, and Salt of Tartar, dissolve in Water very quickly. Some again dissolve by the assistance of a moderate Heat, whereas if it is much increased, they lose this virtue, nay, and acquire a contrary power of coagulation; witness Water, which, when it is warm, will dissolve the White of an Egg, but when it boils, will coagulate it after it is dissolved.

How does
Fire assist
Menstruums?

But if we examine more nicely into the manner in which Fire thus assists *Menstruums*, we easily conceive, that it must do this, in the first place, as it puts in motion, impells, and agitates their ultimate Particles. Some farther efficacy, likewise, in this case, must be ascrib'd to its dilating the dimensions of all kind of Bodies. And lastly, as it often divides and carries off the Particles of Bodies, and thus dissolves many itself, it by this means unites its power with that of the *Menstruum*, and so operates jointly with it. In all these respects, therefore, Heat promotes the proper action of *Menstruums*, and makes them proceed more successfully, and hence, as a concurring cause, becomes necessary to them. And, indeed, in most cases, in the very act of solution, though, at first, perhaps, it is slow, the Heat successively increases, whilst the solution is effecting, which then always goes on more efficaciously, and hence

hence is commonly pretty evidently observed to have its activity more and more augmented, as the Body is dissolving. Nay, and the action of those *Menstruums* too is likewise increased by Heat, which whilst they are dissolving, produce an intense degree of Cold: This you have taken notice of in the solution of *Sal-Ammoniac* in Water, which, if the Water is warmed, will be dissolved sooner in it than if it is cold.

The changes, therefore, that are observed to be produced in Bodies by the dissolving action of *Menstruums*, seem chiefly to depend upon the very close union that arises between the ultimate Particles of the *Menstruum*, and those of the Body dissolved, and not to any real alteration induced by the *Menstruum* upon these separated Particles themselves. I am sensible, some Authors of the first rank in the Chemical Art are of a different opinion; but the thing itself, I think, favours this doctrine. For if we consider the most perfect Metals, Gold, Silver, and Mercury, when they are thoroughly corroded by their solvent Acids into a pure Liquor, how mightily altered do they appear in all their parts? and yet if they are again accurately separated from their Solvents, which may be easily effected, you may procure from them again the very same metallic Particles they were combined with, which being melted together, will give you the true Metal, without the least alteration. Hence, then, it evidently appears, that the *Menstruum* did no ways affect the intimate nature of the Particles of the Metal, but only separated them asunder, and then adhered to their external Surfaces. * This, likewise, when it is dissolved by Vinegar, or other Salts, may be again regenerated from them, without any alteration. But again, if you mix Metals with one another ever so intimately, in the Fire, and in whatever proportion you will, they will return again in the Cupel, perfectly pure and simple. I formerly distilled Gold and Silver with Mercury above fifty times, and yet when the Mercury was again separated from them, there constantly remained the very same Gold or Silver that there was in the Amalgama. Dissolve Salts, in what quantity you please, in Water, and by a proper inspissation you may procure them again, without any alteration. If by melting Salts together, you mix them ever so intimately over the Fire, by diluting them afterwards in Water, and inspissating them according to art, they will be found again perfectly the same as before. And farther, if you dissolve Salts in Oil, when they are recovered again they will be very nearly the same. Nay, even fixed Alkali's, when, with Earth that will vitrify, they are converted into Glass, may, even in this circumstance, by a chemical management, be resolved into their former Principals. Sulphurs dissolved with Salts, or united with Metals, confirm the same thing; as well as Alcohol mixed with Oils, Resins, and other Substances. These instances, then, are sufficient to evince, that the action of *Menstruums* is really the same as we have ascribed to them.

To this you will in all probability reply, that by means of these solutions, performed by *Menstruums* alone, there are very often produced new Bodies, which were never observed before. This, you'll say, is the case of Sugar of Lead, made by boiling a *Calx* of Lead with the strongest distilled Vinegar; for this will consist of the Acid of the Vinegar attracted into the Elements of the Lead, and yet if you distill this Salt of Lead in a very strong Fire, it will not yield back again a Spirit of Vinegar, but a particular Liquor that is inflammable. To this I answer: This observation is really just, and there

E e e

may

* This I don't understand, and forgot to mention to our Author. Shou'dn't it be, Lead likewise, &c.

The action
of *Menstru-
ums*.

Very seldom
alters the
Elements.

may be brought many instances of the like nature; but then, at the same time, we must carefully consider, that the Particles of the *Menstruum*, when they once strongly adhere to the Surfaces of the dissolved Corpuscles, are not always again very easily separated from them, but are often so closely united, that they are capable of being moved about with them, and continue a long while in this union. And hence it comes to pass, that the Operator frequently imagines, that the nature of the Body is destroyed, when, in reality, the new appearance arises only from this simple conjunction of their Particles, which continue still perfectly the same. This is easily conceived of by an example. If one has a very sharp Lancet, by itself, its power of dividing appears evident to every body. If this is afterwards put into a Case, it perfectly loses, so long as it remains there, its power of hurting, though it still continues in all respects the same as it was before. Examine this Lancet again bare, and it immediately discovers its former nature. Hence, therefore, you see, the more easily the sheath comes off, the sooner will the Lancet recover its first appearance; and if it was almost inseparably fasten'd to it, every body would be ready to assert, that the Lancet was alter'd. But let us consider again a little Cylinder of choice Silver, gilt over thick with Gold, and immersed in pure *Aqua Fortis*: In this case all the Silver will be intirely dissolved by this *Menstruum*, and there will remain in the *Aqua Fortis* a hollow Case of Gold, of a disagreeable, black colour, and perfectly intire. In the instance mentioned, therefore, it may happen, that the acid Particles of the Vinegar may be united with the Particles of the Lead, in such a manner, that they will not be separated by distillation, but will rather rise along with them. And hence any person would be deceived, who should imagine, that the Acid, by its union with the Lead, was converted into a new kind of inflammable Liquor. And, indeed, it seems exceeding probable, that this alteration that is here observed arises much more frequently from such an adunation, than from any change in the real Substance. And in separation, the same thing must be supposed to hold good; for it very often happens, that the Body to be dissolved consists of very different parts, some of which will be intirely dissolved by the *Menstruum* made use of, whilst others will not be affected by it, but will be divided from the former, and appear separately by themselves. If afterwards therefore the *Menstruum* is drawn from that part which it had dissolved, the matter that remains will be very different from what was made use of for the solution: And hence an unwary person would be ready to infer, that this Body, which he would look upon as a new one, was produced by the transmuting vertue of the *Menstruum*; whereas it had in reality effected nothing more than a mere separation of its parts.

Act solely by motion.

From all now that has been hitherto delivered upon this head, it evidently follows, that all known *Menstruums*, whilst they perform their office, act solely by motion, notwithstanding, the Chemists have supposed their action to be so abstruse and mysterious; for if a *Menstruum* did not put in motion the parts upon which it acted, then those parts would remain the very same they were before; which is contrary to the supposition.

But one that arises from a particular cause.

In the mean time, however, though this is undeniably true, yet it is not so easy to comprehend the physical cause, by which this motion is excited in the *Menstruum*. For so long as the *Menstruum* is alone, it remains perfectly at rest;

nor

nor is the Solvend in motion till it begins to be moved by the *Menstruum*; and yet as soon as ever they are brought to one another, within a certain distance, and in a determin'd degree of Heat, there arises a new, and frequently a very great motion, which was in neither of them before, but is now in both of them. Upon a careful consideration, now, of this matter, we cannot safely attribute this effect to any of the common origins of motion. In Propulsion, Gravitation, Elasticity, Magnetism, or any other general cause, if there is any other, we shall in vain seek for the Principal of this Agitation; for this is peculiar to the Solvent and Solvend, and not common to Bodies in general. Each of these, however, deserve a particular and accurate Examination; as a person who is thoroughly acquainted with the powers of *Menstruums*, will understand the principal part of the Chemical Art, and be capable of performing its most beautiful Operations. And, indeed, whilst we are upon this head, this task is absolutely necessary, on account of the authority of some very great Men, who are of opinion, that the actions of all Bodies whatsoever may, and ought to be explain'd solely by mechanical Laws. Let us therefore examine the matter fairly, and see what will be the issue.

First, then, I say, that whenever any solvent *Menstruum* dissolves its Solvend by what the Mathematicians call a pure mechanical motion, then the Particles of that Solvent must be agitated by some cause, which, though they were at rest before, will put them in motion; and this cause, for the most part, is Fire. The Particles, then, of the *Menstruum*, being thus moved by this cause, must strike upon the Corpuscles of the Solvend, which as yet cohere together, must impress their motion upon them, and by this means abrade and separate them from the solid Body, and that, either by exerting this effect upon the external Surface of the whole Body, or by insinuating themselves within its pores, and acting there, likewise, in the same manner. This, now, I am of opinion, every body will agree can be in this case the only mechanical manner of acting; which, as I will allow to have some effect, so, at the same time, I think it necessary to caution you, that it is a great deal less than persons generally imagine. Fluid Bodies, indeed, surround, press, and penetrate the Substances that are immersed in them; but then they afterwards make very little alteration in them, by their bulk, hardness, figure, and weight. I confess, indeed, that, by a motion communicated to them by the grand mover Fire, they are carried against the extreme Surfaces of the Solvends; but how little efficacious must this power be, which acts equally both upon the Fluid, and upon the hard Body, and therefore cannot exert an applying and impressing force upon it: These, certainly, must be sought for somewhere else. Can you imagine, that a mechanical Instrument, a Wedge, for instance, suppose it ever so perfect, could ever divide a piece of Wood, only by being placed close to it, or by swimming gently about it? Certainly, there is here something more necessary: It must first be fixed fast into the Body to be divided, and then, by an external force, it must be struck and driven forwards, and that without its being able to slip out whilst it is thus in motion. Try, now, if you can find all these requisites in particles quietly disposed, and freely swimming about in a soft Fluid, and wanting intirely a propelling power. But we'll suppose, for once, both the parts of the Solvent, and those of the Solvend, to be divided by a mere mechanical force, and that they are now just swimming among

Not mechanically, except rarely. Such a Solution more nicely examined.

one another; then, certainly, if there was not at the same time some other power likewise, the very moment they are thus separated, and become fluid, they would dispose themselves according to their specific Gravities, that is to say, the heaviest would sink to the bottom, and so the rest, in order, wou'd settle in distinct *strata*, nor would the heavy continue mixed with the light, nor the Solvent with the Body dissolved. When Metals, Stones, or other hard Bodies are worn away by the fall of Water from on high, or by the force of a rapid stream, you know very well, that the Water then acts only by a mechanical power, and is able indeed in this manner to divide the very hardest Bodies into their smallest Particles; but then the impalpable Powder thus produced does not mix with the Water, or is united with it, but sinks, and is collected at the bottom; and though it is agitated very frequently, yet as soon as ever it comes to be at rest again, it presently subsides. And the same thing you have observed, likewise, in the solution of Bodies consisting of terrestrial and oily parts, in boiling Water; for as soon as ever the heat of the Water has melted the Oil, it presently ascends and swims at top, whilst the earthy part falls to the bottom. These solutions, therefore, may so far be looked upon as mechanical. In this manner act, likewise, the Currents of Rivers, rapid Winds, the Sounds of great Cannon, and Thunder; and here always, as soon as ever the separation is made, and the concussion is over, the Solvent and Solvend recede from one another, as their gravities variously determine them. And thus in the fusing of Semi-metalline Glebes, Antimony, for instance, with Salts and Metals, the whole Mass, whilst you urge it with a violent Fire, appears in the Crucible to be intimately mixed together; and yet when you remove it from the action of the Fire, pour it into a melting Cone, and suffer it to stand quiet, the *Scorie* soon rise to the top, and form themselves into a Crust, whilst the pure metalline part by its weight subsides to the bottom. But a repulsive force also is sometimes a cause, that Bodies, which are mixed together, separate again from one another. This we see evidently in a very strong, alcalious *Lixivium* and Alcohol, and in Oil and Water; where not only their gravity, but this repulsion, likewise, makes those parts, that are of the same nature, collect themselves together. Metals too sometimes do the same, when they are in fusion; as appears very remarkably in Mr. *Homburg's* method of purifying Silver. We are persuaded, therefore, that those *Menstruums* alone act purely by a mechanical power, which after they have by a mechanical motion arising from their size, hardness, figure, weight, and impulse, divided Bodies into their small Particles, recede from these Particles, either upwards or downwards, according to the determination of their specific gravities, nor afterwards produce any considerable alteration by such division. By this mark, then, I think, one may be able to determine whether the action of any given *Menstruum* is properly mechanical; and such a Solution, if any such is observed, may by this means be easily distinguish'd from all others.

What Solution is not mechanical.

Whenever, therefore, we see any solution performed by means of a *Menstruum*, where the Particles of the Solvend, after they are separated from one another, cohere with those of the *Menstruum*, and remain equably intermixed with them, though there is a considerable difference in their comparative gravities, we then ought to conclude, that this Solution was effected partly by a universal, mechanical power, which almost always concurs, but chiefly by some other cause arising

arising from the particular relative disposition of the Solvent and Solvend to one another, by which power we suppose the Elements of one attract those of the other from their former concrete, and being combined together after the Solution is compleat, compose numberless new *Species* of Bodies.

Give me leave to explain this whole affair by one Example. If a Ball of soft Clay is thrown into Water, and this is set over the Fire, and made to boil; then the Particles of Water, being put in motion by the action of the Fire, will divide the Ball of Clay into its least Corpuscles, which will be intermixed through the whole Water so long as it is kept boiling; but as soon as ever the impelling force of the Fire ceases to act, and the Water is suffered to be at rest, and cool, then all the Clay soon subsides to the bottom. This, then, I should chuse to call a mere mechanical Solution, because the Particles of Water impell those of the Clay, by the motion they receive from the Fire, and when they are deprived of this, they continue to act no longer.

An instance
of a mechanical
Solution.

On the other hand, if a Ball of *Sal-Gem*, whose specific gravity is greater than that of Water, is put into 4 times its weight of boiling Water, the heat of the Water will presently dissolve it; but then, too, when the Solution is compleated, and the Water suffered to stand quiet and grow cold, all the Salt, though it is heavier, will still continue distributed through the whole bulk of Water. Hence therefore it evidently appears, that there is some quality in the Water, by which it unites itself with the Elements of the Salt in such a manner, that they are not capable of disengaging themselves by their weight, but are forced to remain suspended. Here, then, you will no doubt begin to suspect, that there are fewer *Menstruums* that perform their office, by a pure mechanical power, than persons generally imagine. In this manner, indeed, Water dissolves Ice, Water Water, Alcohol Alcohol, and other such Liquids one another. But there is observed, likewise, a great deal of difference in the cohesion of different *Menstruums* with the Elements of the Body dissolved; some of them cohering much more firmly than others: And hence the Corpuscles that are produced by *Menstruums* become very various; for among these, some are found to be so immutable, that they refuse to be resolved again into the simples from which they were compounded; whilst others very easily part again, and become what they were before the Solution. But of these there is no End.

An example
of a Solution
not purely
mechanical.

According to the distinctions, therefore, thus laid down, I could venture almost to distribute all the *Menstruums* I am acquainted with into four distinct Classes. To the first of these I wou'd reduce all those which act only by a simple mechanical power; which, therefore, may be explained, and understood by those mechanical principles which consider the powers that are common to all known Bodies in general. Of these, now, there are but few, and those generally very simple. The second Class should contain those *Menstruums*, which, though they do in some measure act by a mechanical impulse, yet, at the same time, perform their office chiefly by a power of repulsion. To the third should be referred those which act principally by a mutual attraction between the Particles of the Solvent and the Solvend; which very frequently occur, and are vastly numerous. Whilst the fourth and last should comprehend all those which operate by the concurrence of all the former together: And this will be much the greatest of all; as in almost all the actions of *Menstruums* a mechanical, repulsive,

Division of
Menstruums
from their
manner of
dissolving.

pulsive, and attractive power are united together. If it was possible, now, to accomplish, that *Menstruums* should be reduced into order, according to the difference of their manner of acting, and then be distributed into inferior classes, then the doctrine of Chemistry might be brought to the certainty of a Science; and consequently, it might always be foretold, what would happen in a particular Operation; and thus chemical experiments might be made vastly useful to the other branches of Natural Philosophy.

An example
of a purely
mechanical
Menstruum.

Of each of these solutions, now, I'll give you an ocular proof, that you may be the better prepared to understand what follows. For an Example, then, of a mere mechanical one, besides those mentioned above, let us take the separation of melted Silver into little Particles, when it is poured into cold Water. This the Metallurgists call Granulation, and it is performed in the following manner. I take an ounce of the best Silver, and put it into a strong, clean Crucible, and cover it so close with a clean Tile, that nothing from without can fall into it. I then heat the Crucible gradually, till it is almost red hot, and then put it into a strong Fire, which is kept blowing till the Silver is melted and runs like Water. The Silver then being thus thoroughly fus'd, holding it up pretty high, I pour it, as you see, a little at a time, into the cold Water, that is at least a foot deep in this Vessel; and at the same time you hear the Particles of the melted Silver passing through the Water, with a gentle, hissing noise, and perceive, that as soon as ever it comes to the Water, it flies asunder into little Grains, and in this form sinks to the bottom, both the Water and the Silver continuing exactly the same they were before. In this example, then, you see, that the Silver, when it comes melted from the Fire, and is thrown into cold Water, both divides the Water, and is divided by it, and that when the division is over, they recede unaltered from one another, and dispose themselves according to their respective gravities. If you have a mind to perform this operation yourselves, all the circumstances that I have mentioned must be carefully attended to, otherwise the Experiment will not succeed, as you have here observed it. The same may be performed with Gold.

An example
of a repelling
one.

If Copper, now, had been melted in the same manner, and then dropped into cold Water, as soon as ever it came to the Surface of the Water, it would have been repelled with an incredible *impetus*, and the whole substance of the Copper would have been so minutely divided, that scarce two Particles of the Metal would have remained united together. By this instance, then, it appears, that there are *Menstruums*, as in this case Water, which, by means of a repelling force, very surprizingly dissolve other Bodies, as we see here in melted Copper. And the event had been the same, if Gold or Silver had been mixed with the Copper, for if the mixture had been thus melted and thrown into Water, it would have flown about in the same manner. But here let me caution you not to venture too rashly to make this Experiment, which can't easily be performed without great danger to the Operator.

An example
of an attract-
ing one.

In the third place, now, I'll give you an example, where different Substances being brought into contact, divide one another, and then unite pretty strongly together. Into this earthen pan, then, which is not glaz'd, I have put four ounces of Flowers of Sulphur, and covered it carefully with a Tile, that when the Sulphur is melted, it may not take Fire. This, now, I set upon such a Fire, as is just sufficient to melt it, and to keep it in that condition, and no

more.

more. In this Bag, which is made of very thick Cloth, and is very clean, I have put six ounces of the purest Mercury, and tied the back very fast at top; and the Mercury, you perceive, does not pass through the Bag, except it is compress'd. I now take off the Tile, and squeeze the Mercury very gently into the melted Sulphur, so that it falls into it gradually, in very small drops, and a very little at a time, and all the while this is doing, the Sulphur is kept constantly stirring with a warm *spatula*, which is continu'd till all the Mercury is perfectly mixed with the Sulphur. You perceive, now, there remains but one Mass, which is black, drawn out as it were into strings, and very brittle, and which, if it is examined with a microscope, glitters, and discovers some appearance of Mercury. Here, then, you have an instance of a fluid *Menstruum*, indeed, but a dry one, and a hard, dry, solvend Body, which, when they come to have their smallest Particles in contact with one another, attract and retain one another so strongly, that upon the application of Fire to them afterwards, they do not quit their hold, but rise united together, and are converted into a Cinnabar. The principles, now, that are here conjoined, how different were they, as to their origin, weight, kind, and volatility, and how distant from a combination with one another? And yet when they are brought thus close together, how tenaciously do they cohere together? What now were the causes that brought about this adunation? Why, first, the Fire, which melted the Sulphur into its distinct elements. Secondly, the division of the Mercury whilst it was made to pass through the Bag, as through a very fine sieve, by a very small quantity at a time. Thirdly, the continual agitation of the melted Sulphur, and the Mercury that fell into it, by which means they were accurately mixed together. But all these, now, did nothing more than barely apply the Sulphur to the Mercury; and therefore, fourthly, there is some other power in the Sulphur and Mercury, by which, when they thus touch one another in such a vast number of Surfaces, they attract each other into so strong a cohesion, that they require some great force, or some other power attracting one of them more strongly, to separate them from one another. And this reciprocal attraction acts here as the principal cause. And hence, fifthly, arises this constant combination, as the ultimate effect, which is so great, that if you sublime this composition in a close Vessel, it will not be divided into Mercury and Sulphur, but they will both ascend at once in very small particles of Cinnabar, in every one of which they are both always found to be united together. Nay, though after you have once performed this operation, you repeat it again in the same manner, you will not, even then, be able to separate them afunder, but on the contrary, will force them by this means into a more intimate union. It's true, indeed, that the Cinnabar, after it is once made, will not rise so easily as it did the first time, but will, upon every fresh attempt, grow still more and more fixed in the Fire, 'till it at last becomes of an exceeding fixed nature; but even in that case, the volatile, mercurial part will not divide from it, but will remain so entangled in the Sulphur, that it will not be able to disengage itself, though it is at last exposed to an exceeding strong Fire. It is no wonder, therefore, that some novices in the art should, upon the sight of this Experiment, be led to imagine, that they could in this manner produce even Metals themselves, by the adunation of these two Principles, Sulphur and Mercury;

Mercury, thus effected by the Fire, of which the Adepts unanimously agree, that Metals are compounded. They found, however, upon better examination, that they had only laboured in vain, the Sulphur in every operation still remaining Sulphur, and the Mercury under a proper management, still returning true Mercury; but as he says in *Sendivogius*, never wiser. The truth of this appears evident, by making use only of a very dry *Menstruum*, that will attract the Sulphur more strongly than the Mercury does. Take, for instance, 12 ounces of Cinnabar that by Sublimation is rendered exceeding fixed, reduce it into Powder in an iron Mortar, and then add to it the same quantity of Filings of soft native Iron, not Steel, which too must be fresh filed, not rusty; rub these then accurately together for a considerable time, and then, as before, sublime them in a Cucurbit with a strong Fire: And what then will be the consequence? Why the Mercury, to the quantity of six ounces, will rise pure, and fall in its original form, into the Water in the Receiver, and at the bottom of the Retort, there will remain a fixed Mass composed of Sulphur and Iron; for Iron being thus exposed to the Fire, most greedily unites itself with the Sulphur as its *Menstruum*, and repels the Mercury from its cohesion with it, which then flies off separately, and laughs at the too credulous Alchemist. The same thing may be effected by using a fixed alkaline Salt, instead of Iron; for as soon as ever the Salt comes to be melted by the Fire, it dissolves the Sulphur, unites itself intimately with it, and by this means dislodges the Mercury. Quick Lime too, will do the same. Another instance of a merely attracting *Menstruum*, we have in the following Experiment. Take 2 drachms of Flowers of Sulphur, add to them in a glass Mortar 3 drachms of Mercury, and with a glass Pestil rub them together, the longer the better; and by this means, the Mercury will gradually disappear, and become united with the Sulphur, and when they are intimately mixed together, they will produce a very black Powder, which was continually changing its appearance during the rubbing: And the blackness of this Powder will be so much the greater, as they are longer rubbed, and more closely united together. Hence, if you continue rubbing it a good while, it will at last become exceeding black and very fine, and if it is left to itself, in a short time it naturally hardens into a black Mass. This Substance, now, very intimately contains a latent Mercury, and fixes and retains it, in such a manner, that if it is taken by Animals in great quantities, it does not act with the efficacy of Mercury, which cannot be recovered from it again, except by the contrivances abovementioned: This may be sublimed too into a very red Cinnabar. This some of the avaritious Alchemists observed likewise, and rejoiced over their black Powder. They imagined it to be the head of the Crow, which the Adepts had told them appears in the beginning of the grand Operation, when the Principles, Sulphur, and Mercury, are properly united together. Thus again, you have an instance of a dry fluid *Menstruum*, and a solvent Body, divided only by a simple mechanical Attrition, and then by the power of Attraction remaining closely conjoined with one another.

An instance
of an attract-
ing and re-
pelling *Men-
struum*.

I have here now some very good common Antimony reduced to Powder. This I put into this clean Crucible, which I cover close with a Tile, and when it is gradually heated, set it upon this Fire that on every side surrounds it. You see now, the Antimony begins to fume a little, and whilst I keep it on the

Fire 'till it melts, and runs like Water, it emits a great quantity of a whitish Smoke. The Crucible I then take off of the Fire, and let it stand quiet 'till it is perfectly cold. If you examine, now, the surface of the Antimony, which is now condensed by the Cold, it looks rough, unequal, and full of holes. I'll now break the Crucible; and you see the Mass of Antimony towards the lower part is solid, and shines with a metalline cast, whilst at top it is spongy, whitish, and yellowish, intermix'd with a lead Colour. Here, therefore, you see that the Fire, by melting the Antimony, has resolved it into its metalline, and sulphureous parts: That hence, these being set at liberty, have associated themselves together, the metalline with the metalline, and the sulphureous with the sulphureous, whilst the metalline parts have driven from them the sulphureous ones, and these have done the same by the metalline. And here, whilst this Solution was brought about by the Fire, Fusion, Attraction, Repulsion, and Gravity, all joined their concurring efficacy to produce this effect. If you imagine that this Experiment don't so properly belong to the nature of *Menstruums*, this at least you will allow me, that, by the help of it, we come to the knowledge of many things which actually happen in their operation.

But that I may still exhibit to you some farther instances of the action of *Menstruums*, and thus lead you to a proper conception of those which act by the concurrence of different causes, I here again take an ounce of Salt of Tartar, and half an ounce of Flowers of Sulphur, rubb'd very briskly in hot mortars, in a hot dry Air, and still continuing very hot, and put them into a Crucible upon the Fire, and cover them. You perceive, now, how soon they are both melted together, tho' the fix'd Salt melts with so much difficulty when it is by itself. This dissolved Matter, now, I pour out of the Crucible upon a clean Stone, and you see we have a homogeneous Mass, than which nothing melts more easily in the Air, especially, if it is reduced to Powder; for as you perceive, it immediately runs into a very red Oil. Hence then you learn, what a very strong adunation there is brought about between this dry *Menstruum*, and the dry Body of the Sulphur, which is so incapable of ever being dissolv'd by Water, and yet now by the efficacy of the *Menstruum*, melts sooner than any thing with the Water of the Air, which it seems to attract into it with a vast deal of greediness. But please to take notice of the following Experiment, which is more extraordinary, and what one would less expect. I have here four ounces of the choicest Antimony levigated to a very fine Powder, and rubb'd with 2 ounces of hot dry Salt of Tartar, in a hot dry Air, and with a hot Pestil and Mortar. This Mixture, now, I put into a Crucible, and melt with a very strong Fire 'till it is perfectly fluid, and then pour it into a melting Cone. And now it is cold, I strike it out, and you see it is become one homogeneous Mass, very equably dissolved through the whole Body, which flowed in the Fire just like Water. It is farther, as you observe, of an ash Colour, and it in some measure resembles Glass, is of a caustic taste, dissolves in the Air, and then changes its Colour to a bright red: Here then the fixed Alkali, the Sulphur of the Antimony, and its metalline part, are very minutely divided by the action of the Fire, and united into one kind of Body, which does not happen in these very often. But give me leave to add one more Example to the same purpose. I have here an ounce of the purest Sil-

ver, and three ounces of the best Copper. These I put into a Crucible, and melt in this Coal Fire, and now they are perfectly fused, pour them out into this little iron Mould, where we have a homogeneous Mass of Metal very equably mixed together, and scarcely separable again, except by the help of Lead in the Cupel. In this Operation, now, one Metal is the *Menstruum* of the other, as soon as ever they come to be both melted. And then it is plain, the Particles of each of them unite rather with those of the other Metal, than they do with one another, as betwixt all the Particles of the Silver, there is an equal distribution of Copper, and as notwithstanding their different Gravities, they don't separate from one another. Nor can this arise only from the action of the Fire, which may melt them indeed, and blend them together, but can never possibly mix them together in such an equal proportion. This operation, too, farther teaches us, that the mercurial part of the Silver unites itself so strongly with that of the Copper, that it will not afterwards part with it; for otherwise, the melted Silver would sink to the bottom of the Crucible, and the melted Copper swim at top of it, and after they came to be at rest, they would separate into two distinct *Strata*, as we see Oil of Tartar *per deliquium*, and Alcohol, when they are mixed and shook together in a Vessel, soon return into two perfectly distinct Bodies, which by no Art whatever can be mixed together. And here, which particularly deserves our consideration, both when they are in fusion in the Fire, and afterwards concreted in the Cold, they continue throughout mixed exactly in the same proportion. These Examples, then, Gentlemen, are sufficient to give you a notion of the various manners in which dry *Menstruums* act upon one another.

The causes
of Solution
concurring
in *Men-
struums*.

If you please, then, carefully to examine the instances we have given, and consider maturely what we have said, you will have an idea of the Solution of Bodies by *Menstruums*, very different from that which the Chemists and Philosophers commonly have, who by the true Principles of things, have endeavoured to explain chemical Operations. For they have always imagined here some mechanical Acrimony, corroding by a universal mechanical Power; and when they have observed that a *Menstruum* that corroded one Body, would not often corrode one that was softer, they have racked their Brains a thousand different ways, to reconcile these contrary appearances. We, investigating Nature by the help of Experiments alone, proceed in the following manner.

First Fire.

Upon the most careful examination, then, into the concurring causes of Solution in *Menstruums*, Fire first offers itself to our Observation. And this, if we consider it in all the various degrees which Experience has discovered to us, will be found to be almost a universal Solvent, inasmuch as it dissolves almost all Bodies, if it is applied to them in a proper strength. For if we proceed gradually from the warmth of a Man in health, to the utmost violence of *Tschirnhausen's Focus*, and make Experiments upon different kinds of Bodies through the whole compass, we shall scarcely find any that will not melt, or be divided into their least Particles, by one degree of Heat or another. For if some of them grow hard, as Bricks, in a certain degree of Heat, yet in a greater they will melt and vitrify, as is evident in the Furnaces made use of for fusing Metals. And tho' some few, indeed, will not be melted at all in the most intense Heat that we are at present acquainted with; who knows, if this was still farther increased, but these at last would dissolve likewise. We must
by

by all means acknowledge, therefore, that the power of Fire must always be very strictly attended to in the proper action of *Menstruums*. Without the assistance of this Element, certainly, the mercurial parts of Metals could never be so surprizingly united into one Mass.

In the second place, in order to understand the action of any *Menstruum*, we must consider likewise, whether there did not concur a strong and continued mechanical attrition; for this may often supply the place of Fire, and effect in some measure what Fire would have done, had that been present. For whilst Attrition attenuates, and divides Bodies, and reduces them into very minute particles, it gives them an opportunity of acting upon one another by these very small corpuscles, and thus mightily favours a very intimate Mixture. This appeared evident in the Grinding-Mill of Monsr. *Langelot*, which is said to have ground Gold into a potable Liquor; concerning which, the celebrated Author, who has wrote a Treatise upon this subject, deserves to be consulted. And among the Observations of Mr. *Homburg*, we are told, that all Metals, Gold itself not excepted, have, by being rubb'd for a long time with pure Rain-water, been converted into a Liquid.

Next Attrition.

In the third place, it is farther to be observed, that when the Bodies to be dissolved have been melted into their ultimate Particles by the Fire, or been minutely divided by the Attrition just explained, or, in particular, have undergone the whole energy of them both together; then, if their Particles thus separated are intimately mixed together, it often happens, that a repulsive force, which was latent before, discovers itself openly to our Observation; which is amongst the greatest secrets of the Chemists. An instance will best explain what I mean. Melt some very pure Lead in an iron Ladle, and add to it three times its weight of choice Mercury, and mix them together, and you will have a Composition, or *Amalgama*, of a bright Colour, like that of the purest Silver. Keep this by you for years, and it will remain exactly the same, without any alteration. If you afterwards rub it in a glass Mortar with a glass Pestil, or in a wooden Bowl with a wooden Pestil, you'll find to your surprize, that the whole Mass will grow perfectly black; and if you then put Water upon it, and continue to rub it, and then pour off the Water, which will be black and turbid, there will again be a pure *Amalgama* left behind. This now will keep its appearance as before, and remain pure for a long time; and yet if you repeat the former Operation, it will again become black; nor will you, as I have learnt by Experience, be able to come at the end of your work so easily as some Authors promise you. Here then we see evidently, that the Mercury thus mixed with the Lead, does not at first repel this black Matter, either from the Lead or itself; but when by this mechanical Attrition, the attenuation, mixture, and application of the different Particles, become greater, and more intimate, there then arises such a power in the Mercury and Lead upon one another, that the intimate mercurial parts of both come into the closest union, and by this means repel from them, or as the old Alchemists called it, spues out the heterogeneous matter, which could not be separated from them by any other method, without a vast deal of difficulty. If this *Amalgama* now is distilled and cohobated with Mercury a great number of times, the action of the Fire will have the same effect, as the rubbing had before, and produce the same black Matter capable again of being diluted

A separation sometimes happens by means of a repulsive force excited by these two.

and separated by Water. Here again, then, evidently arises a repelling power, by the efficacy of which, this separation is obtained very easily. Whether this now can be effected in any other manner, I know not. Silence here is best: A word to the wise is sufficient.

Or by Attrition.

In the fourth place let me observe, that both the Particles of the Solvent, and the Solvend, when they are melted, or agitated by the Fire, attenuated by Attrition, and mixed together, often discover an attractive Power which before lay concealed, and by which they are then associated together in a surprizing, and frequently a very efficacious manner, whence afterwards arise great variety of new Bodies, which never appeared before, and which can scarcely be produced by any other means. The Operation just mentioned, with the *Amalgama*, may serve here too for an Example: For in this there is effected, by this attractive Power, a wonderful Adunation of the mercurial Particles of the Metals, which discovers itself to the Operator, after the repelling force has separated the heterogeneous Matter, which prevented the homogeneous Particles coming into a perfect union. This, therefore, being expelled in the manner explained, and the remaining part in both being perfectly depurated, the mercurial parts become intimately united together, and produce something one would not expect.

Hence the production of a new Body.

In the fifth place, if a *Menstruum*, after it has dissolved a Body, let the manner in which it effects this be what it will, I say, if this *Menstruum*, after the Solution is over, can be totally separated from the dissolved Matter, so that they may both again exist distinctly, then the Body dissolved appears by itself in a new form, and is for the most part converted into a *Calx*, or into some other kind of new Body.

Hence solid *Menstruums* act as Fluids.

From the whole, then, we see, that almost all *Menstruums*, whether solid or fluid, at the very time when they are in action, are reduced to the nature of Fluids, Attrition, perhaps, alone excepted, which often, without any assistance, renders Bodies fit for Solution: But even in this case, that the Solution may be compleat, the Attenuation must be so subtil, that the Bodies rubb'd, put on almost the form of Fluids.

I'll now, then, give you an Example, in which all these causes, Fire, Attrition, a repelling force, an attracting one, and a mechanical one, act together in dry *Menstruums*, and all their effects, viz. Attenuation, Concretion, Transmutation, and Separation, are produced at the same time; and in this Experiment I shall proceed in such a manner, that it may serve you as a pattern for any of the like nature. I have here, then, 16 ounces of common Antimony purified only by fusion, and then being suffered to settle as I shewed you before, which I have taken care should be pounded and rubbed in an iron Mortar, till it is reduced to a very fine Powder. This Powder, now, you know consists of a common Sulphur, intimately intermixed with another part which is called the metalline, or mercurial part of the Antimony, tho' there does not appear in it the least sign of these two different substances, even tho' you examine it with a Microscope. I take then of the purest stony concretions of Rhenish Wine, commonly called Tartar, 12 ounces, reduced likewise to a subtil white Powder; and of very pure Nitre 6 ounces, which, now it is finely powdered, you see is as white as Snow. All these Powders, then, I dry as thoroughly as possible, then mix them, and take care they are for a considerable

considerable time rubbed well together in an iron Mortar, that by this means they may be intimately intermixed with one another. The compound Powder then weighing 34 ounces, I set by for farther use. I now again take 6 ounces of Tartar, and 3 of Nitre, reduced separately as before into a fine dry Powder, and accurately mix them together, and from the acid Tartar, and salt Nitre, have a very subtil dry Powder, which still impresses upon the Tongue an acid taste. Now then please to observe. Into this Ladle, which I have placed on an open Fire where there is no Smoke, and which is now almost red hot, I throw in a little of this Powder of Tartar and Nitre, and you see the very moment that it falls into it, it puffs up, boils, throws out small sparks, bursts into a Flame, and leaves a white Mass, here and there a little greenish, which is perfectly fixed and alkaline. On this then, I throw a little more of the Powder, and the same *Phænomena* happen over again; and thus I proceed till all the Powder is used. Here then we see, that when the acid vegetable Salt, and the saline terrestrial Salt come to be exposed to the Fire, they fume, sparkle, burn, and are fixed into an acrid Alkali; and that all this is performed, almost, in a single point of time. But by an Experiment, that I shewed you before, I made it appear, that if a fixed alkaline Salt is rubb'd with Sulphur till they are intimately mix'd, they will flame instantly in the Fire, and the Sulphur being totally dissolv'd, will be converted into a new Body. Hence, then, you readily perceive, that if Tartar, Nitre, and Sulphur, mix'd in a small quantity, are thus thrown into a Vessel heated red hot, there will immediately be produced a fixed Alkali, which the Sulphur will instantly lay hold of, dissolve, and convert into a Mass of a peculiar nature. Having a right notion of this, therefore, let us now see what will become of our Powder of Antimony, Tartar, and Nitre, when that likewise is exposed to the Fire. To this purpose, I have placed a strong Crucible in the Fire, which was first gradually heated, that it might bear the sudden application of a strong Fire without cracking; and I have chosen one that will at least hold three times the quantity of the Powder to be thrown in. The Crucible, then, I thus cover with a Tile to keep the Dirt out, and increase the Fire gradually, till it is all over red hot. In the mean time too, I take care to have the Powder of Antimony, Tartar, and Nitre, made pretty hot, but cautiously, that it don't take fire. I now, then, take off the Tile, and with an iron Ladle throw in about two drachms at once of this heated Powder; and the very moment it comes to the bottom of the Crucible it bursts into flames, smokes, sparkles, flames, grows red hot, and lies quiet. I then proceed again to sling in the same quantity, which you see has the like effect, and so continue to the end, covering the Crucible every time, till the Ebullition is perfectly over. The whole Powder, then, being thus thrown in and deflagrated, I make the Fire so strong, that all the matter in the Crucible may be melted, and flow like Water; and after that by putting in a Tobacco-pipe, I have found this to be the case, I keep it some time in this degree of Heat. In the mean time, I have by me a conical brass Vessel, which I make very hot, and then rub over on the inside with a piece of Tallow Candle, so that the whole Surface may be covered with this pinguious Matter. And this I have found by Experience to be safer, than making use of Oil; because if there happens to be ever so little Water in it, it may produce a ter-

rible effect. The Matter then still continuing perfectly fluid, and the Crucible red hot, I take it out with a pair of Tongs, the Claws of which are suited to the figure of the Crucible, that there may be no danger of its slipping, and gently pour the melted Powder into the Cone, upon which you see, a Flame instantly bursts out like Lightning. This proceeds from the Tallow with which the inside was smear'd over, which now takes fire, and by its Flame prevents the melted substance's concreting with the Vessel. I now let it stand till it is cold, and then turning up the Cone, and striking it, the whole Mass is discharged, as you see, into this Bowl, and is now divided into two parts that are perfectly distinct: The upper part of which, or that towards the Base of the Cone, is of a dark brown colour, weighs 14 ounces, and is what the Workmen call the *Scoriæ*: These are brittle, of a caustic taste, and brown colour, melt in the Air, and then become red, and consist of a fix'd alkaline Salt produc'd from the melted Tartar and Nitre, and the Sulphur of the Antimony, reduced by the Fire with that Alkali into one Body; which afterwards being fused with an intense Heat, was repelled by the other metalline part of the Antimony, and rose to the top, whilst that at the same time by its weight subsided to the bottom. This too you see here likewise, which is of a white bright colour like Silver, is very ponderous, and on its upper or broader part, has the figure of a Star: And, indeed, it would be of a true metalline Nature, were it not for its brittleness, which makes it readily fly asunder, and renders it capable of being powdered. In this one Experiment, then, you have had a specimen of every thing that I have been explaining to you in the action of dry solid *Menstruums*. For in the first place, by a mechanical Attrition, all the three Substances were reduced into exceeding small Particles, and hence were rendered capable of being intimately mixed together. In the next place, the Fire melted, moved, and blended them all three with one another. Then, thirdly, the Salt of Tartar, and the Sulphur of the Antimony deflagrating together, in an instant produced a fixed Alkali, which immediately laid hold of the Sulphur of the Antimony, and, by an attracting force, acting reciprocally between them whilst they were thus intimately mixed together, this fixed Alkali and the melted Sulphur were united into one Body, which was still in a state of fusion. In the fourth place, from the same Operation, there arose likewise a repelling power between the metallic Reguline part of the Antimony, and the alkaline Salt, which never suffer themselves to be united in the Fire, but repel one another, and dispose themselves into distinct *Strata*, according to their respective Gravities. Hence, then, we see plainly, the reason why the metalline heavier part sunk to the bottom of the Cone, whilst the alkaline sulphureous one rose to the top, and thus gave rise to two new Bodies, *viz.* the alkaline sulphureous *Scoriæ*, and a starry Regulus of Antimony. A mere mechanical Power, an attractive one, and a repulsive one, therefore, were the cause, in this Experiment, of the Solution and Separation. The mechanical Attrition, by reducing the Bodies into very small Particles, and thus vastly increasing their Surfaces, was the occasion of their having their points of contact greatly increased. The Fire proceeded farther to agitate them, and mix them together, excited, augmented, and continued their attractive and repulsive Power, dissolved the whole Mass, and all the parts of it, set fire to the Salt of Tartar, Sulphur and Nitre, and

and thus very much increased the strength of the Fire itself. The Tartar and Nitre, after the Deflagration was over, produced a true fixed alkaline Substance, the Nitre yielding a most acrid Alkali. This Alkali absorbed all the remaining Sulphur, and discharged the metalline part of the Antimony from it, which it had no effect upon. And lastly, the whole Mass help'd to increase the force of the first, whence arose a more rapid motion and concussion, and at the same time, a Smoke, and Soot, by which means 16 ounces and 2 drachms of the original 34, were dissipated and lost, the *Regulus* weighing only 3 ounces and 6 drachms, and the *Scoriæ*, as I mentioned before, 14. If you have a mind, now, Gentlemen, to perform this Operation yourselves, you must be sure to do it with a great deal of caution, if you would expect it to succeed. For in the first place, if your Crucible is not sufficiently large, the Matter will boil up in melting, and run over the edges. If the Matter is not reduced to an exceeding fine Powder, it will crackle and fly about. If the Powder is not thoroughly hot, when it is thrown in, it will chill the Crucible, and split it. If you don't wait till the detonation of that you have thrown in, is intirely over, and the whole is grown perfectly red, nay, and is fluxed too, before you proceed, then the part that is not melted, will collect itself into a solid Crust upon the Surface, and will confine that which is underneath at the bottom of the Crucible, which being resolved in the mean time into an Alkali, Nitre, and Sulphur, will have the vertues of a true *Pulvis Fulminans*, and will in a little time be discharged with a most prodigious noise, and dash all to pieces; the danger of which can only be avoided by the cautions abovementioned. But again, if the whole Matter is not kept melted, and flowing like Water for some time in the Crucible before you pour it out, the pure *Regulus* will never be rightly separated from the *Scoriæ*. If you don't make the Cone pretty hot, there will be danger of its splitting, when the melted Matter comes into it. If you don't rub it over with Tallow, the Matter often concretes with it, nor will suffer itself to be separated afterwards. If there happens to be the least drop of Water in the Cone, the Operation will prove exceeding dangerous, the Matter all flying about with a vast force and noise. If you don't pour the Matter in whilst it continues perfectly fluid, neither the *Regulus*, nor the *Scoriæ*, will dispose themselves in their proper place: So many cautions are necessary to this one Operation.

These things, therefore, being premised, we may now examine a little more nicely the actions of *Menstruums*, both solid and fluid, upon their Solvents, so far as they may be understood and explained in a pure mechanical manner: And for the sake of that valuable set of Men the Mathematicians, it will be worth while to endeavour to set this Matter once in a proper Light.

And that we may do this most effectually, please to consider in the first place, that in all Nature, there is not any one Body that falls under the cognizance of our senses, whose parts cohere so tenaciously, or rigidly together, that they may not be separated from one another by a mere mechanical force, without the concurrence of any other cause. As an instance of this, let us take a Diamond, which has been called by this name, on account of its excessive hardness, which was described by the Ancients as being insuperable, and yet we see is forced to submit to the Saw of the Lapidaries, who can accurately too split it asunder, and at pleasure grind and polish it into various Figures:

But

How far the actions of *Menstruums* are merely mechanical.

The hardest Bodies are dissolved mechanically.

But to this purpose you know, the Workmen make use of nothing but pure mechanical Instruments, and a motion of the same nature.

By the soft-
est Bodies,

But again, in this simple mechanical division of Bodies, the most fluid, and consequently to our senses, the softest, is capable of wearing away, and dissolving, the very hardest we are acquainted with. Drops of Water falling from on high, hollow the most rigid Stones, wear away Metals, and in short, diminish every thing they fall upon. The force indeed of single drops, appears to us as it were, nothing at all, and yet, when it comes to be constantly repeated, it produces very considerable effects. The softest Leather, by a continual Attrition, will polish the hardest Stones, Metals, and even Glass itself. The Surface of a wooden Wheel will consume any Body whatever, applied to it as it runs round, into invisible Particles. Hence, therefore, we may fairly conclude, that by a continued repetition of their action, the softest Bodies are capable of resolving the most rigid into such minute particles, as don't fall any longer under the notice of our Senses.

Whose Ele-
ments are
exceeding
hard.

It will help us now to conceive more easily of this surprizing *Phænomenon*, if we suppose, with some Authors, that the invisible ultimate Particles of all *Menstruums* whatsoever, ought to be looked upon as hard, and almost immutable, altho' the Body they compose seems exceeding soft to our Senses, on account of their receding very readily from their contact with one another. And this Opinion, indeed, by an induction of particulars, seems to be very much confirmed. The Elements of Fire overcome the hardness of all Bodies whatever; and yet they are prodigious small, and let their action be ever so violent, never appear to be in the least altered. No-body has ever observed the least change induced upon a Particle of Air, tho' this Element often brings about such various and powerful changes in other Bodies. Water, than which nothing is softer, whilst in a state of Fluidity, consists of Particles so immensely hard, that let them be compress'd by ever so great weight, or power, they have never been found to be altered. And the same, in the ultimate Particles of Earth, has appeared abundantly evident. The most subtil Spirits of Alcohol, how soft do they appear to the Organs of our Senses; and yet who, after a hundred Distillations, Digestions, and Compositions, has ever discovered the least sign of any alteration in their Elements. And as for the Spirits of Salts, as they are called, which are chemically drawn from them, and are so exceeding acrid, if we examine them, what an incredible immutability do we find in them, and consequently, as one may fairly infer, what an extreme hardness; tho' the Philosophers imagine them to be sharp like Needles, and hence easily mutable. That indefatigable Gentleman, however, Monsieur *Homborg*, having digested them for years with a constant Fire, and in close Vessels, has found them at last the very same without any alteration. *Du Hamel. l'Hist. de l'Ac. Roy. p. 497, 498.* That mild acid Vinegar alone, after four years, was changed into something of a different nature.

Hence Fluids
dissolve the
hardest Bo-
dies mecha-
nically.

There might other Arguments be produced to the same purpose, but what has been offered sufficiently demonstrates, that the ultimate Elements of the softest Fluids, if they are considered separately, are very durable, and therefore very hard. And as this is very evident, so likewise we clearly learn hence, that the ultimate Particles of *Menstruums*, if they are strongly pressed, and moved against

against the Corpuscles that compose the Solvend, may produce such an attrition as is capable, if sufficiently repeated, of wearing away, and dividing the greatest and hardest Bodies into their minute Particles; as we see in the hollowing of Stones by drops of Water.

And this happens particularly when the constant action of a strong Fire produces such a perpetual collision, and attrition against these Surfaces. In every solution, however, thus supposed to be mechanically performed by the Particles of *Menstruums*, there is this considerable objection, that the Elements of the *Menstruum* being driven against the surface of the Solvend, would easily recoil again, and hence could not produce any remarkable effect.

And this, indeed, is in some measure true, but then their own proper Gravity, and the vast pressure of the Atmosphere, taken notice of in our History of Air, will apply them very powerfully to one another. At the same time, however, it is very evident, that where *Menstruums* act only by a simple, mechanical power, without any other concurring cause, they in reality effect but very little: And on the other hand, we know as certainly, that a strong external application of a Fluid to a Solid vastly increases its dissolving power, though all other circumstances continue the same. The Bones of an old Ox will boil a great while in an open Vessel, without any considerable alteration; and yet if they are boiled in *Boyle's* or *Papin's* Digester, they grow soft, and dissolve in a short time, tho' here there is only this difference, that in the last case the particles of Water are prodigiously compress'd against the Bones, and agitated upon them with a violent attrition.

Thus, then, we intelligibly enough conceive of the first mechanical manner in which some *Menstruums* act, viz. by wearing away Bodies by attrition upon their external surface. But when the Particles of the Solvent do not only thus separate the external Corpuscles of the Solvend, but act likewise upon the internal parts, and thus dissolve their whole Body; then these particles seem to insinuate themselves into the Pores of those Bodies, and there effect the very same thing upon the internal Surface that forms those cavities, as we made it appear they did before upon the external. There is one considerable difficulty, however, in this affair, and that is, rightly to comprehend the manner in which the Solvent thus enters into the Pores of the Body to be dissolved. This, I confess, is not so clear as a body could wish; because we have but a very few Experiments, where there is nothing but a pure mechanical action, and for this reason we are obliged to call in to our assistance some of those, where there is a concurrence of a mechanical, and some other causes together.

In the first place, then, there must be some proportion betwixt the Pores of the Body to be dissolved, and the particles of the *Menstruum* by which the solution is to be performed: For if these Pores are large enough to admit the *Menstruum* into them in a liquid form, then the case will be the same as we just now mentioned; if they are too small, then the internal parts will scarcely be dissolved. And hence it comes to pass, that when the particles of a simple *Menstruum* collect themselves by a mutual association into somewhat larger Corpuscles, they do not then so readily dissolve the Bodies exposed to them, as being scarcely able in this form to penetrate into them; though afterwards, if they are diluted with Water, and thus have their particles removed from contact

taët with one another, they may then be able to enter into these Pores from which they were before excluded. This you see in the following experiment. In this Urinal I have an ounce of the best Oil of Vitriol, of my own preparing, depurated by distillation from all its *Fæces*, and by ebullition, from all its Water. This Liquor is so pure, that in very cold weather it congeals into solid, chrystalline Glebes, and melts again with the warmth of a thaw. This Oil of Vitriol I have heated to the degree of boiling Water, by keeping the Urinal some time in Water that was boiling. Into this Oil, now, I throw 5 drachms of hot Filings of Iron, and mix them together by shaking the Glafs; and you observe what a prodigious rarefaction is instantly produced without any Fumes or Ebullition, the matter, indeed, which is of a grey colour, appearing puffed up, but continuing at rest. But please to take notice of this second Experiment. I have in this other Urinal 1 ounce of the same hot Oil of Vitriol, to which I now add three ounces of Water, heated likewise, that they may be mixed without danger of breaking the Glafs, which would happen, if the Oil and Water were put together cold; for then the sudden heat produced would make the Glafs burst asunder. Into these 4 ounces of Liquor I throw 5 drachms of Filings of Iron; and there arises, you see, a prodigious Ebullition, Effervescence, and a Fume, that has a smell like Garlick, and the whole Body of the Iron is perfectly dissolved into a green Liquor. In the same manner the famous *Bohn* and *Boyle* tell us, Silver and Lead will not dissolve in the strongest Spirit of Nitre, though if it is diluted with Water, they will be corroded by it immediately. But that you may be judges of this yourselves, please to attend to the following Experiments. In this Vessel I have 1 ounce of the strongest Spirit of Nitre that can be made, into which I put half an ounce of *Minium*, and they remain quiet, without any Effervescence, and in the cold will continue so a considerable time. Again, I have here 1 ounce of the same Spirit of Nitre, but diluted with eight ounces of Water: To this I add $\frac{1}{2}$ an ounce of *Minium*, and they remain at rest as before. But again, in this Vessel I mix 1 ounce of pure Silver with 1 ounce of the same strong Spirit of Nitre; nor do these discover any motion or ebullition. And lastly, in this Glafs there is 1 ounce of this Spirit mixed with the same quantity of Rain-Water, into which I throw 1 ounce of pure Silver; and these you see, likewise, in this degree of Cold continue perfectly at rest. But as soon as ever, now, the Fire begins to put these four mixtures in motion, there is presently brought about an agitation, solution, and ebullition, which appears in the pure Spirit to be weaker and slower, in that which is diluted, brisker and more efficacious. See *Boyle* upon this head, in his *Philos. Ess. Bohn. Chem.* p. 156. Let us now, then, Gentlemen, consider what we can deduce from these Experiments to our present purpose. In the first place, then, it hence evidently appears, that acid Salts, when they are converted into Spirits, as they are called, may be diluted with a greater, or less quantity of Water. Secondly, that by the concussion of the Glafs this dilution is so much promoted, that by this means the Water may be very equably mixed with the Salts, though before, the Acid stagnated at the bottom, and the Water rested quietly at top; as the pinguious *Striæ* in one part evidently demonstrate. Thirdly, that between every two saline Particles, as many aqueous Particles, as the Artist pleases, may be in this manner interposed, if he will only add a proper quantity of Water. That hence, therefore, in the

the fourth place, it may be effected, that these Particles, thus diluted, shall not any longer be united into saline Glebes, but shall separately swim about amongst the Particles of Water, with which they are intermixed. Hence, fifthly, these saline Elements, thus swimming about in the Water, seem capable of insinuating themselves into the very small Pores of the Bodies to be dissolved; inasmuch as they now exist in their smallest form. In the last place, it is probable, that these acid, saline Particles, when they were not diluted with Water, associated with one another, and thus were in some measure concentered into coherent, little Masses, which by this means became too great to penetrate into these little vacuities. These things, then, being duly considered, the opinion we just now offered seems sufficiently probable.

In the second place, if we would rightly understand the powers of those *Menstruums* that perform their effects in a mechanical manner, it is necessary, by all means, to consider the figure of the solvent Particles: For it appears, by the mechanical demonstrations of the Geometricians, that mechanical actions depend principally upon the figure of the acting Bodies. For a Body, remaining perfectly the same in all other respects, but only changing its figure, becomes fit to perform a great many things, which it was not capable of before. This I generally explain by this simple Example. Take an ounce of Steel, and form it into a Sphere, a Cube, a Knife, a Lancet, a Polygon, a Dagger, a Pyramid, an Adz, a Saw, or a File, and will it not in every one of these shapes acquire a new, and very different power from what it had before? The same Body, therefore, being variously shaped, acts always with a new power upon the Body which it is made use of to dissolve. But by this means it often happens, likewise, that the capacity of the Pores become fit to admit Solvents of certain Figures, rather than any others. And hence it seems to come to pass, that the reciprocal vertue betwixt the Solvent and Solvend, is often perfectly changed or destroyed, when either one or both have the figure of their surface altered. This, indeed, it is exceeding difficult to give an ocular demonstration of; as neither the ultimate Particles, or Pores of Bodies can scarce possibly be rendered visible: But if from what we observe in larger Bodies, we may be allowed by analogy to conclude concerning the more minute, we must infer, that this will likewise hold true in those Particles of Bodies which escape the distinct observation of our senses. Unless, perhaps, some persons may imagine, that the solvent Elements are not changeable in any respect; though this I think does not appear so probable; as the Elements of Bodies seem to be one thing; those of Solvents another. In many, at least, it looks as if this mutability must be admitted. In the mean time, that a very efficacious power of acting arises between Bodies, from the mere figure of the ingredient, and admittent, the illustrious *Boyle* formerly evinced by the instance of a Key and a Lock, in which, solely from the size and figure, there is produced such a particular power of acting, as is peculiar to those two alone. Hence, therefore, we infer, that the proportion, likewise, between the figure of the solvent Elements, and the Pores of the Body to be dissolved, is the occasion of a great number of very particular effects in these merely mechanical solutions; and that hence, from the bulk and figure of these Particles, the most remarkable, corporeal changes are continually brought about. Lastly, by the figure alone of a given Body, very often are produced very surprizing effects, depending only upon that particular

conformation. If a metal Bell, for instance, is cast into a proper shape, how wonderful are its operations? Suspend it freely in the Air, and strike upon it only gently with a Hammer, and its whole *series* of Circles, quite from top to bottom, will recede from their circular figure, and every one of them run through an infinite number of *Ellipses*, till they come to their internal limits, and will then run out again beyond their first circular figure into elliptical ones, till they come to their external limits, so that alternately cutting one another, perpendicularly to their diameters in these circles, they describe by these undulations both ellipses and circles. But these excursions, now, are exceeding swift, and performed reciprocally backwards and forwards, and by this means agitating the Air, produce brisk undulations in this, likewise, to an incredible distance, and thus propagate sounds and tremulous concussions, by which alone very surprizing effects are wrought upon the Bodies of Animals, Vegetables, and Fossils. And all these changes depend intirely upon the formation of the Bell. The following Experiments, likewise, are usually referr'd hither, in which it is supposed the figure of the Solvent is altered, with respect to that of its Solvend. Take an ounce of the choicest Oil of Vitriol, and drop into it gradually six times as much of the purest Alcohol of Wine, prepared without any Alkali, shaking the Glass after every drop. Digest these for a considerable time in a tall Vessel accurately closed, and then very cautiously distill them till the mixture begins to grow black. When you observe this, fix on another clean Receiver, and patiently and prudently urge it with a very soft Fire; and there will rise in this gentle Heat a suffocating, sulphureous Phlegm, that excites coughing most violently, and with it a sweet, fragrant, volatile Oil of Vitriol, weighing almost six drachms, which must be carefully secured. *Hoffman. Obs. Phys. Chem.* If this, now, prepared in this manner, is poured upon Iron, it produces very different effects from what we observe from mixing this Metal with native Oil of Vitriol. The same, likewise, is true of the strongest Spirit of Nitre, made sweet according to art with three times as much Alcohol, and then put upon Iron. Nay, and that the purest Spirit of Salt, edulcorated in this manner, will not dissolve Gold, but will take away its colour, was long ago observed by the great *Boyle*. The same sweet Spirit of Nitre, too, will no longer dissolve Silver, though before it corroded it so greedily. These *Phænomena*, now, Authors of note have ascribed to an alteration in the figure of the corroding Elements; for whether you impute it to the combination with the Alcohol, or the distillation, or both together, the form of the corrodents, certainly, will be always changed.

The Third.

But whilst we are considering these merely mechanical solutions, there seems to be still a third cause, which may very much concur towards the activity of the Solvent; and that is, to suppose the ultimate Elements of the *Menstruum* to be endued with a proper rigidity, and to be able to insinuate themselves in such a manner into the Pores of the Body to be dissolved, that one part may be fixed in it, whilst the other stands out above the Surface. For if we imagine this to happen all over the porous Surface, and thus conceive it to be grown rough with these *Spicula*, which are thus inserted but are not able to proceed any farther; then if a motion is excited in the *Menstruum*, the agitated particles will strike upon the exterior parts of these Wedges, and that, every moment in various directions. Hence, then, must necessarily arise in these particles a power of cleaving and dividing asunder the

Corpuscles

Corpuscles of the Solvend; as we see timber cleft to pieces by the assistance of Wedges. And that this, now, is the case in *Menstruums*, is certainly exceeding probable; especially if we consider, that in these solutions those surfaces that were smooth before, almost always grow rough and unequal. And indeed in mechanical solutions, this third cause seems to be the most efficacious; as we can clearly conceive of the active power of those inserted, and variously agitated Wedges; as the ultimate Elements of the Solvent are infinitely numerous; and as the Pores of the Solvend are distributed through every point of its Surface, as appears evidently from the fineness of the Particles when they come to be separated.

Lastly, a fourth cause that promotes mechanical Solutions, is Fire, For this The fourth. it is that principally agitates, applies, and renews the application of the solvent Particles, whenever these happen to be qualified in the manner above-explained. This it is that, by its concurrence, puts the whole in action; without this the three other causes would be intirely without effect. A Wedge though it is fixed into a piece of Oak, has no manner of efficacy towards cleaving it asunder, if the external percussio of the Beetle is not superadded. And thus, tho' the Elements of the Solvent, in size, rigidity, figure, weight, and elasticity, are perfectly suited to the pores, resistance, and hardness of the Body to be dissolved; though they are brought into contact with it; tho' they have one of their extremities fixed into it, whilst the other part stands out above the Surface; I say, though all these circumstances concur together, they will be able to induce no change upon the Solvend, unless the active percussio of Fire comes in to their assistance. Nor does Fire only act thus directly upon these *Menstruums*, but it assists them, likewise, as it puts in motion and agitates the Air, which presses upon them with a prodigious weight, and thus applies their Particles to one another, by which concussion it produces an attrition upon the surfaces of the Bodies to be dissolved. And hence the elasticity, weight, and agitation of the Air excited by Fire, assists, likewise, the powers abovementioned; as does also concussion and attrition. This then, Gentlemen, is all that pure Mechanics can furnish us with, that I know of towards understanding the actions of *Menstruums*. This some Gentlemen, of great authority, have thought sufficient to explain all the *Phænomena* that have ever been observed in their Operations. But, with submission, though we are ready to acknowledge, that in all the actions of every kind of *Menstruum* whatever, all these mechanical powers are present, and do assist and co-operate; yet still we cannot for this reason allow, that they alone, without the concurrence of any other cause, are capable of perfecting the whole Operation.

Nay, on the contrary, we take the liberty to assert, that it very seldom happens, that any *Menstruum* whatsoever acts with all its energy, by the assistance of these causes alone. And this we think is so evident to an unprejudiced inquirer, that the incomparable *Newton* was obliged, from the observations he had made, to add some others of a quite different nature. But that the Geometricians may not charge us with asserting this rashly, and without sufficient grounds, let us examine the matter a little deliberately. When a Body, then, is immersed, and is at rest in a Fluid, endued only with mere mechanical properties, and this Body has no power, with regard to this Liquid, but a common Mechanical force alone not sufficient. mechanical

mechanical one, what mechanical Operation will then naturally follow? Why the fluid Matter being at rest, will, from its weight, and the subtlety of its parts, surround and compress both the external surface of the Body, and the internal one of the Pores, which it is capable of penetrating into. And hence, according to the laws of Hydrostatics, the consequence will be nothing more than a bare compression of the parts, without any division, or so much as the least alteration of its figure; unless the Body should happen to be soft, and yield but little resistance, and at the same time should have its Pores full of a Fluid lighter than the surrounding one, and capable of being condensed or expell'd; for then, the Mass being condensed, would have its figure, bulk, and specific gravity altered, and by this means would rather come to a more settled state of rest, and cohesion, than to one of dissolution. But suppose, now, that by the application of Fire, the Elements of the *Menstruum* were put in agitation, why then, too, if both the Fluid and Body immersed, considered separately, are homogeneous, the effect of the *Menstruum* will be pretty nearly the same; for the Fire acting equably upon all the Elements of the Fluid together, will still continue to press the Body equally on all sides. When it is raised, indeed, to such a degree, as to make the Fluid boil, and produce those unequal and explosive motions that are the consequence of it, it may then, by these irregular percussions, rub off somewhat from the surface of the Body, especially if any Particles happen to stand out above the rest. But this, now, of how little consequence it can be of in the Solutions we daily see performed by *Menstruums*, every body that knows any thing of the matter must easily conceive; especially if we consider, that Hartshorn will not be so much dissolved by being boiled for a long time in Water, in which it is every way surrounded, as it will by being suspended in such a manner, as to be exposed to its Vapour; as the alchemistical solution of Hartshorn evinces. But then let me caution you, that if any Matter contained in the Pores of the Solvend should be dilated by the Fire, dislodged in Bubbles, and so break through the inclosures where it was confined, and thus divide the Body, this solution must not be ascribed to the mechanical action of the *Menstruum*, but to the rarefying force of the Fire acting upon this elastic Matter. Whilst I have seriously weighed all these things, I have frequently doubted with myself, whether the Air itself, in which are Oils, Salts, and Spirits, or any other *Menstruum*, whether fluid or solid, ever operates in their solutions of Bodies by pure mechanical Principles; especially considering that they themselves are scarcely ever simple and perfectly pure: And upon examination I have found, that there are intermixed with them all various parts of different powers, which have their proper and peculiar virtues, by which they attract, repel, and change Bodies after various manners. Whoever, therefore, ascribes more to a mechanical power than the All-wise Creator has allotted to it, is certainly in the wrong: This, as every thing else has its proper limits, within which if we keep, we shall act wisely, and may so far safely make use of this cause for explaining the Operations of the Chemical Art. These then, Gentlemen, are my sentiments upon this head; which the love of truth has drawn from me. How distant these are from the charge that has been publicly fixed upon me, that I pretend to explain all chemical Operations by mechanical Principles, you yourselves are judges. This certainly is imposing upon the World, and imputing to me

me what is vastly different from my way of thinking, and what I constantly oppose, as, I believe, there is no man living less pleased with this opinion than myself.

Having thus, then, dispatched the Doctrine of *Menstruums* that act by a mechanical power, I come now to examine those which execute their office by some particular virtue, and do not operate by any of those qualities with which the Author of Nature has endued Bodies in general. And these, in reality, are so numerous, that there are scarce any that do not come under this head. It will be necessary, therefore, to digest this vast multitude into certain Classes, prefixing to each of them some distinguishing character, to which they may be reduced. And this method will have this evident advantage, that it will both assist the memory, and give us an opportunity of referring any new ones, that may be found out, to some that were known before, and thus, from the affinity of their nature, easily understanding the force of their action.

Of Menstruums that act by a particular virtue.

Of WATER and WATERY MENSTRUUMS.

In the first place, then, I shall treat of Water, and watery *Menstruums*; which will make up the first Class.

Water, then, congealed with Cold, being mixed with dry or fluid Salts, volatile or fixed alcalious ones, volatile or fixed acid ones, and compound ones, as also with fermented vegetable Spirits, both dissolves, and is dissolved; and in this sense, therefore, why may it not be referred to solid *Menstruums*? This it does in the most intense cold, and always by this means excite a greater degree of it. See p. 97. and following, where this affair has been handled already, and therefore may be here properly omitted.

The proper dissolving action of Water, however, strictly so called, begins then, when this Element continuing still in a state of fluidity, is in the very next degree to freezing. This, therefore, according to our former observations will be, when *Fahrenheit's* Thermometer stands at about 33 degrees; for then a hoar-frost begins to be formed in the Air. But that great Mathematician *Romer*, during the severity of the Winter 1709, is said to have observed at * *Gedanum* the same Thermometer, of which he himself was the first inventor, fall from the freezing point 33 to the degree 1; and consequently the Cold had then increased 32 degrees beyond a freezing one. But as this place is in 40 degrees North Latitude, and therefore 50 degrees from the North Pole; as the cold always grows greater and greater, the nearer you approach to the Pole; and as no body has ever yet been able to get thither, the excessiveness of the Cold proving fatal long before one can come near it: Hence we certainly know, that the Cold about the Pole must be greater than any that has ever yet been observed, though to what degree it rises there it is not possible to determine.

But rather when it is a Fluid.

This, however, which is sufficient for our present purpose, we may be absolutely sure of, that through the whole extent of Cold, from the degree 32 to those unknown limits, pure Water can never perform the office of a liquid

Its force different in different degrees of Heat.

* If our Author means *Dantzick* here, which is the only place that I know of that this word signifies, that lies in about the latitude 54, and, consequently, but 36 degrees from the Pole: This does not at all, however, invalidate the force of the argument.

Menstruum. But as Water, now, by the application of Fire to it, may be heated to 214 degrees; hence its action, as it depends upon Fire, may be so far increased, but no farther, so long as it is upon the surface of our Earth, and exposed to the open Air; for under these circumstances it is not possible to give it any greater degree of Heat. If we remember, however, that Water is capable of receiving so much more Fire into it, as it is compressed with a greater weight of the Atmosphere, then we may clearly conceive, that the power of Water, when increased by Fire, in the deepest recesses of the Earth, may be so immensely great, that its dissolving force thus augmented may be greater than that of any other *Menstruum* that we are here acquainted with. But be this as it will, this we are sure of, that Water with us, as Water, has its dissolving power confined within 32 and 214 degrees of Heat.

But limited.

To the very great happiness, therefore, of the present age, we are able to measure the power of Fire upon this first *Menstruum*. And here it is very entertaining to take a view of the various methods of Nature's working in these different degrees of Heat; for in many solutions performed by Water, its dissolving power increases in proportion to the Heat to which it is exposed, and remits, and grows less again, as that is diminished. Thus we find, for instance, that Water 33 degrees hot will contain a certain quantity of Sea Salt dissolved in it, which, thus residing in it, will prevent its being frozen with that degree of Cold, in which pure Water begins to be congealed; for the interposed Salt seems to hinder the Surfaces of the Particles of Water coming into contact with one another: But if the Cold comes to be increased much above the degree in which pure Water freezes, then the salt Water likewise begins to be reduced into a less space, and the Salt, being pressed out by the contracted Water, begins to collect itself into little chrySTALLINE Grains at the bottom of the Vessel. And if afterwards the Cold grows gradually sharper and sharper, the Water will by degrees discharge more and more Salt, till at last, being pretty nearly freed from it, it will be intirely converted into Ice: And here, in every degree of this increasing Cold, there will be more Salt separated from the Water than there was before. On the contrary, now, if in Water 33 degrees hot you dissolve as much Salt as ever it will take up, and then increase the Fire till you make it boil, throwing in a few grains of Salt upon every new degree of Heat, you will then find, that it will gradually dissolve more and more Salt, till the Brine begins to boil, but then will dissolve no more, though you keep it boiling for a considerable time. In the former case too it should be added, that Water which discharges its Salt by means of Cold, and then freezes, when afterwards it comes to be thaw'd, will dissolve again the same Salt that was separated from it.

As appears
by Experi-
ments.

But that you may have ocular demonstration of the truth of this, please to attend to the following experiments. In the first place, then, I take an ounce of pure dry Sea Salt reduced to powder, which I put into this clean glass chemical vial, and then pour 3 ounces of clean Water gently down the sides of the neck, and set the Vessel by in the degree of Heat which the Thermometer at present stands at. In this other Vial I have exactly the same quantity of Salt and Water as in the former, and hold it in the same degree of Heat, but this I shake very briskly about, adding now and then a small quantity of Salt, till it won't dissolve any more. This third Vial, likewise, is furnished with Water and

and Salt, as the other two. In this brass Kettle, now, which is upon the Fire, and has Water in it, I put the second Vial which contains the Water and Salt dissolved by concussion; and this third, which was not shook at all; and by gently increasing the Fire gradually heat the Water. You perceive, now, evidently, that as the Heat grows greater and greater, the Salt in the Vial that was not shaken, begins to be more and more dissolved, and that much sooner, and in a much greater quantity than that is in the first Vial, which I set by in the present heat of the Air: So that now, within a short time, the dissolution of the Salt in this vial which is at rest, is equally effected by the application of Fire to it, as you saw it was before in the second case by shaking the Vessel. But into this Vial, now, which has the Salt dissolved by concussion, as the Heat gradually increases, I continually throw in a few grains more of Salt, and this I continue to do till the Water in the copper Vessel begins to boil; and you see there is now a considerable quantity of Salt diluted in this Water, besides what it could dissolve, when the Vial was shaken about, though it was agitated very strongly. Having thus, then, thrown into this Vial, standing in the boiling Water, so much Salt, that the Water in it will not, in that degree of Heat, dissolve the last Grains I put in, I now take out the Vial with its Water thus saturated with Salt, by means of the Heat of the boiling Water, and wiping it clean, set it by, that it may gradually cool. As the heat of the Water, now, decreases, the Liquor which before was pellucid, begins, you perceive, to grow opaque, and turbid, a Pellicle forms itself upon its Surface, the Salt is precipitated to the bottom; and now it is reduced to the temperature of the surrounding Atmosphere, it has discharged almost as much Salt as it had dissolved more in the Heat of the boiling Water, than it had in the external Air. Having thus, then, observed these Experiments, please now to turn your eyes to the first Vial, which I set by with 3 ounces of Water, and 1 of Salt. And here you see part of the Salt is dissolved at the bottom, whilst a considerable part of it remains intire, as before. And that part which is thus dissolved is not mixed with the Water, but continues at the bottom of the Glass, in form of a heavy, pinguious, and, as it were, tenacious Liquid; and if it is not shook, will continue in that manner for a long time. If you shake it about, however, it dissolves in the appearance of little Eels, and becomes dispersed through the incumbent Water, nor ever separates from it again, and subsides to the bottom. This, now, being thus shaken from the bottom, another portion of the Salt is dissolved, and keeps at the bottom too as the former did, till it is agitated and mixed with the Water that is less salt, and swims at top of it; and the operation will be found to proceed in the same manner, till almost all the Salt that was put in is dissolved in this quantity of Water. In order, now, to make these Experiments, you see I have made use of two glass Vials, whose necks are so long, that nothing could exhale from the Brine in the belly of them, whilst they stood in the boiling Water; which is necessary to be observed: And you took notice, that I heated these necks, lest being exposed cold to the hot Vapour of the Water, they should fly to pieces.

If you please, now, we will take a view of some of the *Phænomena* which offer themselves to our observation in these simple Experiments, and which deserve to be properly considered. 1. Then it appears hence, that neither the Particles of the Salt, or the Water, are any ways changed in this Operation,

H h h

but

Corollaries
hence deducible.

but that they are only so united together, that the Water is now come into contact with the Salt, in the same manner as the Elements of the Salt and the Water, separately considered, were in contact with one another; which kind of solution is called mere mixture. 2. That the Heat, in proportion to its Strength, increases the mixing power in such a manner that both the Solution is performed quicker, and a greater quantity of Salt is dissolved in the same quantity of Water; and this is constantly the case, so long as the Water is capable of admitting any farther degrees of Heat. 3. That aqueous *Menstruums*, which are perfectly saturated with Salt, if they are afterwards exposed to a greater degree of Cold, grow turbid, and deposite some saline Corpuscles; but upon being restored to their former Heat, recover their transparency, and dissolve again the Salt they had discharged. 4. That the Water is condensed by Cold, and the Salt dissolved in it compacted into chrystals, which melt again upon the return of the Heat. And this is true, to such a degree, that even Oil of Vitriol itself, that is perfectly dephlegmated, will continue fluid in a Vessel accurately stopp'd, but by an increase of Cold will be condensed into a solid Mass, which in a warm Air will dissolve again spontaneously. 5. That boiling Water, when it is thoroughly saturated with Salt, is heavier than that which is pure. Hence it comes to pass, that this Brine, whilst it is boiling on the Fire, appears by the Thermometer to be hotter than simple boiling Water. And hence, if a glass Vessel, with this Brine included, is set in boiling Water, the Brine can never be made to boil by the heat of that Water, but requires a greater degree of Heat before it will discover any signs of ebullition; tho' if pure Water was thus put in boiling Water, that likewise would boil immediately, as you have had the pleasure of seeing. 6. So far, therefore, the cause by which Water is a solvent *Menstruum*, is Fire, of which being deprived, it ceases to act. The truth of this, congelation evidently evinces; for this beginning at the degree 32, and descending 72 degrees lower (p. 100) the Cold through all the degrees of that decreasing Heat more efficaciously expell'd almost all kinds of Salts dissolved in the Water, and that to such a degree, that even Spirit of Nitre itself became concreted into icy Globes. Hence, then, we evidently demonstrate, that as Cold gradually increases, it in proportion separates Salt more accurately from Water, and expells it perfectly when it comes to be thoroughly frozen. The same cold too deprives Water of the power of dissolving Alcohol; for in the Winter of the Year 1729, I exposed Ale, Wine, Vinegar, and Brine, in large flat Vessels, to that severe Cold, and the Frost reduced almost all the Water of these Liquors into a soft, spongy kind of Ice, and united the strong, generous Spirits into one Liquid; so that piercing the icy Crust, one might pour out a fragrant, and very sapid Liquor, now separated from the Water, with which it was before diluted. And the more intently the Cold was increased, this separation was constantly so much the greater. Cold, therefore, deprives Water of that property of a *Menstruum* by which it dissolves Alcohol and acid Salts. And it is exceeding probable, that the greatest Cold, possible in nature, would condense Water into such a Body, as would have no dissolving power at all; but such a Cold as this we are not acquainted with. 7. Hence we see, seventhly, that the proper power of Water, by which it is capable of dissolving Salts, or any other Bodies, and keeping them dissolved in it, and united with it, is

not of itself sufficient for this purpose, but absolutely requires the assistance of Fire to be able to retain them in a state of solution. 8 What has been delivered, if it is applied to the animal Fluids, the human in particular, will be of excellent service to us, tho' it is but very little attended to. For among all the Fluids that are observed in a sound Body, Water is the principal, and much the greatest in quantity, and is always found intermixed with every one of them without exception. In this, therefore, the Elements of all the other animal Humours are dissolved, and circulate together with it, and are kept by it in a proper state of fluidity. And hence does it not evidently appear, what surprizing alterations this Water, which is so obnoxious to Cold and Heat, must induce upon these Humours? Examine the Blood drawn out of the Veins, and how wonderfully do you find it changed from itself by only being exposed to a gradually increasing Cold? Observe this Urine, which was made but a few hours ago by a healthy man that was fasting, and yet you see, in this cold season, it has already deposited a thick sediment at the bottom of the Urinal. But please to attend, now, whilst I gradually heat this Water over the Fire; and you perceive it dissolves the *Fæces* that were separated from it, and that in a short time it becomes just the same as when it was made. Hence, therefore, let us learn, what considerable alterations may be brought about in the living Body, by the variation of the heat of the Water contained in it. And whilst we are upon this head, I can hardly help absolutely inferring, that the dissolving Power which Water has as a *Menstruum*, always increases exactly in proportion to the augmented Heat, till it comes to a state of ebullition: This all the Observations we have proposed confirm the truth of.

But how dangerous is it, to please one's self with generals in Physicks, to recede ever so little from Experiment, or too hastily to come to conclusions? For there are other Experiments, and those not a few, which would induce one to believe, that the dissolving power of Water decreases in proportion as its Heat increases; an undeniable demonstration of which I shall now exhibit to you. In this Urinal I have some clean Water warm'd to the heat of the human Body. Into this I throw these Balls made of wheaten flower, work'd with Water into a soft, tenacious Paste; and don't you observe how they melt, are diluted, dissolved and mixed with the Water, and render it turbid? Into this other Urinal, now, which stands over the Fire, and in which the Water boils, I put some more of the same Balls; and these you perceive do not dissolve, but on the contrary, though they are thrown about by the force of the boiling Water, grow hard, nor have any of their Corpuscles beaten off. But again, with this Water, warm'd as before, I mix the white of a new-laid Egg; and you see it dissolves, and when it is diluted in the Water, disappears: But now as I make the Water gradually hotter and hotter, it begins, you perceive, by the Heat of this Water now in a greater motion, to be formed into fibrous concretions, and at last grows totally hard. Here, therefore, you have an ocular demonstration, that upon increasing the Heat from one certain point, the white of an Egg begins to harden, and grows continually harder and harder; and yet, from a certain limit of Cold, to that degree of Heat in which the coagulation first appears, upon every fresh addition of Heat, it is more and more diluted. The same thing holds true in Dough, our Blood, and that of other Animals.

The power
of Fire in
Water vari-
ous.

Substances
soluble by
Water in
every degree
of Heat.
First, Salt.

Hence, therefore, we must reduce into Classes those Bodies which are always certainly dissolved by Water, in every degree of Heat that can be communicated to it. Of this kind, then, are 1. All *Sal-Gems*, Fountain Salt, Sea Salt, Nitre, and *Sal-Ammoniac*, as well the *Cyrenaican* and *Ægyptian*, as the factitious. 2. All pure, volatile, alkaline Salts, whether spontaneously produced by putrefaction, or artificially procured by distillation, from Animals, or Vegetables. 3. Every kind of fixed alkaline Salts prepared from Vegetables by burning them. 4. All sorts of acid Salts that are naturally generated, either in the vegetable, or fossil kingdom. And to these we must add all vegetable Acids, procured by a proper fermentation, when by this fermentation there is a production of Spirits, and particularly when by a double fermentation those Spirits are prepared, which are commonly called Vinegar. And again, hither must be reduced those Acids, which by distillation are procured from most kinds of Woods, hard and ponderous ones in particular, as Oak, *Guaiacum*, *Sassafras*, and the like; as likewise all Vinegars, which, by distillation, have acquired the name of distilled Vinegars. The condensed Vapour, too, of burning Sulphur belongs properly to this Class; as well as that Acid which by a very strong Fire is drawn from Alum, Vitriol, Nitre, *Sal-Gem*, and Common and Fountain Salt. 5. Compound Salts, artificially produced by combining together alcalious and acid Salts to a perfect saturation. And these are very numerous, on account of the variety of the fixed, volatile Alkali's, the great number of vegetable and fossil Acids, and the diversity even of those of the same kind. But though all these, now, thus prepared, will dissolve in Water, yet let me caution you, that among these, that which goes by the name of vitriolated Tartar is dissolved by it with the most difficulty, and will very quickly again harden in it into a solid form. 6. Those singular and surprizing Salts, the Borax's, may likewise be diluted in Water, but not easily, and not without a large quantity of Water, and a strong Heat continued a good while; and hence, if either the Water is lessened, or the Heat abates, they presently form themselves again into solid Masses. 7. Native, vegetable Salts, produced from their Juices, by dilution, filtration, inspissation, and then letting them stand a good while quiet, as the essential Salt, as it is called, of sorrel, and others; all which are so easily dissoluble in Water, that they can scarcely be kept from melting of themselves. 8. And lastly, the Salts of Vegetables, which are generated from Wine, or the Juices of Plants perfectly fermented and depurated, adhere to the Casks, and go by the name of Tartars. These, if they are pure and hard enough, will continue dry in the Air, nor will dissolve in their own Wines. In Water they are diluted with difficulty, not without a great Heat, and twenty times their weight of Water; and as soon as ever either the quantity of Water, or the Heat necessary to keep it boiling is diminished, they immediately run into little solid Globes. But except Borax, Nitre, Tartar, and vitriolated Tartar, all the other Salts will not only dissolve in Water, but are in their nature so averse to being kept dry, that they even run with the Water they attract out of the common Air; the pure acid Salts, and the volatile and fixed Alkaline readiest of all. As for the acid ones, certainly, it is exceeding difficult to exhibit them pure and dry, nor can it be done, except when it is vastly cold. And when you take fixed alcalious Salts out of a melting Fire, if they are exposed even to a dry Air, as soon as ever their Heat abates a little, they immediately grow damp

damp with the moisture they draw out of it. Hence, therefore, it evidently appears, that these Salts have a secret power of attracting Water into their dry and bibulous Substance. In the action therefore of Water, by which it dilutes these Salts, there are two Powers, which ought carefully to be distinguished from one another, conspiring together, one of which dissolves, the other attracts, and both in conjunction make up the efficacy of an aqueous *Menstruum*. Here, however, we must not omit taking notice, that there are some Salts, which when they are alone, are vastly greedy of Water, and yet when they are combin'd together form a third, which admits it with a great deal of difficulty. What, for instance, attracts Water more greedily than Oil of Vitriol; or what parts with its Water harder than the Alkali of Tartar? And yet if you accurately mix these two together in such a proportion, that the Composition shall by no sign distinguish itself to be either acid or alkaline, you will then have a dry Salt that will dissolve in Water but slowly. The same thing is observed to hold true in other saturated Salts, thus produced by combination, tho' perhaps in a somewhat less degree. But farther, in order to the perfect Solution of all these Salts, there is required a certain proportion of Water, which if you do not keep up to, there will be some Salt remaining undissolv'd at the bottom. And when Water, in a certain degree of Heat, is so thoroughly saturated with any particular Salt, that it will not dissolve any more of it, yet this *Lixivium*, thus impregnated, will in the same temperature take in some other Salt of a different nature. Thus, for instance, if you put Sea-Salt into Water that is saturated with Nitre, you will find the Water will dissolve a great part of it, tho' it would admit no more of the Nitre. And even then, when it is thus saturated with these two, you may afterwards add *Sal-Ammoniac* with the same success.

In the second place Water, as a *Menstruum*, dissolves all those Bodies, which from the large mixture of some Salt in them, are called saline. All these contain one of the Salts abovementioned, which makes up the greatest part of them, being intimately united with some other parts, which are neither Salts, nor of a saline nature, but belong to some other class of Bodies. To this kind we may reduce; 1. All natural *Sapo's* of Plants, which we have before taken notice of and explain'd. Of this sort we there told you, are the ripe juices of all kinds of summer fruits whatever; in all which the Water, Oil, Salt, and Spirit of the Vegetables, are most accurately mixed and concreted together, and all which are readily dissolv'd in Water. (See p. 39.) 2. Some singular concreted juices, different from the former, which are generated, and brought to perfection in some particular part of the Plant. Pulp of Cassia, Manna, Honies, and Sugars, are referr'd hither. These, indeed, may in some measure be reckon'd among the former, tho' they differ in the marks just mention'd, and evidently contain less Water. They are *Sapo's*, however, abounding in an Oil and Salt compounded together; and hence they are capable of being perfectly diluted with Water; even the Gums themselves not excepted. 3. The more liquid juices of Vegetables, which circulate in their proper Vessels through every part of them. Of this sort are the Fluids that run from the incisions made in the Birch, Walnut-tree, and Vine in the spring season. All these, of which in different Plants there is great variety, are *Sapo's* too diluted with a great deal of Water; and hence are thoroughly disposed

Secondly,
saline Sub-
stances.

disposed for a farther dissolution in an aqueous *Menstruum*. 4. All the humours of Animals hitherto observed, are very easily dissolved in Water, except the fat alone. None of these native Humours, however, are more greedy of Water than the Bile, as I learnt formerly, when I endeavoured, with a gentle Heat, to inspissate some of it fresh taken out of an Animal, in order to form it in Pills, and render it fit for keeping. But what was the consequence? Why the Mass spontaneously dissolv'd in the Air. 5. All Soaps made of an express'd vegetable Oil, a fix'd vegetable Alkali, and the igneous part of Quick-Lime, mix'd together by the help of boiling Water, and then by a proper coction inspissated into one Mass pretty closely concreted together. As likewise those Soaps which are prepared from distilled vegetable Oils, compounded with a very acrid igneous Alkali, very dry, and very hot, made likewise with the sharpest stony quick Lime: These are made by simply mixing these Substances together, and then exposing them in a low place to the open Air. To this head, likewise, belong those very choice Soaps prepared in a more curious manner, from the purest distilled Oil united with a simple volatile alkaline Salt, without the admixture of any Water, and perfected by a gentle, cautious, secret, repeated Sublimation, which then produces a most excellent Medicine. And lastly, those artificial Soaps the most subtil of all, made by a proper combination of the most perfect Alcohol, with an exceeding pure volatile alkaline Salt. These, if they are manag'd in a proper manner, are changed into a very volatile, saline, saponaceous, sulphureous Snow, which generally, tho' improperly, is called the *Offa Helmontiana*, by Raymund Lully, (*Spiritus Vini acuatius Sale-Ammoniac*) Spirit of Wine sharpened with Sal-Ammoniac. To which likewise we may refer one more, which they prepared from Alcohol, and Tartar intimately united together, by some method which was kept a secret. In all these Soaps, Chemistry is continually finding out some new, and very efficacious *Menstruums*, which are used very safely to excellent purpose in the healing Art. Now this is particularly remarkable in these, that tho' Oils, when they are alone, won't admit of a union with Water, yet they will be dissolv'd by it when they are thus combin'd with Salts. Salts, when they are by themselves, attract Water; and so they do Oils. Hence, therefore, we learn the methods by which Oils may be diluted in pure Water. 6. To these saline Bodies may be referr'd, sixthly, with regard to an aqueous *Menstruum*, Vitriols as the Chemist calls them, or Chrystals, which are generated, when the Solvent Salts, Acids in particular, divide Metals into their smallest Particles, and adhering to them very tenaciously, become concreted with them into little Glebes, which are intirely dissoluble in Water, without any *Fæces* remaining, so long as they retain this true vitriolic form. Of this kind are the Magesteries, Sugars, Salts, and Vitriols, as they are called, of Gold, Silver, Lead, Mercury, Iron, Copper, and Tin, whilst they continue compounded of the acid Solvent, the Water, and the Particles of the Metals mixed together in such a proportion, that they remain clear and pellucid, like Glass, or Chrystal. The greater quantity now of the solvent Acid is added to the Metal formed into Vitriol, the easier always will it afterwards be diluted in Water. But if the Water is dissipated from the Vitriol by a gentle Heat, so as to render the Glebules opake, then the metalline Particles presently dispose themselves in such a manner, that they will not be so easily dissolved in Water

ter as they were before. Nay, if you continue to dry these Chryftals in this manner, they will at laft not be capable of Solution at all, tho' they will ftill retain a confiderable part of their folvent Acid. An evident inftance of all this we have in Mercury. If you take an ounce of this Fluid, which is abfolutely indiffoluble in Water, diffolve it in an ounce and a half of good Spirit of Nitre, and then fightly infpiffate it, you will have a Liquor which you may dilute with pure Water as long as you please. When you have let this Liquor ftand quiet for fome time, it will at the bottom fhoot into Chryftals, which are exceeding cauftic, whitifh, and femi-pellucid, and will diffolve, infantly, and totally, in Water. Dry thefe now into a white, yellow, red, fcarlet Powder, and then Water will not intirely diffolve them. In this refpect, therefore, Water diffolves thofe Metals no further than with regard only to the Acid that adheres to the metalline Surfaces; and for this reafon, the Water immediatly lets go the Metals as foon as ever they are by any means deprived of their Acid. Hence Metals, when they are diffolved in Acids, and then plentifully diluted with Water, may be rendered potable, be received into the human Body, be there mixed with its Fluids, and act upon its Solids, and by this means bring about thofe effects which it is able to perform upon either of them. And the effects, indeed, of thefe, are frequently obferved to be very confiderable; as by their acid and metalline quality they act upon both thefe parts very powerfully. This efficacy, however, remains no longer than whilft they continue in this fluid form; but as this depends chiefly upon the adhering Acid, when that is remov'd, their potability or mifcibility is deftroy'd likewife, and they are converted into a *Calx*, and Powder. Hence, then, we underftand, how long medicinal vitriolic Waters continue efficacious, *viz.* fo long as a folvent Salt is able to keep the diffolved Metal diluted and fustain'd in a large quantity of Water; for as foon as by the inactivity or poornefs of the Salt, they come to depofite an Ocre, they immediately grow flat and good for nothing. What now has been faid of the action of an Acid, with regard to Water, will hold good likewife in Metals diffolved in alcalious Salts; as Copper, for inftance, when it is diffolv'd in a ftrong Spirit of *Sal-Ammoniac*, gives a violet Tincture, but being again deprived of its Salt, is wonderfully chang'd, and turn'd into a dirty Powder. The fame thing, likewife, is obferved in thofe Solutions, which are performed upon Metals by native or compound Salts. Thus *Sal-Ammoniac*, or Sea-Salt, will by certain methods diffolve Metals in fuch a manner, that they will afterwards fuffer themfelves to be diluted with Water: And fo long thefe likewife are capable of producing a great many effects in the human Body, but in fuch a manner, that here too their action is limited particularly to their folubility in Water. But as in every other part of Natural Philofophy, fo here likewife, it is very difficult to lay down a general rule that will in all cafes be found to hold good: For the Solution of Antimony, made with the ftrongeft Spirit of Sea-Salt which adheres to the corrofive Sublimate of Mercury, called Butter of Antimony, is thoroughly faturated with an Acid; and hence, according to the Doctrines laid down, one would be apt to imagine, that it might be eafily diffolv'd in Water; whereas, we find on the contrary, that if you pour Water upon it, the antimonial part turns immediately into an exceeding white *Calx*, which being fufed with a
strong

strong Fire, produces a very beautiful *Regulus* of Antimony, which cannot be dissolved in Water by any Art whatsoever.

Thirdly,
terrestrial
Bodies dissolved in
Acids.

But to proceed to those Bodies which are purely terrestrial. These likewise, if they are first corroded by Acids, may be perfectly diluted in Water, and lie there so concealed, that the whole Liquor shall appear perfectly pellucid; and hence these too are capable of operating in this form. Take Chalk, for instance, when it is plentifully corroded by an Acid, and you may dilute it in Water at pleasure. And, indeed, I scarce know any Earth that may not be dissolved in some Acid or other, and under this change impose upon our Senses. Hence, therefore, we may conclude, how little we can judge of the purity of Water, with respect to any Earth that may be contained in it, purely from its perfect transparency: Nay, the true ultimate Earths, produced from the Bones, Flesh, Shells, and other parts of Animals, may be thus dissolved in Acids; and therefore, all these too, may, in this sense, be so far diluted in Water itself, and afterwards, by various methods, be recovered from it again.

Not Alkali's.

But tho' earthy Substances, when they are thus corroded by Acids become by this means dissoluble in Water, yet we see on the contrary, that when they are intimately united with Alkali's, they are no ways capable of this Solution. This we see evidently in Glafs, which is compounded of an Earth and an Alkali intimately blended together, whose union the closer it is, the less will Water be able to affect them. What a vast difference do we here find then in Earth, with regard to its Solution by Water, as it is corroded by one of these Salts, or the other? Alkali's dissolve it more subtilly into a fix'd, pellucid, very hard Substance, which so powerfully resists the dissolving power of Water, that there is no Substance, which in this respect, exceeds it. It appears to me, however, still more surprizing, that the very subtil, volatile, alkaline Salts of Animals, should by their union with an Earth, form a Mass that will bear the action of boiling Water without being dissolved: But the Stone that is generated in Animals is such a Body, consisting of these Principles, and an Oil combined together. This, to the great unhappiness of many poor creatures, in whatever part of the Body it happens to be formed, is capable of propagating itself, and increasing in its magnitude; for it has a power of absorbing and uniting to its Mass, a Matter similar to itself, from those animal Humours which are nearest to putrefaction, as the Bile, and the Urine, in which the Salts become almost alcalious; and these again lay hold of the fine Particles of Earth that are abraded from the human Body in the course of circulation, and thus by associating with them, produce new stony Elements, and thus continually increase the terrible monster.

Hence we
learn the
reason of the
natural action of Animals.

Whilst I seriously now consider these things, I can't think but there appears an evident reason, why the All-wise Author of Nature, has made all the Elements of Animals, a very few excepted, of the acescent kind: For the acid Salts, by this means, predominating in the Stomach, dispose the Nutriment to a much happier Solution than the contrary wou'd; as the hard parts of the Food for their cohesion depend principally upon an Earth, and hence wou'd by alcalious Salts be reduced with more difficulty into a liquid Chyle. But as soon as ever now the Chyle is prepared, and from this there is a matter to be separated, that is proper for the formation of the Solids, then this acescent quality,

quality, necessary before in the Chyle, is intirely altered, and the Salts become of an alcalescent nature, which, uniting with the terrestrial Elements they meet with, compose a Mass not dissoluble in Water, but fit to contain and keep the Fluids within their proper bounds. Bones, we experience, if they are immers'd in alcalious Fluids, retain their firmness; whereas, if they are kept in Acids they grow soft, even so far as to become flexible, as the great *Ruyseb* told me he had often taken notice of in his anatomical Inquiries. This, it is certain, is very evident, that when the power which the human Body has of converting Acids into Alcalescents, comes to fail, then the Bones, Cartilages, and Teeth, become lax, weak, soft, and flexible; as in ricketty Children, in particular, falls continually under every ones Observation. Hence may Surgeons and Physicians learn, how imprudent it is to make use of the sharper Acids for whitening the Teeth; for tho' they flatter us with a present beauty, yet the Teeth by this means soon grow insensible, loosen, and drop out. How much better, therefore, for this purpose are the milder *Lixiviums* of fix'd Alkali's well diluted, by which the earthy Particles of the Teeth will be no ways injured.

After these, Sulphurs offer themselves next to our Examination, which tho' they are absolutely indissoluble in Water, so long as they are alone, yet suffer a perfect solution in it when they are intimately united with Alkali's. And hence again we may best understand the nature of sulphureous Waters; for what I observed to you before concerning metalline medicinal Waters, holds true here likewise. But volatile alkaline Salts also, can so resolve Sulphurs, as to render them capable of being diluted with Water: And hence it is evident, that Water assisted by Alkali's, may be able intirely to dissolve Sulphurs. And as this happens often in those Sulphurs that lie intimately concealed within Metals, and Semi-metals, by this means, tho' before they were latent, they then come to light, and discover themselves openly. And hence it comes to pass, that such Preparations, which are trifling to Persons acquainted with these things, are sold about for the profoundest *Arcana*: And in this manner even Princes themselves have been imposed upon. Thus we saw a Liquor prepared from Antimony, sold under the grand Title of a *Panacea*. A few drops of this taken in a glass of Wine, was immediately to cure diseases without any sensible effect: And, indeed, in some cases it was of service. But these secrets, when they come to be known, generally lose all their reputation, and these monopolizers no longer enjoy the gain of their boasted mysteries. After a proper Examination of the matter, I found this to be the Preparation. Upon native Antimony, reduced by long rubbing to a very fine Powder, pour twice the quantity of Oil of Tartar *per deliquium*, or the Alcahest of *Glauber*; then digest them together in a tall Bolthead for a considerable time, and pretty hot, and the liquid Alkali will gradually dissolve the Sulphur that lay concealed in the Antimony, and thus will extract a red kind of a Tincture, which has an igneous taste, a disposition anti-acid, is heating, aperient, diuretic, and diaphoretic. But to confess ingeniously, one may at once have as good a Medicine, by boiling common powder'd Sulphur in a *Lixivium* of a fixed acrid alkaline Salt; as this Sulphur is perfectly of the same nature with that in the Antimony; and as the metalline part of the Antimony is no ways affected by the Alkali. If you take powdered Antimony too, and according to art manage it with an alkaline Spirit, prepared from *Sal-Ammoniac*, you will thence likewise procure a golden sulphu-

Fourthly,
Sulphurs united with
Alkali's.

reous Tincture, as formerly the illustrious *Boyle* plainly made appear, that such a one might be prepared with simple Sulphur. But to what purpose is it to discover these cheats? Mankind love to be deceived; the rich frequently don't value things except they pay for them; and as for avarice, and extravagant pretensions, there's no pretending to restrain them.

Fifthly, the
most tenaci-
ous Refins.

Those Bodies, likewise, that consist of so tenacious a *Gluten*, that they absolutely resist the power of Water, may nevertheless, by being intimately united with either fixed or volatile Alkali's, be brought to be intirely dissolved in it; for by this means they lose their tenacity so repugnant to this Element, which they then admit betwixt their separated Particles, and so suffer themselves to be diluted by it. And hence we observe, that the putrified Urine of Animals, the *Faces* of burnt Wine, all sorts of Soaps, Bile, Honey, Sugar, and the Yolk of Eggs, if they are mixed with these Bodies, make such an alteration in them, that they afterwards become dissoluble in Water; so that the power which Water has of washing and scouring, depends almost upon these alone. To this head belong Oils, Balsams, Colophonies, Refins, and Gum-Refins, all which at last come by this means within the reach of the efficacy of Water, tho' they were perfectly indissoluble in it before. These then, Gentlemen, are the chief things that occur to me concerning the power of Water, as a dissolving *Menstruum*, that I can honestly deliver to you as matters of fact; nor do I know any thing more upon this head, but what may be referred to what has been delivered. I am well enough acquainted with those things, which the top Masters of this Art have advanced in their Writings; but the love of truth, and that integrity which is the distinguishing character of a good Man, and which I wou'd endeavour to have a proper regard to, won't suffer me to lay them before you as true. For to deal honestly with you, I am in doubt myself, whether they have not attributed more to their inventions, than was really in them. But let that be as it will, for my own part, I confess ingeniously, that I never have been able to discover those singular *Arcana*, which they make such a boasting of. If you please, however, I'll just mention to you the Doctrine of *Van Helmont* upon this Subject; and that asserts plainly, that all Bodies are by the *Alcabest* alone converted into a Salt, that has perfectly the Weight of the former Body, and may be intirely dissolved in Water. If this was the case, it must necessarily follow, that the power of Water must extend universally over all Bodies: Nor, indeed, to those who suppose that all things were produced from Water, is it so surprizing, that all Bodies whatever should be resolved into Water, Fire alone excepted, which, perhaps, for that very reason, they suppose not to be corporeal. I observed to you, indeed, myself, when I was explaining the mechanical power of Water in Solutions, that this, tho' of so exceeding soft a nature, if it falls from high, will in time divide every kind of Body whatever into exceeding small Particles; but that these, when thus separated by the motion of the Water, continued afterwards mixed with it, I cou'd never understand. I mentioned likewise what Monsieur *Homborg*, a Gentleman of uncommon assiduity, and undoubted veracity, has told us concerning Water's dissolving all sorts of Metals by being rubbed with them: But I cautioned you at the same time, that the Air had a free communication with them, which always makes an addition of almost every kind of Salt, especially in the Laboratories of the Chemists. For my own part, Water seems to me to furnish only a Vehicle for the Elements of

of Bodies, by which they may be capable of entering into Animals and Vegetables, and there be mixed and applied, and bring about whatever is necessary, either for the support of their life, or increase of their magnitude: If this alone is wanting, the whole remains a dry unactive Mass. And this seems to be the extent of its power.

The Doctrine, then, of Water, as a Solvent, being thus laid down, it will be necessary to say very little of watery *Menstruums*; as it would be almost only repeating the same things over again. A few Observations, however, which perhaps deserve to be taken notice of, I shall here subjoin.

Hail falling in Summer time, after great Heat and Thunder, and caught in a clean Vessel, has a different power from any other Water whatever; for this, of all Water, is the purest, as it was carried to a vast height in the Air, was congealed in the upper Regions of the Atmosphere, and thus in a solid form descended to the Earth.

Snow that falls in Winter, when it is exceeding cold, and there's no Wind, if you collect it in a high sandy desert place, and take it just from the top as soon as ever it comes down, produces the purest Water next to Hail.

Dew is a confused mixture of a great many things together; for in this are aqueous, spirituous, saline, and oily Vapours, and dry Exhalations of every kind whatever. And on this account it differs prodigiously from every other aqueous *Menstruum*: For it is generated only after a long continued Heat has scorched up the Earth; and consequently, when the Rays of the Sun, by their great strength, have carried up into the Air Particles more fixed than those of Water, which afterwards, when the Heat begins to abate, descend again upon the Surface of the Earth, Water, Plants, and Animals, and fill the dry and parched ground with a fresh supply of moisture. And hence, as I told you before, the virtues of it can scarcely be determined, or reduced under any head. And indeed it is a collection of such different Principles, that I don't wonder many persons should have imagined that there lay concealed in Dew, the latent Matter of a universal Salt, from which might be produced a Salt, which they call'd (*Congelatus mundi Spiritus*) *The congealed Spirit of the World*. But I pass by these things, to proceed to the other Species of *Menstruums*, adding nothing more than this one caution, that the Water in the Air very often performs the office of a *Menstruum*, where persons unwarily imagine, that the effects are owing to the proper efficacy of the Air.

Of Oils, and oily Menstruums.

Of the Character and Nature of Oils, I treated before, in the History of Animals and Vegetables, when I laid before you the different parts into which their compound fabrick might be resolved, p. 38, 43, and again, when I was examining the *Pabulum* of Fire, p. 175, 208, Oil then, to be considered now properly as a *Menstruum*, is a fluid Juice, or that may by a gentle Heat be rendered so, pinguious, inflammable when it is hot, and by no means miscible with Water. If any one imagines, that Alcohol ought to be ranked among the Oils, 'tis excepted only by the last property, as this will readily enough mix with Water: In all the other qualities of Oil, it perfectly agrees with it. All Oils, now, that have ever fallen under our Observation, are either native, as they exist in the Bodies they are generated in; or are prepared by

Art, the chemical one in particular, and then are always changed from their natural disposition. Nor can we help making this distinction between them, as on account of their surprizingly different efficacy as *Menstruums*, they are absolutely distinct from one another. Oils, then, or native oily Juices, are every where discovered as such, both in the Fossil, Animal, and Vegetable Kingdoms: When Art, which makes some alteration in them, is called in to separate them from their proper repositories, it effects this, first by boiling pinguious Substances in Water, by which means the Fat being melted, and freed from its confinement, rises to the top of the Water, and may be there collected, not a great deal altered from its proper nature. A second method of procuring them, is by pounding the oily Substances very well, and then putting them between two hot iron Plates, and with a Press pressing out the Oil. And in this case too, if you don't make the Plates too hot, the Oils will be very little different from the native. Sometimes they are separated likewise by bare melting them; and then the Bodies that abound with the oily Matter, are gently torried with a proper Fire, by which means their Oils and oily Substances are forced out, and so collected. This, in the Preparation of Pitch from the Coniferous Trees, is sufficiently evident. Upon this head the Treatise of *Axtius* deserves to be consulted. Lastly, these Oils are drawn from Bodies by Distillation, and that either by carrying them up by the help of Water, or Fire alone; or drawing them off (*per latus*) obliquely, as in the retort; or determining them downwards, which is called *per descensum*.

That do not
congele.

In these last Oils, which for the future we shall call distilled Oils, it is almost constantly observed, that they have never been found to have been frozen in the greatest degree of Cold, but have always retained their fluidity. But among the expressed Oil, some have been observed to harden with a sharp Cold into a solid Mass, composed of little Spheres united together, as is sufficiently known in Oil of Olives, Rape Oil, and many more; whilst others, as we see in Linseed-Oil, won't congeal even in a severe Frost. With regard now to this remarkable difference in these Oils, I have not, upon the most careful Examination, been at all able to discover what should be the cause of it: I refer it therefore to some secret quality, which we are forced to acknowledge, discovers itself only by Experiments, nor can be reduced to any known Law. It is a vast happiness, however, to mankind, that such a matter should have this property of continuing liquid in a most intense Frost, which at the same time, by means of a Wick once set on Fire, is capable of supplying us with light. But here we must farther observe, that the proper dissolving action of those Oils that will thus freeze, begins then only, when they are in the very next degree to congealing, but still appear in their liquid form: As therefore, some of these Oils freeze sooner than even Water itself; hence their dissolving power is, with respect to Cold, included within a narrower compass than that of Water. Those Oils, on the other hand, that keep fluid in the greatest natural Cold, always retain their dissolving faculty. Hence, therefore, it appears at one view, that it is impossible to fix any one certain point of Heat, from which the power of Solution of all Oils in common shall begin; tho' this in any one *Species* of Oil may be nearly determined, when once it has been accurately observed. If we consider now this property of Oils, how surprizingly do we find, that Oil of Linseed, tho' it retains its fluidity in the severest Frost

Frost, has really at that time no more heat in it, than the hardest Ice, or any other frozen Oil?

But farther, if you apply Fire to Oil, and increase it very cautiously and gradually, when it comes to a heat of 212 degrees, which is that of boiling of Water, it is then very far from boiling. Water, now, when it once comes to boil, cannot, by the application of the strongest Fire, have any more heat communicated to it; but Oil from the degree 212 grows gradually hotter and hotter, and before it boils is found to have admitted 600 degrees. No wonder, therefore, that boiling Oil should be so much hotter, and burn more terribly, than boiling Water. But here, too, we observe, that all Oils, if they are exposed to the same Fire, don't boil equally soon. Those, for instance, that are lighter, and more subtil, boil easier, and acquire less heat; whilst others take up more time, and grow hotter: Thus rectified Oil of Turpentine boils pretty soon; Linseed Oil with more difficulty. Hence, then, we perceive how difficult it is to determine the power of Oil as a *Menstruum*; for in Oil of Linseed, for instance, this power begins at the greatest degree of known Cold, and increases to the degree 600, and in every degree of increase it always acquires a new active virtue, and that, whether you apply it to the same Body in different degrees, or to different Bodies in the same degree, or different ones. In both these respects, therefore, you see there is an infinite latitude. But to make these things evident by ocular demonstration,

In the first place, then, you see this brass Kettle, which contains some pure Rain-water. Into this I set three Boltheads, as near as possible of the same size, and figure, and filled nearly to the same height, one with Alcohol, another with distilled Oil of Turpentine, and the third with Oil of Olives: And in the Water, with them, I place one of *Fahrenheit's* mercurial Thermometers. I now apply Fire under the Kettle, and keep the Water continually stirring, that it may be heated as equably as possible. The Water in the Kettle, now, has at present acquired a heat of 175 degrees; and now you see the Alcohol in the first Glass boils pretty strongly; this, therefore, I remove. The Water being kept frequently stirred, and growing hotter and hotter, has now arrived to the degree 213; and that you see, now, boils likewise; nor does the Mercury in the Thermometer dilate itself any farther, though, as you observe, I increase the Fire, so as to make the Water boil very violently. But the Oil of Turpentine, now, does not give the least sign of any ebullition in the second Glass; nor the Oil of Olives in the third. Here, then, you perceive this surprizing difference: Alcohol, though a very subtil, inflammable Oil, boils a great deal sooner than Water; Oil of Turpentine, which is so much lighter than Water, and pretty subtil too, is not at all put in motion with the heat of boiling Water, though this Oil is inflammable likewise; nor has the boiling Water more effect upon the Oil of Olives: Neither inflammability, therefore, nor levity, nor volatility, can be the occasion of this difference, since Oil of Turpentine is so volatile, that it rises in distillation with boiling Water.

But please to attend to a second Experiment. With the very same *Apparatus* as before, instead of Water, I have put in the Kettle the strongest Brine of Sea Salt that can be procured by boiling Water. To this, now, I apply Fire, as in the other case, and keep the Brine stirring, too, in the same manner. You see, now, here again, that as soon as the Brine comes to be heat-

Admit of a great deal of Fire.

This appears by one Experiment.

Another

ed to 175 degrees, the Alcohol boils as before ; which therefore I take away. The Thermometer is now risen to the degree 218 ; and now the Brine begins to boil, likewise ; which, therefore, you perceive requires 5 degrees more to bring it to this state, than pure Water. The Thermometer, however, in this case, will still continue to ascend gradually a little higher ; because in this strong ebullition the Water continually evaporates, and the remaining Liquid of consequence grows denser, which at last would be nothing but mere Salt. In this Experiment, therefore, when we have once observed the degree of heat at which the Brine begins to boil, it is sufficient. The Oil of Turpentine, in the mean time, and the Oil of Olives, discover, as yet, no signs of ebullition.

A Third.

But to proceed to a third, which I shall perform with a great deal of caution. In this small Vial, the Bulb of which is of an equable capacity, and the neck pretty long, I have put some Oil of Turpentine, which fills $\frac{2}{3}$ of the Bulb. The whole Vial, now, both Bulb and Neck, I heat gradually and equably, lest otherwise it should fly when it comes near to the Fire. The Glass, then, and Oil being thus heated, I hold it over the clear Coals in this Chaffing-dish, bringing it continually nearer and nearer to the Fire. Are not you surprized, now, that it don't yet begin to boil ? But observe it, now it just touches the Fire, and you may perceive an ebullition : And you see, too, it don't boil gently, but vehemently ; and at the same time makes a considerable noise. And though I have now removed the Vial from the Fire, you observe the agitation, noise, and ebullition, continue a good while in the Oil, though both Alcohol and Water presently cease boiling when they are taken off the Fire : But you'll want to know what degree of Heat this Oil acquired before it began to boil : This you may discover in the following manner. Take some Linseed-Oil, in a brass Vessel, place a mercurial Thermometer in it, and the Vial with the Oil of Turpentine, and set it over the Fire ; you will find, then, that the Oil of Turpentine in the Vial will boil a good deal sooner than the Oil of Linseed in the Vessel, and at the same time the Thermometer will indicate the degree, which, if I remember right, I found to be 560. As this Oil, now, in boiling sends off its more volatile parts, the *residuum*, which will be thicker, will require presently a greater heat to cause an ebullition. And this more difficult ebullition, and necessary communication of a greater Heat, will increase every moment, in proportion to the spissitude of the remaining Oil. Hence, therefore, it will not appear surprizing to the Physicians, that these thick Oils, when they are put in agitation, produce such a prodigious Heat ; which Observation, if I am not much mistaken, is both exceeding beautiful and useful. But these agreeable speculations carry me beyond my purpose.

A Fourth.

But to proceed to a fourth Experiment. I have here in this Vial some Oil of sweet Almonds fresh drawn, which, after all the cautions observed in the former Experiments, I at last set on the open Fire, till the Glass is ready to melt ; and now you see the Oil begins to boil, not before. And the motion you perceive of this Oil, when it boils, is quiet, equable, and without noise, and continues so to the end ; and yet the Heat of this is more than 600 degrees.

The quantity of Fire in Oils.

From the consideration, now, of the Latitude in which Oils will bear the application and increase of Fire, which is almost three times greater than that of boiling Water, we very easily perceive, that the dissolving power of Oil, considered

considered as it depends upon Fire, must be proportionably so much greater in Oil than in Water. For as most Oils retain their fluidity at the first degree of heat in the Thermometer, in which Water begins to freeze at about 33; and as the compass of Heat which Water can pass through, whilst fluid, is but 180 degrees, *viz.* from its freezing point 33, to that of its ebullition 213, whereas from the first degree of Linseed Oil's fluidity to that in which it boils is at least 600: Hence it evidently appears, that the possible power of the Fire in that Oil, is to the same in pure Water, as 10 is to 3; which what mortal living could possibly have discovered *a priori*? But if we consider farther, that many Oils, when they are inspissated, will take in still a good deal more Fire, we see, that the power of Fire in Oils will be still farther extended.

In the mean time, however, this is most certain, that if any of the parts, or the whole Bodies of Animals or Vegetables are accurately immersed in Oil, they will keep them without alteration, secure from dissipation, fermentation, or putrefaction; and they may be preserved in this manner, though the heat of the Air should be as great as has ever been naturally observed. Insects, too, that are so very troublesome in this particular, will be kept off, likewise, by the Oil that swims at top; so that by this means they will remain intire, as long as they are thus defended. And, indeed, when these substances have been so long immersed in Oil, that they are perfectly penetrated in all their parts, they then seem to have acquired an almost incorruptible nature, and may be preserved a prodigious while. This appears evidently in Bodies that have been thus treated; upon which principle depends chiefly the art of embalming; of which by this means we discover both the origin and efficacy.

The power
of warm Oil
upon Ani-
mals and
Vegetables.

But when Bodies, now, are suddenly thrown into boiling Oil, they presently acquire a hard, and almost stoney Crust over them, which is of the same colour that they get by being exposed to the open Fire, *viz.* yellow, red, and at last black. The other part, in the mean while, that lies under this Crust, being agitated by the prodigious heat of the ambient, boiling Oil, and having its motion at the same time repell'd, stopp'd, and as it were suffocated, is surprizingly altered, concocted, digested, and maturated, and at last grows consolidated, and is exceedingly well fitted for keeping a long time. But when the substances, that are thus immersed in Oil boiling hot, are full of aqueous Juices, as Flesh or Fish dried on the out-side, then these humours being agitated under this Crust, with more than a boiling heat, the parts grow very tender, retain all their juices, and become exceeding well fitted for digestion and nutrition. And Meats thus prepared too, are very durable; for all the principles of Bodies, treated in this manner, being intimately united together, and helping to render one another more perfect, produce a substance secure against any inconvenience from external causes.

The effect
of boiling
Oil upon
the same.

From what has been said, then, we may by the way deduce some truths, which one would scarcely have expected. In the first place, then, it appears hence, that the degree of heat which Fire is capable of communicating to Bodies, is not in proportion to the densities of the Bodies heated. Secondly, that the same Body, if it is gradually rendered denser, will admit a greater quantity of Fire, in proportion to the increase of its specific gravity. Thirdly, that a Body's being capable of taking in a larger quantity of Fire, does not depend

Corollaries
hence deduc-
ible.

depend upon its combustibility. Alcohol, when it once comes to boil, admits no more Heat or Fire; nothing in nature is more combustible than Alcohol; and yet there is no Liquor that we know of, which will not receive more Heat than this. Here again, then, we see how difficult it is to come at general truths; and that the true properties of Bodies must be determined by an examination of the particulars. From these things, then, thus first demonstrated, we may deduce a great many Corollaries, of which this is a remarkable one, that we may dissolve some Metals intimately in some sorts of Oils, so that by this means there shall arise a Mixture, which will not easily again be resolved into its principles. By this Art there have been some valuable secrets found out, both in Mechanics and Physick, which we could not want, without a good deal of inconvenience.

Upon Metals.

But to return to our Experiments. A fifth, now, I am going to make before you, that I never exhibited in this manner before. Into this Vial I have put half an ounce of *Minium*, and now pour on it an ounce and a half of Oil of Olives, which, by shaking, I mix thoroughly together. And you see I have made choice of the same sort of Vessel I made use of and described before, and have used the same caution in gradually heating it at a distance. I now hold the Bulb of it just over the Fire, till the Oil begins to boil, and you perceive, now, the Liquor is boiling hot, the powder of the *Minium* is dissolved, mix'd with it, and compounded with it, into one Mass. But at the same time, you observe, likewise, that this Mixture was not effected till the Oil was brought to a prodigious degree of heat, which the *Minium*, then, was no longer able to resist. Hence, then, we learn how to prepare a Balsam of Metals, and a Cement, that will powerfully resist Water. But a sixth, which is a new one, likewise, and more surprizing, I perform in this manner. Into this Vial I have put half an ounce of Shot, and I now pour upon it an ounce and a half of Oil of Olives; and, with the same caution as before, set it over the Fire. Who, now, would have believed what we at present see? *viz.* that the Lead melts and runs, like Water, at the bottom of the Glass, though the Oil don't boil, nor so much as emit any Vapour. Hence you see Glass is melted with more difficulty than Lead. But now, whilst I hold it in a stronger heat, and the Oil begins to boil, you observe, the Metal begins, likewise, to be dissolved by it. Glass, however, you see, will not be dissolved by Oil, let it acquire whatever degree of heat it is capable of. Hence, therefore, we see why melted Lead burns less violently than boiling Oil; and for this reason it will bear being handled immediately, if the person's hands are incrustated over with a very dry Chalk. If any person, here, has a mind to imitate this Experiment, let me warn him to do it with a great deal of caution, or otherwise it may prove a very fatal one: For if a drop of Water should any ways come into the Vial, it would all burst to pieces, with a vast *impetus*, and bring the Operator into imminent danger. Let me warn you, likewise, that the Vapours which arise from boiling Oil are sometimes of a watery nature, which being collected in the neck of the Glass, and trickling down again in form of drops of Water, would occasion the same misfortune; for Lead in fusion is vastly impatient of Water. A seventh Experiment let us make with Tin; of which I have here half an ounce, mixed with an ounce and a half of Oil of Olives, which, in the same manner as before, I set over the

the Fire. You see, now, the Tin runs like Water at the bottom of the Glass, and though I put it in, in Filings, it is collected into one Mass. You perceive, likewise, that it now begins to be dissolved and mixed with the Oil. But eighthly, and lastly, I have here a composition of Lead and Tin mixed together in equal proportion, whilst they were in fusion. Of this Mass I have taken half an ounce and poured upon it an ounce and a half of Oil of Olives. I keep it now upon the Fire, as before, till it boils. You see, then, the metalline Mass melts and runs a great deal before the Oil begins to boil, and sooner than either the Tin or Lead would have been melted alone. There are many more curious things of this nature, but I must proceed no farther upon this head, as I have been rather too prolix already.

Give me leave, however, just to mention a few things to you, that follow from what has been said, and are worth taking notice of. First, then, Oils are disposed to receive and retain a great deal of Fire in them before they thoroughly boil. Secondly, there is not any one known Fluid in Nature, to which more heat may be communicated, than to Oil; for all *Lixiviums* and Oil of Vitriol boil sooner, and grow less hot; Mercury, too, sooner in some measure, or perhaps equally. Thirdly, Oils may be urged with a prodigious force of Fire, before they will be dispersed into Vapours, and rise out of the Vessel in which they are contained. In the fourth place, Oils are capable of communicating their heat to the Vessels in which they are boiled; and hence, tho' you may boil Water in a leaden or a tin Vessel, yet you can't boil Oil in the same before they will melt. Fifthly, Oils communicate their heat to Metals that are put into them. Sixthly, it is not easy to give Oil a greater degree of heat than what it naturally acquires when it is made to boil. If any person has a mind to increase this collection of Fire in Oils, he must contrive some method to compress it in its Vessel, with a greater force than that of the common Atmosphere, and then, indeed, the heat will be augmented proportionably, as we took notice before in Water and Air. And hence we easily conceive, that if Oil, when in the deep recesses of the Earth it is compressed by a vastly increased Atmosphere, should happen there to meet with any great Fire, it might conceive an immense heat. And if then, whilst it was thus prodigiously hot, it should chance to have Water break in upon it, what Earthquakes might be hence produced? Without doubt vastly exceeding all imagination: May any thing now of this kind possibly happen in Mount *Ætna*, *Vesuvio*, *Hecla*, and other *Vulcano's*? Certainly, amongst other causes, this deserves some regard with the Philosophers. Seventhly, liquid Oils will not permit a greater heat to be communicated to the Vessels that contain them, than they actually have in themselves; and consequently will prevent Fire's melting any Vessel that requires more than 600 degrees of heat to effect it. And eighthly, and lastly, here again we observe, that the wise Author of Nature has set limits to Fire, that in Oil, a Matter vastly inflammable, it might not grow insuperably violent.

But farther, in explaining the dissolving power of Oils, it is absolutely necessary we should add this consideration, that the expressed crude Oils of Vegetables always contain some Water. This is evidently seen in express'd Oil of Almonds, by boiling it in a Bolthead; for then the watery Vapour that arises, being stopp'd upon the Sides of the long neck, is there plainly collect-

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Corollaries
hence deducible.Oils act by
their Water.

ed in form of drops; and these afterwards running down again into the boiling Oil, produce a pretty extraordinary motion, noise, and crackling within the Glafs. Hence, with respect to this latent Water, Oils act differently upon their solvend Bodies, in different degrees of heat; and the cracklings likewise that are produced during the ebullition make some variation in the solution. And for this reason, when by boiling a good while the Water is expelled, the power of an oily *Menstruum* is considerably altered, nor dissolves Bodies in the same manner as a crude one.

And their
occult Acid.

But those Oils, likewise, besides a Water, generally contain some subtil Salt, for the most part a volatile, acid one, which in many of them almost discovers itself by its Smell, and is of an exceeding penetrating nature. These Salts appear, and shew themselves in form of acid Spirits, which collect themselves together like Water, separate from the Oil, nor will easily suffer themselves to be mixed with it again. It is not so easy, however, to disengage this Acid from its Oil; for if you take the native Oil that spontaneously oozes out of the Firr, Larch-Tree, or Pine, and gradually melt it over the Fire, then, from the beginning to the end, both in a small, and the greatest degree of heat, this acid Spirit will be separated from it; though at the beginning, indeed, with more ease, and in greater quantity. And the same thing holds pretty nearly, more or less, in the others.

And by both
together.

Whenever, therefore, the Chemist would accurately determine the dissolving power of these Oils, he must always first carefully consider, whether the effect performed by the Oil was not owing rather to the Water, or the Acid, than to the proper Oil itself; for otherwise we may be liable to run into very great errors. The Painters inform us, that those Paints that are dissolved in boiled Oil, are much readier taken in than those that are mixed with crude, and that the Paintings with the former dry pretty soon, whereas, those Colours that are mixed with crude Oil, lose more of their native beauty, and are a great while a drying. And in the same manner, that particular power, which the softest Oils are said to have, of dissolving Metals in a gentle heat, seems as if it ought chiefly to be ascribed to their latent Acid, and by no means to their true oily part. Thus, for example, if you mix the soft Oil of Olives, with a very fine powder of Iron, Brass, or Lead, and then digest them together for a good while in a gentle heat, part of the Metal will be dissolved and mixed with the Oil, will give it a colour, and often impregnate it with some remarkable vertue. But to suppose this to be the real dissolving power of Oil, as Oil, is to extend it beyond its proper limits; for when, by a continued ebullition, it is thoroughly freed from this adhering Acid, it then retains this power no longer. And thus the Polishers of Brass and Iron have long observed, that if these Metals, when they are polished, are exposed to the Air, they can't be kept from contracting Mould and Rust, by only rubbing them with crude Oil, though they may be very well secured by boil'd, especially if there is a little Ceruss, or Lead Ore, boil'd in it, by which all its acidity is absorb'd, and it is excellently well fitted to defend the beauty of such Bodies. And that there is in distilled Oils the same Acid the egregious *Hoffman* has demonstrated by an elegant Example, in his valuable *Physico-Chemical Observations*. p. 56. 57. Where, by rubbing distilled Oil of Lavender-flowers, and distilled Oil of Turpentine, with Salt of Tartar, he observes a
neutral

neutral Salt to be hence produced, arising from this Alkali, and an Acid drawn out of the Oils. And lastly, even a gentle distillation of these Oils, will extract some Salt from them; as we see in Oil of Turpentine and Juniper, which being treated in this manner, yield something of an Acid.

And as for Oil distill'd from *alcalescent*, or putrefied Vegetables, or the parts of any Animal whatever, this abounds so plentifully with volatile alkaline Salts, that these are separated from them, in large quantities, by a gentle Fire, and appear in solid little Glebes, as white as Snow. If you would attempt therefore to explain the proper virtues of Oils, you must first carefully free them from all their Salts, and then, by examining them when they are pure, you may be able to judge of their virtues without danger of mistake.

A volatile
Alkali often
in them.

But before we treat of Oils as *Menstruums*, it is still much more necessary and useful, to consider how long Oils do actually continue Oils. And here there occur many surprizing *Phænomena*: For Oils, either prepared with Water *per Veficam*, or drawn with a dry Fire in a Retort, whether sweet-scented, or fetid, if they are cautiously distilled in a Retort to a dryness, the Vessels being kept accurately closed, they leave an Earth at the bottom, gradually lose their viscosity, and grow more subtil, fluid, and transparent. And if you repeat this operation to the fourteenth time, or oftner, you constantly have an Oil different from the former, and every time some remainder, till at last you thus procure a penetrating anodyne Medicine, mighty efficacious in some grand diseases: But every repetition, likewise, you have a different *Menstruum*. And hence *Van Helmont*, the Father, in his *Aurora Medicinæ*, published in *Dutch*, p. 188, by a repeated distillation of human Blood with Spirit of Salt, till no *Fæces* remain, thinks he prepares a diaphoretic Medicine, which like a *Menstruum* dissolves all those preternatural viscidities in the human Body, which often give rise to fatal obstructions. The famous *Hoffman*, too, confirms the preparation of such a Medicine, and highly extols it for its virtues. *Obs. Phys. Chem.* p. 59. And another Author, tho' less indeed to be depended upon, was bold enough to assert, that in such an Oil as this you have a universal Medicine. But these things the Chemists of former ages have given us an account of. And indeed this is certain, that from Oils treated in this manner, such *Menstruums* are procured as have an excellent and scarcely imitable dissolving power. Upon this head, *Raimund Lully* and *Isaac Hollandus* have given us whole processes, which are fully enough described, and deserve consulting.

Simple Oils

And lastly, every kind of these Oils contains farther something vastly subtil, and volatile, which resides in them, but still may be separated from them: This we treated of formerly, under the title of the *Spiritus Rector*, or *Archæus*. This Spirit is active, odorous, sapid, the Son of Fire; and is the true cause of incredible effects. This being generated in the Oils, and held down, and retained in them, endues them with a singular virtue, very efficacious, and scarce to be found any where else: And hence, when it comes to be perfectly separated from them, it leaves them vastly less active, nor hardly any longer distinguishable from one another. And as from many of them it spontaneously exhales with a gentle heat, it soon mixes itself with the Air, and leaves them effete, and incapable of performing what they could before. Thus then I have said enough of Oils to enable us to come to a

And a *Spiritus Rector*.

certainty about their effects, considered as simple and homogeneous. And, indeed, the dissolving power of pure Oils seems chiefly to consist in their being able to admit a prodigious heat into their substance, and communicate it to other Bodies.

What true
Oils dissolve.

In the first place, then, Oils will mix with Oils; most of them with all others. Some, indeed, there are, that will not mix so easily, as appears in the distillation of Turpentine and Amber, where the Oils that rise in different degrees of heat, are found to be different in weight, thickness, colour, and situation, nor suffer themselves to be readily mixed together. The rest mix very easily. Secondly, true resinous Bodies melt, and are then sufficiently dissolved in Oils. As, thirdly, are most sort of Gums, especially if they have any thing of Resin mixed with them. Fourthly, Oils that are thicken'd, or, as they are called, Balsams, Tears, and Colophonies, are all diluted in Oils. As, likewise, fifthly, Sulphurs themselves, whether found naturally in the Mines, or produced by Fire, and that both liquid and solid; for these all suffer themselves to be dissolved by Oil, even though they lie concealed in other Bodies. Thus Antimony, if it is reduced to Powder, sublimed into Flowers, and then boiled with Oil, will in a short time yield a thick, red Balsam of Antimony, arising only from the Sulphur of the Antimony, resolved in the Oil, whilst the reguline part remains unaffected, but deprived of its Sulphur. And the same thing holds true, likewise, in other semi-metals, that abound with Sulphur.

Of proper spirituous Menstruums, or Alcohol.

Alcohol
among the
secret Men-
struums.

Those Alchemists, who were reckoned among the Adepts, throughout all their Writings make mention of Spirit of Wine. And this, when it was reduced to the greatest subtlety, they made use of, in the preparation of all their other secret *Menstruums*. This is evident in the *Circulatum* of *Paracelsus*. And for this reason, the indefatigable *Weidenfeldius* was induced at last to believe, that these Adepts have plainly enough described all their *Arcana*, except their philosophical Spirit of Wine, which, was it once come to be known, every thing would be sufficiently clear. Whether this, however, be really the case, I have reason to doubt; and, indeed, it is easy to make it appear, that the Spirit of Wine, which these famous Authors describe by its proper marks, is the very same that we have at present. This its subtlety; volatility; the manner of its preparation; its fragrance; the streaks that run down in its distillation; its burning away without any Water remaining; the burning of a Cloth wetted with that Spirit; its union with Salt of Tartar; its adunation into the *Offa Helmontiana*; the extraction of the subtil Sulphur of Animals, Vegetables, and Fossils with it; and lastly, its balsamic property of preserving Bodies, and securing them from putrefaction, abundantly demonstrate. Besides these properties, however, that we find in our Alcohol, these great men, I confess, ascribe other vertues to it, which at present we are not able to discover, as in particular its power of dissolving Salts: But then it still remains a doubt, whether this difference arises from our not knowing the proper Spirit, or from our not knowing some secret, but necessary method of preparing these Salts. Let this, however, be as it will, it is certain, there is often in those things something very surprizing. Some of the top Masters in Chemistry have publicly declared

clared in their Writings, that it is not possible to unite Alcohol with a pure fixed Salt; and no wonder: For if the least moisture conceivable has infected either the Alcohol, or the Salt, they can never be perfectly combined together: But when pure Alcohol, and perfectly dry Salt of Tartar are mixed together, a saturated tincture is soon extracted, and there is a true combination of the Alcohol and Tartar. For these Reasons, then, we can't sufficiently inquire into the nature of this Liquor, to which, on account of its excellence, we give the first place among spirituous *Menstruums*. This Alcohol, then, is obtained from nothing but Vegetables; and from them, only by Fermentation and Distillation. The best is prepared from Wine, *Hydromel*, and Malt Liquor. These Liquors themselves, if they are thrown upon Fire, put it out; and yet the Fluids that first rise from them in distillation, which are somewhat pinguious, limpid, sapid, and odorous, and are then called Spirits, upon the application of Fire to them, burst into a Flame, and burn away, tho' they are still very readily mixed with Water. And when afterwards by proper methods the Water is intirely separated from them, they then become true Alcohol, which we described before, when we treated of the *Pabulum* of Fire, p. 187, & *seq.* Hence Alcohol, upon every account, seems to be an exceeding subtil vegetable Oil, which, whilst it was thicker, consisted of Particles, which strongly attracted one another, collected themselves into drops, repell'd Water, and refused to be mixed with it, but being converted into Alcohol, have lost a good deal both of their attractive and repulsive power. Hence Oil comes to be called Alcohol, when it will mix with Water, and at the same time will totally burn. The Oils of Animals and Vegetables, likewise, may be altered and attenuated, in such a manner, by a perfect putrefaction, as to become so subtil and volatile, as to take Fire, whilst they are dispersed in the Air. Nay, and by repeated distillation, those Oils, in particular, come to be so exceeding fine, that they will bear in some measure to be diluted with Water, though not so readily as the former Spirits. Before, now, we can pretend to give any account of the dissolving power of these Spirits, we must first determine what this Spirit is: For the common Spirit of Wine, we know, consists of a good deal of Water, a liquid, volatile, acid Salt, a disagreeable Oil, and Alcohol: Rectified Spirit of Wine contains less Water, the same volatile acid Spirit as before, less of the nauseous Oil, and more Alcohol: Perfect Alcohol, prepared by itself, is composed of Alcohol, and something still of a liquid Acid: This Alcohol, once drawn off gently by distillation, from a fixed alcalious Salt, becomes perfectly pure. No body, therefore, concerning these things, should pronounce too rashly.

May be united with a fixed Salt.

1. Pure Alcohol dissolves Water, and is dissolved by it; as likewise all aqueous Fluids.
2. And hence all Wines, of what sort soever.
3. All spirituous, fermented Acids; of which kind are all sorts of Vinegars.
4. All pure Oils.
5. All true vegetable Resins.
6. Gum-Resins for the most part.
7. Pure volatile alkaline Salts.
8. Fixed alkaline ones, when they are perfectly dry.
9. Most *Sapo's*.
10. Sulphurs, dissolved and opened in alcalious Salts.

What Bodies it dissolves.

But native, compound Salts it does not affect, as Sea Salt, Nitre, and *Sal-Ammoniac*; nor pure Earth; nor Sulphur; nor Mercury, Metals, Semi-metals, Gems, or Stones.

What not.

Of

Chemical
Spirits an
ambiguous
term.

Of the Menstruums called Spirituous, both Alcaline and Acid.

A great many of the Chemists have referred two sorts of *Menstruums* to the oily and spirituous ones, which ought rather to be placed amongst the saline, or the compound. And this happened, because they almost always had some appearance of oilyness, and at the same time were generally found to be volatile, liquid, and very subtil. Under this name of Spirits, therefore, went some Alkali's and some Acids, as they both appeared volatile, subtil, and subpinguious, tho' they were still, in reality, as different as almost any two things whatever. Nay, and even among the particulars of each kind too, there is observ'd a very great diversity. Let saline spirituous *Menstruums*, therefore, be divided first into Alcaline and Acid; for this distinction is absolutely necessary. Then let the alkaline spirituous be distinguished from another, as some of these are of a compound nature, others of a simple one. The most simple of these consist of Water, and a very subtil volatile alkaline Salt, which together compose a kind of limpid, thin, subpinguious Liquor; of this kind is the pure alkaline spirit of *Sal-Ammoniac*. And to this head belong an infinite number of others, produced both from Animals and Vegetables, when they are perfectly freed from all their Oil; for these may be prepared by Distillation from the hot antiscorbutic Plants, from every putrified Plant, and from every part of the animal Body, and are every where to be met with among the curious Chemists. But those, now, which are more compound, consist chiefly of Water, a Salt, which we shall by and by describe, and a fetid Oil; and they may be resolved into these Principles. These appear to be of a more pinguious nature than the former. These last Spirits, therefore, as they are called, are composed of a volatile alkaline *Sapo*, diluted in such a quantity of Water or Phlegm, that it is not capable of dissolving any more. And as for those Spirits, which for the most part are volatile acid Liquors, these likewise among the Chemists have obtained the name of Spirits, because these, in the same manner, are volatile and subtil, and in Distillation produce, as they run down, a kind of pinguious *Striæ*. All these, however, upon Examination, appear to be acid Salts diluted in pure Water; for even Oil of Vitriol itself, which is considerably fixed in the Fire, will, if it is distilled some number of times with boiling Water, become great part of it volatile. And the case is the same with Oil of Sulphur *per Campanam*.

A great many of these belong to Salts.

Upon these considerations, therefore, I think it will be much the properest method, to separate these abovementioned from the spirituous *Menstruums*, and place them among the saline, which is what I shall now proceed to.

Of the simpler saline Menstruums.

Salts necessary to be known.

Whoever is not acquainted with the tastes of Salts, will never arrive at the knowledge of our *Arcana*, is a maxim amongst the Alchemists: And no wonder, as a great many Salts are vastly efficacious in the Solutions of Bodies. And if we can put any confidence in the greatest Masters of the Art, that famous Solvent the *Circulatum* of *Paracelsus*, was made from Salt. This, however, is past all dispute, that in the class of *Menstruums*, Salts obtain every where the principal place. For this reason, I have for a long time taken a great deal of pains in these things, to see if I cou'dn't discover in them what was cer-

tain and useful; that I might at last reduce this Doctrine, often exceedingly confused, into some kind of order, and then candidly communicate it to you.

By Salt, therefore, we mean a Body that may be diluted in Water; that may be melted in the Fire if it does not first fly off; and that affects the Tongue with that sensation which we call Taste. What Salt is.

When this, now, is either artificially, or naturally perfectly pure, and without Mixture, it appears to consist of Globules so minute, that its single Particles are not capable of being distinguished by the most accurate Microscopes; and consequently, even these will give us no light at all into their figure. Nay, farther, when these saline Bodies are resolved into their pristine ultimate Elements, from whence they were concentered, they then seem to become perfectly volatile, and when they are separated from one another, and freed from every thing else, disperse themselves about, and mix with the Air. This we saw sufficiently plain from Experiments, whilst we were treating of Earth, p. 369, &c. When these ultimate Elements, therefore, of pure Salt, are so concentered into Masses, as to offer themselves to the examination of our Senses, they then always have something else intermixed with them, which serves as a *Vinculum*, to bind and hold these volatile Particles together; and this in particular is Water, and Earth, which are capable of keeping them thus in union for a long time, and forming them into such large Corpuscles. Hence, therefore, we very evidently perceive, that as the first Elements of Salts can scarcely ever be confined in Vessels, so very little can be asserted concerning their chemical, or other virtues. In the mean time, however, when they come to appear in a durable form, then, as compound Bodies, we may be able to come at some certainty about them. The Elements of these insensible.

In order to this, then, let us examine into the principal difference that is observed among them. And this I think in the first place, ought chiefly to be ascribed to the real difference that there is in their constituent Elements: For tho' we can't come to examine these, when they are separate, and alone, yet without dispute, tho' all agree in their volatility, yet each sort has always some distinct and proper virtue. But secondly, this difference may arise from the diversity of the other Principle, which being united with the former pure Salt, composes the Salt that falls under our Observation; for what reason is there, that this, in various Salts, may not be of a different nature? All kinds of Salts, therefore, we distinguish into such as differ 1. In their saline Principle. 2. In their uniting *Basis*; or 3. In both together. And then in respect of this saline Principle, and this first Division, I reduce Salts, and consequently, saline *Menstruums*, conveniently enough into the following Classes. 1. Into fixed Alkali's. 2. Volatile Alkali's. 3. Native vegetable Acids. 4. Fermenting vegetable Acids. 5. Fermented vegetable Acids. 6. Vegetable Acids procured by Combustion. 7. Vegetable Acids procured by Distillation. 8. Native fossil Acids. 9. Fossil Acids by burning. 10. Fossil Acids by Distillation. 11. Native Salts, called neutral ones, as Borax, Nitre, Fossil-Salt, *Sal-Gem*, Fountain-Salt, Sea-Salt, and *Sal Ammoniac*. 12. Other Salts that are compounded of these. All these Salts, therefore, must now be examined in order, that we may ascribe to every one of them its proper and peculiar virtues, and by this means come to a true knowledge of them, as they may be made use. Kinds of Salts.

use of in the Solution of Bodies. To begin then in the first place with the fixed Alkali.

Of a fixed Alkali, as a Menstruum.

A fixed Alkali.

The word *Kali*, made use of upon the *Eastern* coast, and in *Egypt*, signifies a certain Herb, abounding in Salt, that grows about the sea-shore, and the banks of the *Nile*, and on those too of that famous River *Belus* in *Syria*, as *Pliny* assures us from ancient Authors. This Plant, if it is burnt in an open Fire, when it is come to maturity, produces Ashes that are remarkable for their salt acrid taste, and thus evidently demonstrate how full they are of Salt. If these Ashes are boiled in Water, they yield a strong, acrid, salt *Lixivium*, consisting of the Salt that is drawn out of them into the Water, which being properly poured off, there remains at the bottom of the Vessel another greyish part, which will not dissolve in the Water, nor will burn in the Fire, but is perfectly insipid, and of an earthy nature. If this *Lixivium* then is evaporated to a driness in an iron Kettle, there is left behind a white solid Mass, of a most acrid caustic taste, and perfectly soluble in Water. Since, therefore, *Lix* in the *Latin* Tongue signifies Ashes, and *Lixa* a maker of Ashes, hence *Pliny* very properly says, *Cinerum Lixivium*, L. xxxix. C. 99. And, *Lixivium Cinis*, L. xiv. C. 2. 25. L. xv. C. 18. But *Columella* calls a *Lixivium*, the Water when it is impregnated with this Salt, and filtered. L. xii. C. 41. All these Salts, therefore, for the future, may very conveniently be called *Lixivious* Salts. By terms, however, received into the Art, they are called an Alkali, alcalious, or alkaline Salts. Some likewise call them *Soda* or *Zoda*. From this Salt, and the *Calx* of all Stones that strike Fire with Steel, may be prepared a *Frit* for the making of Glass. For Soaps, they use the same made sharper with quick Lime, and any oily Substances whatever. The best of this sort of Salt, comes to us at present from *Alexandria* in *Egypt*, and *Tripoli*. As all our Physical knowledge, now, arises originally from what our Senses discover in natural Bodies, hence all the distinctions of them must be taken only from such sensible signs: Nor can we distinguish Bodies in any other manner. I now, therefore, proceed to lay down the following Characters of an Alkali, which I think are abundantly sufficient, both for the Chemist, and the Philosopher.

Its Marks.

1. This Alkali, therefore, owes its origin to a vegetable Substance. 2. It is only procured thence by the action of such a Fire, as by burning converts it into Ashes. 3. When it is prepared in this manner, it is always of such a nature, that it will remain a considerable time in the Fire, and thus demonstrate its fixity. 4. In a moist Air, it perfectly melts away and deposits some *Fæces*, being absolutely impatient of long dryness, tho' it is carefully enough preserved in any close Vessel whatever. 5. If you taste it, it impresses a Savour upon the Tongue, joined with a Sense of Acrimony, and that a caustic one; and it excites at the same time a Taste of Urine, on which account these Salts have, tho' not so properly, been called urinous Salts. For the proper Taste of this Salt does not resemble that of Urine, as the first application plainly demonstrates: But when this has been in the Mouth some time, and by its Acrimony has drawn out the *Saliva*, then the neutral animal Salts which are in the *Saliva*, by the power of the fixed Alkali, are deprived of all their acid,

aid, and thus become volatile and alkaline, and then impress upon the Tongue a disagreeable urinous Taste, of which this is the true origin. 6. This Salt, when it is perfectly pure and unmixed, has not the least smell of any kind, being exceedingly fixed in the Fire itself: But as it is vastly greedy of every Acid, if it meets with any Body in which there is a volatile alkaline Salt retained by an Acid, and concealed without any Smell, it then immediately absorbs the Acid, and the latent Alkali being by this means set at liberty and rendered volatile, disperses about an alkaline Smell, which is then falsely ascribed to the fixed Salt. This appears evidently upon throwing a fixed alkaline Salt into warm fresh Urine, upon which the Liquor, that was inodorous before, instantly emits a disagreeable alcalious Smell. 7. Another property of this Salt is, that if it is mixed with any Acid whatever, it presently produces an Ebullition and Effervescence; and afterwards is so intimately united with it into one Mass, that if the Saturation is compleat, the compound, so long as it continues so, discovers no sign, either of an Alkali or an Acid, but there is always by this means produced a third Salt, which the Artists now o'days chuse to call a neutral one. 8. If a pure fixed Alkali is mixed with the Juice of the Turnsole, Roses, or Violets, it presently changes their natural Colour, which is a kind of Purple, into a Green. 9. When the same is applied for some time to a warm human Body, and consequently one that exhales some Moisture, it excites an acute Inflammation, attended with all its Symptoms, which soon turns to a grey, hard, dead, and often black Escar, and therefore is capable of producing at last a true Mortification. 10. All these Salts have a power of deterging and getting out spots; which is never found to be the case in those called neutral. These then are the Marks by which these Salts may be known and distinguished from all others; and by these we shall be able to avoid any confusion in this History of *Menstruums*.

Such alkaline fixed Salts may be procured likewise from any crude, fresh Vegetable, burnt to Ashes, and treated in the same manner as we mentioned of the *Kali*. Out of some Plants, however, by this management, you can get but very little: Of this kind are those, which when they are crude, have such a pungent Smell, as stings the Nose, and makes the Eyes water; for almost all the Salt of these Plants is volatile, and is dissipated, and flies off with the Heat of the Fire. Garlic, the bulbous vomiting Roots, Onions, Scurvygrass, Ladies-smock, Rocketts, Hedge-mustard, Cresses, Radishes, Rapes, Squills, Leeks, Mustard, and the like, I refer hither; in which nature has so far perfected their alcalious Salts, as to render them volatile, as in Animals.

These *lixivious* acrid Salts, now, have been known to the ancients in almost all ages. *Aristotle* tells us, *Meteor* II. C. 3. that the Ashes of burnt Reeds, and Bulrushes, boiled in Water, yield a plentiful Salt. And *Varro de R. R.* L. i. C. 7. informs us, that some of the Inhabitants upon the *Rhine*, having neither Fossil nor Sea-Salt, instead of them, made use of a salt Coal, which they procured from some sorts of Wood: From which it is pretty plain that they knew, according to *Tachenius's* method, to prepare these Salts in such a manner, as to make them less acrid, and to come nearer to the nature of the native neutral ones. Hence *Pliny* asserts, L. xviii. C. 28. that Ashes themselves have the qualities of a Salt, but are milder. And L. xiv. C. 26. that the burnt *Fæces* of Wine have the virtue of Nitre. And L. xvi. C. 11. he

speaks of the nitrous Ashes of burnt Oak. Nay, and they made use of it in Physic too, as we learn likewise from the same Author, L. xxxvi. C. 69, where he says, Ashes, when they are drank, have medicinal vertues. All these authorities, then, to which more might be added, if necessary, sufficiently evince, that the knowledge of Alkali's is not to be look'd upon to be so modern as some Persons imagine.

Prepared by
Fire only.

As far, now, as ever I have been able to inform myself, there was never yet discovered one native Salt with which the preceding Marks wou'd agree, all these alkaline Salts being procured from vegetable Substances by the action of Fire alone. But from the first time that ever Vegetables came to be burnt in the world, these Salts have been always produced, provided the Vegetables were reduced to Ashes. Hence, therefore, in all ages and places where this has happened, there must have been a prodigious quantity of this Salt generated, which always at last with the Ashes sinks down to the Earth. In the revolution, therefore, of such a vast number of years, this Salt, one should think, must have possessed great part of the Earth, and discovered its proper Nature, as we see the mountains of Salt do in the Island *Ormuz*.

Perish again.

But as this, now, is found by no means to be the case, nothing can be more certain, than that the Salts of burnt Vegetables, when they insinuate themselves into the Earth, often, indeed, render it fruitful, but in the mean time, soon lose their alkaline nature, put on the form of a new Salt, and then continue to act in that character.

Not in
Plants na-
turally.

And upon this head, we ought particularly to consider, that no Plant that ever grew upon the Earth, if it was suffered by time to grow dry and carious, wou'd ever yield one grain of a fixed Alkali: But on the contrary, they have been always found either to have been dissipated into such minute volatile Particles, as escape the Observation of our Senses, or else to have left behind them a certain Matter, which upon examination appear to be mere Earth. This universal Experiment, therefore, confirmed in all ages, evidently demonstrates, that Nature, whether you regard their Fluids or Solids, has never intermixed a fixed Alkali in the Composition of Vegetables. Hence, therefore, we assert again, that fixed alcalious Salts are produced by the action of the Fire, and not by any natural vegetating Operation. But this is still farther evinced by the following Experiment, which constantly succeeds in the same manner. Take any of those Vegetables, which if they were burnt wou'd yield a large quantity of a fixed Alkali; let these be brought to putrefaction according to art, so that their whole Substance shall be perfectly putrid; and they will by this means become exceeding fetid, and great part volatile; and if they are then burnt in an open Fire, won't yield one grain of fixed Salt, but will produce only some white, insipid, perfectly earthy Ashes; in which, if you expect to find any Salt, you'll be deceived. You, Gentlemen, therefore, who consider this Experiment in a proper manner, must be of my opinion, that fixed alkaline Salts of Vegetables, which are the only fixed alkaline Salts we at present know of, ought to be looked upon as absolutely the creatures of the Fire; and no doubt but you will think that they are as much so as Glass, which is made from the most lixivious Ashes, melted with the intensest Fire: But as no person living supposes that Glass is really procured from the Vegetable, when it

it is thus put in fusion with a strong Fire, so certainly we must confess the case is the very same with this Alkali.

And hence, in the latter part of this Work, I shall demonstrate, that these alkaline Salts may be very easily resolved into a considerable part that is saline, hard, bitter, and almost vitrescent; into a simple Earth; and into an alkaline Salt, that is stronger and more pure: And thus we shall again see, that these Salts are by no means simple Bodies; but that they are compounded of different parts united together; and that this conjunction of these Principles into one Mass that appears so homogeneous, is owing intirely to the strength of the Fire. Hence, then, it will follow, that Nature never acts by fixed alkalious Salts, as by her proper Instruments, unless only when she receives them first prepared by the Fire: And that even in this case, when she makes use of them thus prepared in bringing about her designs, she then only operates by them, as they are compounded of the three abovementioned Principles; to which, however, as a fourth part, there still seems to remain somewhat of an Oil, as many Arguments induce one to believe.

Arises from
different
parts, united
by the action
of the Fire.

And hence again it appears, that as these fixed alkaline Salts are more and more disengaged by a separation of their constituent Principles, the Salt that arises hence will be continually different; for that which remains after a former separation, will always be of another and more simple nature, and consequently, will have a different power of acting. Take Pot-Ashes, for instance, which yield the best of this sort of Salt. A great part of these is a bitter, hard, pellucid Salt, that does not so readily dissolve in Water. Separate this carefully according to Art, and you will then be able to obtain a purer Alkali, which is fitter than the other, for a good many Operations that are perform'd by Alkali's, which will not succeed so well, if the former Salt remains mixt with the latter. And here we must carefully observe, that these alkaline Salts too, are often surprizingly changed by some other Body's falling in among them, whilst the Vegetables are burning, which being likewise of a fixed nature, may be united, and remain with them in the Ashes. Suppose, for instance, that some Nitre should happen to come among them; then this being fixed with the other vegetable Salt, would produce an Alkali, on which, if you poured Oil of Vitriol, it would emit a fetid Fume, that would smell of Spirit of Nitre; which never is the case, if the Alkali is pure. The same you easily conceive of Sea-Salt, and many others. And lastly, to render this Doctrine of Alkali's still more clear and compleat, we must take notice, that the very burning of the Vegetables, as it is performed in a different manner, will produce different Salts: For it is a known truth, that if the same Vegetable is burnt at once in a brisk strong Fire, it will yield another Salt from what it does, when it is slowly consumed by a smothering one, as we see in the Preparation of the Salt of *Tachenius*. But we must now proceed to give you an account of the principal alkalious Salts, which are made use of in the chemical Art.

Consequently
various.

Among these, then, the commonest sort is that which is called *Potas*, or Pot-Ashes. This is brought yearly by the Merchant's Ships in great abundance from *Coerland*, *Russia*, and *Poland*. It is prepared there from the Wood of green Fir, Pine, Oak, and the like, of which they make large piles in proper Trenches, and burn them till they are reduced to Ashes. These being pre-

The Alkali
of Pot-
Ashes.

sently sifted, were by the Ancients called *Lix*; by the Moderns *Cineres Clavellati*, which name seems to come from the *Clavæ*, or Billets, into which the Wood is cleft, to make it burn more readily, whence *Clavula*, and then *Clavella* seem to be derived. These Ashes are then dissolved in boiling Water, and when the Liquor at top, which contains the Salt, is depurated by standing quiet, it is poured off clear, and makes the *Lixivium*. This, then, is immediately put into large copper Pots, and is there boiled for the space of three days, by which means they procure the Salt they call *Potas*, (which signifies Pot-Ashes) on account of its being thus made in Pots. This Salt, whilst it is hot and dry, must be put up in Casks, the Wood of which is dry, and has no Oil in it, and by this means it may be kept dry; otherwise, if it is exposed to the Air, especially a moistish one, it will run into a pinguious Liquid, which is very heavy, won't admit Air, is alcalious, and exactly like Oil of Tartar *per deliquium*: And by this very action, it deposits again fresh *Fæces*, and that in a very considerable quantity too; for I myself have, in this manner, got 6 drachms of these *Fæces* the first time from one pound. When this afterwards is dissolved by successively pouring hot Water upon it, and by standing is depurated from its *Fæces*, and the pure Liquor that is at top is accurately filtered, then, if it is inspissated to half the quantity by exhalation in a very clean glass Vessel, and afterwards suffered to stand quiet in a cold place, it will soon form upon the Glass little hard Glebes, of a regular figure, pellucid, that never dissolve even in a dampish Air, are diluted with difficulty in Water, are brittle like Glass, of an exceeding bitter Taste, and very much resemble that Salt, which in making Glass is thrown up to the top, and is called the Gall of Glass: This therefore is of a very particular nature: And by this method, one may obtain a great quantity of this Salt. But even in this way of preparing this Salt, you have again terrestrial *Fæces* to the quantity of 4 scruples in a pound: And thus at last you have the alkaline Salt in the remaining Liquor sufficiently pure. This, now, if it is inspissated quite to a dryness, produces a white alkaline fixed Salt, with which, and pure Sand, is made the finest sort of Glass. If this pure Salt now is exposed for a good while to a strong Fire, it will melt, and then always becomes more acrid, and being exposed to the Air in a glass Plate, will again dissolve and deposite *Fæces*. And if these Operations are repeated, as I mentioned before, in our History of Earth, the whole Salt will become volatile, and at last will be intirely resolved into an imperceptible exhaling part, and terrestrial *Fæces*: And thus again, both its Acrimony, and its dryness, will be destroy'd. But it often happens during the repetition of this Operation, that the Alkali changes its first nature, and is converted into a neutral Salt, which easily melts in the Fire like Wax: And hence some Chemists have vainly pleased themselves, that they were Masters of that great secret, an incrated fixed alkaline Salt, which the ancient Chemists so highly extolled. But this only happens from the volatile acid in the Air applying itself to this Salt, and being united with it, by which means a new kind of Salt is produced, compounded of this Alkali, and this Acid, and hence easily flowing in the Fire, but deprived of all its alkaline virtue. But otherwise, the fixed Alkali, procured in the manner we have described, has above all others, every mark which we laid down in defining an Alkaline. This Salt, therefore, we may fairly fix as a standard for all of this

kind, by the character of which we may examine any Salts that we are in doubt about, whether they belong to this Class, or no. And thus again is confirmed what we advanced before, that alcalious Salts, produced by burning, are made up of three Principles, and those very different ones too, *viz.* a pure Alkali, a bitter Salt, and a pure Earth. The true saline part here, now, is greatly less, than any one would imagine, and when it is alone, is volatile, escapes the notice of our senses, and hence, hitherto, we are not come to a knowledge of its proper nature.

The Juice pressed from Grapes that are ripe, spontaneously ferments; and during this operation it is properly called Must. After this fermentation is over, and its thicker *Fæces* are deposited, and it has stood quiet in the Pipe, it becomes liquid, fine, and homogeneous. This we call Wine; which has now deposited abundance of thick *Fæces*: These go by the name of the Lees, or the Mother, and were first dispersed through the Must, then work'd up into Flowers, and Yeast, and afterwards fell down, and were continually collected more and more at the bottom. The Wine, when it is thus become fine, if it is drawn off from the Lees into a clean Vessel, leaves all these thick *Fæces* behind it; from which, by pressing them strongly through thick, canvas Bags, they procure a turbid Wine, which they use for making the strongest Vinegar. The *Fæces* then that still remain in the Bags, dry, and formed into Cakes, if you burn them, will be consumed into Ashes. These, if they are sifted, dissolved in Water, and depurated from the subsiding Earth, yield a clear *Lixivium*. And this, lastly, by inspissation, in great Pots, produces a Salt, very like the former, but purer, and more acrid. This, then, is a second sort of Pot-ashes, which by the preceding fermentation seems to be rendered more subtil than the former. And this is a second general method of procuring an Alkali from every sort of Wine whatever.

An Alkali
from the
Lees of
Wine.

If the Wine, now, after it is fin'd and drawn off as above into a clean Pipe, stands a good while after it is thus perfectly fermented, and fine, there will then begin to appear little shining Bodies in it, like little Particles of Glass, which gradually uniting together into larger Globules, disperse themselves equally round the Vessel, fix themselves upon every part of it that the Wine reaches to, and thus by degrees incrustate over its whole Surface with a kind of stony Matter, called, for this reason, very properly, by the *Germans*, Wine-stone; by the *Chemists*, Tartar. This is always of an acid taste, and produced only from Wine, when it has been fermented, and depurated. Betwixt this and the Lees, now, there is a great deal of difference; for this, in particular, hardens into the form of a Stone, that always continues liquid; this fixes to the upper, lower, and, in short, every part of the Vessel; that entirely falls to the bottom. This Tartar, now, according to the sort of Wine from which it is generated, is red, grey, white, more or less pure, and more or less acid. Acid, rough Wines yield a greater quantity of it; the softer and sweeter, a less. If this Salt is put into a clean glass Vessel, and with a sand heat very gradually and cautiously urged, it gives a *Spiritus Sylvestris*, that disperses itself about, and is not to be confined; then other Spirits but a little acid; afterwards pinguious and thicker; and last of all an Oil, that is the most penetrating of any we know of.

A fixed Al-
kali from
Wine.

When

Prepared by
simple distil-
lation.

When these, now, are all drawn off, there then remains a very black Mass at the bottom of the Retort, which is perfectly alkaline, and exceedingly acrid; and this is the only method that I am acquainted with of producing a fixed, alkaline, acrid, vegetable Alkali in a close Vessel; for all other vegetable substances whatever, being exposed to the strongest distillation in a Retort, produce, indeed, a black Coal, but never, to my knowledge, afford an alkaline Salt, till this Coal is afterwards burnt in an open Fire. But if you then take out this black, alkaline, tartareous Coal, and burn it, you will have a white, alkaline Salt, the most acrid and purest of all the fixed Alkali's. By this surprizing Experiment, then, we evidently see, how much fermentation promotes the production of an Alkali, though at the same time it always heightens, nay, and seems almost to generate an Acid. Both Alkali's and Acids, therefore, are more readily produced by the assistance of fermentation, than without it; which observation, certainly, is of very great consequence, though you will scarcely find it taken notice of.

All Alkali's, however, from whatever vegetable, or in what manner soever produced, when by the strongest Fire they are at last brought to their greatest alkaline perfection, become so perfectly of the same nature, that they can scarcely be distinguished from one another. There is one, indeed, but a very trifling circumstance, wherein they differ, observed in making Glafs, and that is, that Glafs made with the very same Flints, but different, fixed Alkali's, shall often have some diversity in their colour, so that that which is prepar'd with the Alkali of Flints, shall be different from that made with any other. But it is very well known, how small a matter will make a very considerable alteration in the colour of Glafs; as even pounding the Salt in a metal or marble Mortar, will produce a difference. Hence I have sometimes been ready to doubt, whether some metalline Matter might not possibly insinuate itself into Vegetables, and being naturally fixed in the Fire, leave something in their fixed Salt, that might afterwards discover itself in the Glafs. Iron, it is certain, insinuates itself into many Bodies; and, perhaps, it may not be so intirely repugnant to the nature of Copper to do the same.

A fixed Al-
kali from
Nitre.

But the Chemists have discovered another particular method of producing a true fixed Alkali, which we have accurately described by *Glauber*, as follows. Take some pure Nitre in a clean Vessel, flux it till it runs like Water; and it will then scarcely have any visible motion. When it is in this condition, throw a little bit of live Coal into it, and in an instant it will produce a great noise, run about upon the Surface of the Nitre, consume, and then the Nitre will flow quietly again, as before. When every thing is still, throw a bit more in, and you will have the very same *Phænomena*. Repeat this Operation till the Nitre makes no more noise, or is set on Fire by the Coal, and then all that remains will, in every sensible, physical, and chemical property, be a fixed, alkaline Salt; for it has a caustic acrimony; it causes a urinous taste in the Mouth; it raises an ebullition with all known Acids; if it is saturated with Acids, it is converted into a compound Salt, whose nature is determined by the Acid it is mixed with; it has the same effect in changing of Colours, with the preceding Alkali's; the very same precipitations are likewise produced by it; and in the solution of certain Bodies, it discovers

discovers a perfectly similar, not to say the very same efficacy. In this Salt, however, there is yet constantly observed some difference from the former, as it always retains something of Nitre that is not perfectly changed from its pristine Nature. This, indeed, don't commonly discover itself till you pour some of the best Oil of Vitriol upon it; but then there immediately rises a Vapour, which by its smell of Spirit of Nitre, or *Aqua Fortis*, demonstrates, that there is still something remaining in the alkaline Mass, which, by the action of the Oil of Vitriol, rises from the Nitre itself. Nay, and even the Oil of Vitriol, too, generally grows black when it is mixed with *Glauber's* Alkali, whence it appears, that there is still left likewise some of the Coal, which was thrown in and consumed. *Glauber*, therefore, was certainly in the right, in believing this Alkali of Nitre to be in some measure different from other vegetable Alkali's; but when he extols its virtues so highly above all others, it's possible he was a little too fond of his own discovery.

But a third, and the most expeditious way of producing Alkali's in a short time, and great quantity, is as follows. Take of the best and driest Tartar, and Nitre reduced to a fine powder, an equal quantity, mix them together, and throw them, a little at a time, into a clean iron Ladle, made almost red hot, and there will be excited, as we shew'd you before, a momentaneous deflagration, and there will be immediately produced a white, alkaline, fixed Salt. This, too, is like a vegetable Alkali in every mark; but still it has the same peculiarity as the former. For here if you go to make vitriolated Tartar from it, there immediately arises a smell of *Aqua Fortis*, and the Matter turns blackish; a certain sign that there is something of Nitre remaining, in this case, as well as the former. See the egregious *Hoffman. Observ. Phys. Chem.* p. 241.

The same
from Tartar
and Nitre.

And lastly, there is another, and a pretty singular manner, too, of preparing a fixed, igneous Alkali, in a moment, almost, from Nitre, and is as follows. After the Sulphur is separated from Antimony, almost as clear as is possible, there remains the pure metalline part, which is called *Regulus*. Take this shining Substance, put it into a clean Crucible, melt it in the Fire, and when it is perfectly in fusion, add an eighth part of the purest, driest Nitre. You'll then be surprized to find, that this Nitre, which used to flow so easily in a strong Fire, cannot now be brought to flux, without the application of such an intense Heat, as is necessary for the fusing of Copper. But you'll here perceive, likewise, something more extraordinary, and that is, that when it is urged with such a degree of Fire as will melt it, it immediately acquires a golden colour, and when the whole is poured out into a melting Cone, it rises to the top, and appears like a golden Cake. This, now, if it is separated by striking the Cone, is vastly impatient of driness, and is of so acrid, alkaline a nature, that it is perfectly igneous in almost every effect: Nor has the greatest Masters in the Art ever found out any method by which one may communicate to Salt so great a degree of Acrimony. And here we may observe, that Nitre, which is the coldest of all Salts, and has not the least mark of any Alkali in it, when it is thus fused with the metalline part of Antimony, acquires this Acrimony, purely, as it were, by contact. It is credible, now, in this case, that the Sulphur of the Antimony is, by this means very intimately united with the

Lastly, by
contact with
Antimony.

Nitre;

Nitre; for if you take the Salt, thus produced, whilst it is exceeding dry, and hot, and throw it into very pure Alcohol, this presently extracts a very red Tincture from it, whose caustic quality is so great, that it can scarcely be born. This sudden alteration, now, I have observed equally to happen, whether the *Regulus* is made with Iron, according to *Suchtenius's* method, or with Tartar and Nitre, in the common one. But this will not be effected so long as the external Sulphur adheres to it, the Experiment then only succeeding, when this part being separated, the remaining reguline part is perfectly fus'd with the Nitre. The quick change, now, that is here brought about, which we meet with no where else, is so much the more surprizing, as Nitre with Sulphur never becomes alcalious, but is converted into a bitter *Sal-Polybreft*. And what still makes it more extraordinary is, that Nitre, if it is kept a vast while in fusion by itself, will remain the same without any alteration. Nor will Nitre, as we mentioned before, produce an alkaline Salt with Antimony, so long as it retains its Sulphur; though when that is removed, it will with the *Regulus* generate it by simple fusion. Hence, therefore, from the combination of Bodies together in a certain manner, we see what sudden and unknown effects may be produced, which it was not possible to have foreseen; and hence again we infer how likely we are to fall into errors, if we proceed too hastily upon general Principles. But once more, we here observe farther, how easily Nitre grows alcalious through its whole substance, *viz.* as it were, by mere contact; in as much as it is not mixed with the melted Antimony, but precisely flows at the top of it, being perfectly expelled from it. And lastly, we may take notice, that this Salt, which is fluxed by itself so very readily, in an instant, is so altered in its nature, that it becomes the most difficult to flux of any we are acquainted with. Thus then, Gentlemen, I have laid before you all I have been able to discover in any Authors, concerning the origin of fixed Alkali's, and the division of them into proper classes, founded upon it, to which I have likewise added some of their vertues.

The efficacy
of a fixed
Alkali.

The order of our subject leads us now to examine into all those physical operations which these Salts are observed to perform. And that I may do this the most to advantage, give me leave to take notice to you once more, that though from the vast number of Vegetables that are perpetually burning, Nature is constantly employed in generating fixed Alkali's; yet, notwithstanding the infinite quantity that is thus produced, there is not the least appearance of them any where to be found in the Earth; whence it follows, that these Salts must either perish, or be continually changed in their nature. In perfect fixed Alkali's, then, upon examination, the following properties appear to belong in common.

First attracts
Water.

1. They attract Water very powerfully, to a great distance, and from every known Body in which it resides. This is plain from ocular demonstration; for when such an Alkali is taken out of a strong Fire, if it is suffered to remain in a very hot Air, just by the Fire, where we can by no other art discover the least sign of Water, it will even there grow moist, and dissolve: And if it is then put into a clean, dry, glass Vessel, and dried over the Fire, and the Vapour that exhales, is catched, and condensed in an Alembic, it will yield again the pure Water which the Alkali had drawn into it.

Other

Other Salts, now, if they had been moist before, would have been deprived of their Water in the very same place, where the dry Alkali attracted a moisture. These Alkali's, therefore, are true magnets to Water; this they dissolve, and unite with them; by this they are dissolved and strongly united with it; and hence, when they are once dissolved in Water, a Heat as great as that of boiling Water won't perfectly dry them again.

Take, for instance, Oil of Tartar *per Deliquium*, put a mercurial Thermometer into the Vessel with it, and expose it to a Heat of 214 degrees, and you will find the Salt will not be dried. Nay, if you have a mind to effect this, you must put it into a metal Vessel, and keep it continually stirring in a Heat of more than six hundred: Hence, we scarcely know any Body that parts with its Water with more difficulty. I had a mind, now, to inquire into the power by which an Alkali thus attracts Water, the quantity which it takes in, and the space through which this power is capable of exerting itself.

To this purpose, then, I took an ounce of a fixed Alkali, exceeding pure and dry, and putting it in a clean glass Bason, exposed it to a dry Air, in a subterraneous place, that was every way inclosed, nor in the least disturbed by any Wind; and I found, in a little time, that the Water was attracted out of this still Air, to the broad surface of the Salt, and it continued to be so, till the Salt had drawn in near three ounces of Water, but being then thoroughly saturated, it did not imbibe any more. Hence, then, I learned evidently, that this quantity of Water, which was thus attracted to the surface of the Salt, required at least six cubic feet of Air to supply it: For if we suppose the weight of Air to be to that of Water, as 1 to 1000, and a cubic foot of Water to weigh 64 pounds, then all the heavy Bodies in a cubic foot of Air will weigh $\frac{64}{1000}$ of a pound. Let us imagine, now, only half of these heavy Corpuscles to be pure Water, the other half, all the rest of the Bodies that are contained in the Air, and then it appears, that in a cubic foot of Air there will be about half an ounce of Water. If this Salt, therefore, is capable of attracting this Water from so great a space, we discover a new and very surprizing power in Nature. Hence *Sendivogius* said, very justly, the more Alkali's are burnt, the more Water these calcin'd Bodies attract out of the Air. If you are rather of opinion, however, that in this case the Water which is in the Air at a distance, comes into that Air which is nearest to the Salt, and so is exhausted of its Water, I will not contend with you; but this, in the mean time, I am certain of, that the Air, where the experiment was made, and from which the Water was separated, was exceeding still.

But to come at the same thing still more exactly, I took a large glass Bottle, very clean, hot, and dry, and into this I put some pure Salt of Tartar, very hot and dry, likewise, and reduced to Powder in the manner above described. I then presently stoppt the Mouth of the Bottle with a dry Cork, and covered it over with a Hog's Bladder, well rubb'd with Oil, and made very supple, which I tied over it; and I afterwards found, that the Salt, which adhered to the side of the Glass, was grown moist with the Water contained in that small quantity of Air that was included with it, tho' the Air was hot and dry, at the time that the Bottle was closed.

M m m

2. But

Retains it
very strong-
ly.Draws it
from a great
distance.And very
efficacious.

Secondly,
repels Air.

2. But with respect to Air, now, Alkali's seem to have a quite contrary power; for as they attract Water, so they seem to repel pure elastic elementary Air. Indeed one would be apt to think otherwise: For if a fix'd alkaline Salt, when it is perfectly red hot, nay, in fusion, is poured into an iron plate, it will soon attract some Water into it; and as this Water is drawn out of the Air, one would imagine, it should attract the Air along with it, especially, as it formerly appeared, that when Water is by any means deprived of its Air, it always spontaneously takes in more. Nay, and for this reason it would farther seem probable too, that the Salt should attract Air into it, viz. that all the Air that was in it before must have been expell'd by the intenseness of the Fire in which it was melted. On these accounts a person would be apt to infer, that a great deal of Air must be drawn into, and lie concealed in these Salts; and yet if you examine Oil of Tartar *per Deliquium* at the Air-pump; it does not give any indication of Air's coming out, nay, even though you make it hot. Hence, therefore, again every body would conclude, that these Alkali's do not only repel Air, but that they likewise even expel that which is lodged in the Water; and hence, that there is in these Salts a power of repelling Air, and driving it from among them.

Or, perhaps,
attract it ex-
ceeding
strongly.

But you may remember, Gentlemen, that whilst this point was before under examination, we brought it to this conclusion, that it was almost probable, that Alkali's attract Air into them exceeding strongly, and so closely unite it with them, that they do not let it go again, until it is forced from them, by a strong Fire, or being put into an effervescence. *Vide* p. 303, 310. Upon a careful consideration, therefore, of these opposite appearances, I am in a doubt, whether, under this second property of Alkali's, I should conclude, that they perfectly repel Air; or that they unite it so intimately with them, that scarce any Body attracts it more strongly, or fixes it more closely. One of these two must certainly be the case; which of them is so, I dare not assert. Thus you see the extraordinary issue of so many Experiments, performed in a proper manner, viz. a fluctuation between two opinions, that are diametrically opposite to one another. This, however, is the nature of true Philosophy, nor can we any other ways come at a right knowledge of it. These uncertainties, in the mean time, have this evident advantage, that they put others upon farther inquiries.

Do not repel
Alcohol.

These pure, acrid, fixed Alkali's, if they are mixed with the choicest Alcohol, when they come first out of the Fire, attract it into them, and unite it with them; but if there is the least mixture of Water in it, then the Water is immediately attracted, and the Alcohol repelled; nor can they afterwards be united, by any method whatsoever. Nor can this union be effected, if the Alcohol is pure; but there is Water in the Salt. In this manner, therefore, pure Alkali's elegantly divide strong Spirit of Wine into two parts, that are not miscible with one another, viz. into a Water saturated with the Alkali, and into a pure Alcohol swimming at top. And thus, again, plainly appears the reciprocal attractive force betwixt the Water and the Alkali. For take a pint of the purest Alcohol, put into it but a very small quantity of Water, and then throw in such a dry, alkaline Salt, and the Alkali will in an instant draw into it that little portion of Water, upon which there will appear a kind

of

of tenacious Oil about the sides of the Glass, and at the same time, the combination of the Alcohol, and Water, will be perfectly prevented. Hence then we see evidently, how many, and what singular, physical operations may be performed by means of fixed Alkali's, when they act upon those Fluids that are prepared by fermentation, considering them as acting, either by an attraction or repulsion of the Alcohol, or by an attraction of the Water alone. Nay, and these Alkali's act upon these Liquors yet in another respect: For as every Spirit drawn by Fire from any sort of Wine has always a volatile Acid intermixed with it, hence the Acid being greedily attracted by the Alkali, the Spirit by this means becomes much more pure, as it is now freed from its inherent Acids, and consequently will be very different both in its nature and vertues, from what it was before this Operation. And the Alkali itself, likewise, will at the same time be intirely altered, will become a compound of an Acid and Alkali, and if it is perfectly saturated in this manner, will produce *Sennertus's Sal Purgans de Tartaro*. To this Observation, lastly, we are indebted for a preparation of pure Alcohol, without distillation, or any assistance of Fire: For mix only a sufficient quantity of Pot-ashes with common Spirit of Wine, and stir them about till they are thoroughly mixed together, and the Water will run into the Alkali, and the Alcohol will swim at top, which, by a gentle decantation, will come off good the first time. If you doubt, however, whether it is quite pure or no, only put some more Ashes into the Alcohol thus prepared, and by stirring them about, and then pouring the Liquor off, you may easily make it so. In this Operation, however, the Spirit of Wine always discovers a pinguious Oil, which before appeared neither in the Spirit of Wine, nor the Alkali, but is then only generated when they are thus mixed together.

In the fourth place, the power of these Alkali's manifests itself particularly upon distilled vegetable Oils. For if the most acrid, pure, dry Alkali is thrown very hot into a distilled Oil, it attracts it violently into itself, with a mighty hissing noise, and unites it so well with its Substance, that there is immediately produced a kind of Soap, which is still combined more closely, and brought to greater perfection by this mixture's being set in a subterraneous place; for by this means both of them become semi-volatile and form a Mass dissoluble in Water, which is endued with excellent medicinal vertues, and is the *Ens parvum Sapientum*, the *Sapo Helmontianus*, the *Sal-Volatile Tartari Starkeianum*, and the *Corrector Mattbei*. This sort of Medicine was very famous, first in *England*, and afterwards all over *Europe*: For it powerfully softens and resolves almost every kind of viscid concretion that is generated from the humours of the human Body: Hence it incides and attenuates the *Saburra* that clogs up the Vessels, and at the same time it gently stimulates the Vessels themselves, and makes them act with a moderate *impetus*, and thus in both ways proves an aperient, and by Perspiration, Sweat, and Urine, carries off the Matter of the most stubborn chronical diseases. If it is digested too with simple Substances, it alters them, and quite changes their natural disposition, and by this means subdues the virulent efficacy of many of them, and imbues them with new vertues. Its medicinal power, however, as a universal medicine, which is the common fault of Chemists, has been too much extoll'd. But here let me caution you, that this combination can never

Attract distilled Oils.

be effected, if there is the least Water, either in the Alcohol or Oil, and consequently, never by cold Salts. Nor will it succeed, if but a small portion of the alkaline Salt stands above the Oil, and thus, by coming to the Air, grows ever so little moist.

And expref-
sed ones.

Alkali's are easily united likewise with the exprefs'd Oils of Vegetables, or even Animals, as is commonly seen in boiling them into artificial Soap by the assistance of quick Lime, Water, and Fire. And the Substance thus produced is wonderfully efficacious in a great many things, which wou'd otherwise be performed with a great deal of difficulty: But the chief of these are mention'd already under the former head.

And Acids
likewise.

But alkaline Salts, in a particular manner, attract all kind of Acids whatever, whether produced in the Animal, Vegetable, or Fossil Kingdom, and that, whether dry or moist, pure or diluted. And this power of Alkali's, by which they thus attract Acids, is vastly greater than the same with respect to Water: For in this action, by which they unite these Acids with themselves, they violently expel the Air that resides in the Salts, whence arise such numbers of Air-bubbles, which suddenly appear, and then burst asunder. Nay, and by this very combination, they even repel Water itself from them pretty considerable; and when they are thus saturated, they will easily suffer themselves to be dried, or deprived of their Water, which before, when they were separated, they retained very tenaciously. Pure acid Oil of Vitriol, for instance, when it is alone, you can scarcely, by any Art, free from its Water; Oil of Tartar not without a great deal of difficulty: And yet when you mix them together, the Water is expelled in such a manner, that a Salt almost dry appears in the Vessel under it; as is evident in the Preparation of *Tartarus Vitriolatus*. The same is true of other Acids likewise, when they are combined with an Alkali: And from this consideration, many abstruse things in the Doctrine of *Menstruums* may be easily understood. But this Power, by which Alkali's thus attract Acids, is limited and confined within certain bounds; and hence there appears a vast diversity among them, tho' this, indeed, is more owing to a difference in the Acids than in the Alkali's. This affair, the knowledge of which is exceeding useful, the egregious *Homburg* has very happily explained, as indeed he has every thing else he has attempted, in the *Mem. de l'Ac. Roy. des Sc. T. I. p. 52*. A few of the Observations, therefore, which he has there given us, with your leave, I will here lay before you. One ounce of Salt of Tartar, absorbed all the Acid from 14 ounces of the best distilled Vinegar; and hence, after it was dried, it was increased in its weight 3 drachms, 36 grains; the remaining part of the Vinegar being mere insipid Water. By this means, then, we discover the proportion there is between the Acid, and the Water of the Vinegar. From Spirit of Salt, the same absorbed 2 ounces 5 drachms; and hence became 3 drachms, 14 grains heavier. From Spirit of Nitre, 1 ounce, 2 drachms, 36 grains; its weight being thereby increased 3 drachms, 10 grains. From *Aqua Fortis*, it took up 1 ounce, 2 drachms, 30 grains; gaining hence 3 drachms, 6 grains, in its weight. From Oil of Vitriol, 5 drachms; the increase of its weight, 3 drachms, 5 grains. As these, therefore, are the principal Acids, we may easily infer in the first place, that Acids, tho' very different in their specific Gravity, when they have saturated an Alkali, are observed to have the same weight; for Vinegar, which is the lightest Acid

of

of all these, increased the weight of the same Salt of Tartar, as much as the Oil of Vitriol, which is the heaviest, and most pure: The same too is true of the rest, the difference between the greatest and least increase of weight, being no more than 31 grains, and that only in Vinegar, arising from the *Tartarus Regeneratus*'s being dried with a vast deal of difficulty. 2. Hence, therefore, Acids seem to differ chiefly in the quantity of Water they are diluted with, since the pure Acid, when it is extracted, discovers always the same weight. If 14 ounces, therefore, of the strongest Vinegar, cou'd by any contrivance be reduced into 5 drachms of Acid, by separating the Water from it, and collecting together the Acid without making any alteration in it, wou'd then this collected Acid be as strong as Oil of Vitriol? This is certain, it wou'd be then capable of saturating the same quantity of Alkali. 3. We hence see, Thirdly, how great a part of these Acids is Water; and that, therefore, it is probable, Fourthly, that if these acid Salts could be obtained pure without any Water at all, they would then appear in a solid form. This, however, has never yet been accomplished: Very intense Cold has come nearest it of any thing, but not quite completed it. Hence likewise we may conceive what surprizing effects alkaline *Menstruums* may produce, when they act upon Solvents that have any latent Acid in them; or upon those that are actually consolidated, and held together by an Acid, and hence when this Acid is absorbed, fall again into their constituent Elements. How great an Effervescence is by this means excited? What a production of light Bubbles, that presently mount up, and are continually bursting, and by this means cause a hissing noise, and generate a very elastic Air! But all these sudden effects cannot be understood without a right notion of the Doctrine of Alkali's. But I must here take notice, however, that when this affusion of an Acid to an Alkali is performed gradually and cautiously in warm Liquors, and in a large Vessel, and if at the same time the Vessel is shook after every instillation of the Acid; then you will come at last to that temperament in which there will be no farther Ebullition: And this is called the point of Saturation. If you afterwards proceed to pour on the Acid, there will be no more agitation excited, then there is upon mixing Water with Water: And then the Compound thus produced, is neither Alkali nor Acid, but a neutral one concentered of both, which acquires its name from the Acid that saturated the Alkali. Hence the Acids have been called Males, and the Alkali's Females, and the Compound of them both, Hermaphrodites: The Alkali, the *Vacuum*; the Acid, the *Implent*: The Alkali the Chaos, and the Acid the impregnating Spirit. This extraordinary Ebullition and Effervescence, now, that arises between the Alkali and the Acid from the violent expulse of the Air and Water, may be owing possibly to these Bodies impetuously driving out whatever lies between them, when they rush strongly into mutual contact: And then this wou'd not arise from any disagreement, but an association of Principles. Will you hence, therefore, be induced to believe, that Acids abound plentifully with Air, but that Alkali's are without it? Certainly, the strongest Alkali, taken very hot out of the Fire, and hence probably deprived of all its Air, will, if it is thrown into an Acid, produce a prodigious Effervescence. Is this the reason then, that Acids, when they are predominant in Animals, are so very flatulent? Do the Salts produced from a combination of Alkali's and Acids, lose the greatest part of their

Air, and are they hence found to be so little flatulent in the human Body? Are for the same reason, Acids alone, or at least acescent Bodies, disposed to ferment? And does there hence, in fermentation, arise such a tumultuous Air? Does fermentation hence naturally tend to the generation of Acids; Fire, when it burns openly to the production of Alkali's? And does hence Fermentation, the Parent of Acids, perform its work with a small degree of Heat, whilst a greater is necessary to dispose Animals by putrefaction to become alcalious? But to proceed: We farther observe then, that when these Salts are once perfectly saturated, they continue afterwards at rest, nor generate any new motion, tho' you persist in pouring upon them either Acids or Alkali's. Among the natural causes, therefore, by which motions are excited in the Universe that did not appear before, we must reckon Alkali's and Acids, at the time when these are mixed pure together, which cease again, as soon as ever this combination is compleat. Nor can we at all doubt, but that in the action of these alkaline *Menstruums* upon Acids, the Water is expelled out of them as well as the Air, when they thus unite together; for tho' they are perfectly fluid when they are mixed, yet they harden in the very act of combination into little saline Globules, and appear in the Water in the form of pellucid Chrystals, the watery Liquid being driven out, and swimming at top. Nay, and when the Saturation is quite perfect, the Water may be drawn away pure, and without any saline Taste, which being all separated, the remainder is converted into a white, mealy, opaque, dry Powder. These compound Salts too, are easily dried with a gentle Fire; whereas the simple Alkali's and Acids, by whose combination they are produced, either cannot be dried at all, or not without the greatest difficulty. And again, tho' these compound Salts thus prepared, part with their Water easily; yet it is vastly difficult, by the assistance of Fire alone, to separate either the alkaline or acid Salts, so as to procure them quite pure. If any one, for instance, has thus made a *Sal-Ammoniac*, from an alkaline Spirit of *Sal-Ammoniac*, and Spirit of Sea-Salt, he may, indeed, sublime it, by exposing it to the Fire, but he will not thus be able to separate it into the saline Principles of which it was compounded. The same likewise is true of *Tartarus Vitriolatus*, *Sal Marinus Regeneratus*, *Nitrum Resuscitatum*, *Tartarus Regeneratus*, and others. There are, however, some methods found out, by which one may obtain this resolution of compound Salts, into their constituent alkaline and acid saline Principles; and the knowledge of these will lead us into some of the most secret Arts of Chemistry. In order, therefore, to get a proper insight into those, let us proceed to examine some farther properties of Alkali's.

The attraction
of Acids
by Alkali's
various.

Alkali's, therefore, attract all known Acids; tho' at the same time we must take notice, that they attract some much more powerfully than others. This assertion is abundantly confirmed by Experiments. If to an Alkali perfectly saturated with Vinegar, or *Tartarus Regeneratus*, you pour Spirit of Nitre, or Sulphur, or Vitriol, then the latent Alkali will attract into it that Acid, and repel from it the acid of the Vinegar with which it was before saturated; and hence a Liquor, which will be nearly Spirit of Vinegar, may be afterwards drawn from this Compound with a moderate Heat, there remaining a considerably fixed, regenerated nitrous Salt at the bottom of the Vessel: and if you put to it Spirit of Salt, Sulphur, or Vitriol, the Alkali will in the same manner

ner attract them, and let go the Acid of the Vinegar. Again, if you take an Alkali rightly saturated with Spirit of Nitre, and mix it with Spirit of Sea-Salt, there will arise in distillation an *Aqua Regia*, and a nitrous Salt will be left at the bottom, but changed from its former nature. And if upon an Alkali perfectly saturated with Spirit of Salt so that it is become Salt, you pour Spirit of Nitre, the Compound, by distillation, will yield an *Aqua Regia* likewise, and the Salt that remains at the bottom will be of a nitrous kind, containing an inflammable matter that will make it deflagrate, but yet will be somewhat different in its nature, both from the Salt and the Nitre. In these two cases, therefore, as between the acid of the Nitre, and that of the Salt, there is no such great difference with respect to their acid quality, each of these Acids seems in some measure to have dislodged and driven out the other, by which means they both rise mixed together, and both of them likewise, with the Alkali for their *Basis*, help to make up the *residuum*. If you take an Alkali saturated with Spirit of Nitre, and pour upon it Oil of Vitriol, a pure Spirit of Nitre is immediately expelled, and the acid of the Vitriol continues united with the alkaline part of the Nitre, and makes a Salt at the bottom, which has in some measure the nature of *Tartarus Vitriolatus*, tho' it differs from it in some of its qualities; but it has scarcely any thing in common with Nitre. And lastly, if upon factitious or natural Sea-Salt, you pour Oil of Vitriol, there presently fumes up a very volatile acid Spirit of Sea-Salt, that possesses almost all the known virtues of it, except that it fumes more, is more volatile, and its Vapour is of a suffocating nature, till it is corrected by a repeated depuration. All these Experiments, therefore, certainly evince, that those Acids, which are naturally contained in a less quantity of Water, have a power of uniting themselves with Alkali's, superior to that of those, which are naturally diluted with a greater. And this Rule, as far as I know, holds true, and may be laid down universally, that stronger Acids always expel from their residence in Alkali's, those Acids which less powerfully adhere to them. And then, Secondly, these stronger Acids always unite themselves with that Alkali from which the weaker Acid was expelled, and take possession of the place in which that was seated before. Thirdly, the Salt thus regenerated, losing the disposition it had from the first Acid, which is now removed, puts on very nearly the nature of that Salt, from which was drawn the last Acid which is now united with the Alkaline part. In the Fourth place, however, it must be confess'd, that betwixt the Salts thus produced, and those native Salts from which those Acids were drawn, there is always some pretty remarkable difference. Thus, for instance, the *Sal Mirabilis Glauberi*, which is prepared by distillation of Sea-Salt, with the best Oil of Vitriol, is of a very different nature from that which is obtained from Oil of Vitriol, and Oil of Tartar combined together into *Tartarus Vitriolatus*: Which is likewise observed in others. And again, the Salt which is procured by distilling Glauber's Spirit of Nitre, is quite another thing from his *Sal Mirabilis*, tho' both these are supposed to be produced from the same Acid and Alkali. This rule, therefore, which has been laid down by the most famous Chemists, *That Acids always convert Alkali's into their nature in such a manner, that from these Compounds may be constantly regenerated those Salts, which before yielded those Acids*, is too general, and must be understood with some restriction. In the Fifth place, I observe farther, that when these Acids thus poured

upon

upon compound Salt, expel thence the Acids that were united with them before, and unite themselves with the remaining Alkali's, this new combination is effected without any considerable Effervescence: For the first Acid quits its place, and the last succeeds it without much conflict, notwithstanding there arises such a prodigious ebullition, when a pure Alkali is mixed with a pure Acid. Nor does it appear, that any Air is generated by this adunation, tho' in the other case it was expelled in so large a quantity. Does this happen, then, because the Effervescence that was excited in the preceding Saturation, had expelled all the Air, so that now the new Acid does nothing more than enter into the saturated Alkali thus deprived of its Air, and remains there without either expelling any Air, or attracting any? This certainly seems confirmed by this Observation, that if that second Acid is expelled by a stronger Acid, and is then mixed with another Alkali, it will with that raise as violent an Effervescence as the first did; so that in this Operation there shall be produced again the same Heat, Noise, and Air, whilst in the compound Salt there was scarcely any such appearance. Hence then we understand, the wonderful *Metempsychosis* and *Palingenesis* of these acid Salts: By these many philosophical arts may be invented and cultivated: By these, many unheard of changes may be brought about in natural Bodies, of which there are at present no instances, nor any known Instruments, and of which, consequently, no account can be given from any other principles which mankind has hitherto been acquainted with. These things, Gentlemen, it was absolutely necessary to lay clearly before you, whilst we had Alkali's under consideration as solvent *Menstruums*; for in the application of these to various Bodies, you will meet with an infinite number of *Phænomena*, which without the knowledge of this Doctrine, you could not possibly account for.

Problems
hence raised.

There are some other things, likewise, which occur upon this head, that one would be still farther induced to suspect, but which require, however, a more mature inquiry, before they can be admitted as certain: These, therefore, with your leave, I will here add by way of Problems? Do all fixed Alkali's owe their origin to Fire only, as their generating cause? Do all volatile Alkali's depend alone for their production, on a degree of Heat that is necessary to putrefaction? Is it possible in nature, that a fixed, or a volatile Alkali, if exposed to the open Air, can long continue an Alkali? Or will they, by every where meeting with an Acid, or an oily Substance, be converted into a neutral Salt, or a *Sapo*? Does not the same thing happen to them likewise in Vegetables, and in the Bodies of Animals? Is there not by this means continually produced a very large quantity of compound Salts, and of those in particular which will arise from an Alkali, and that Salt whose acid is every where distributed? As natural Acids, therefore, or those which are generated from Vegetables by Fermentation, are always, and every where present, does it not hence happen, that this compound Salt is most frequently of the nature of *Tartarus Regeneratus*, or of that of the *Spiritus Ophthalmicus Mindereri*, which arises from the combination of a pure volatile alkaline Salt, with distilled Spirit of Vinegar, which is not acrid, but vastly penetrating and active, tho' at the same time not endued with much Taste. But amongst all these things, there is nothing, that for very weighty reasons, deserves more to be examined into, than the origin and nature of those Salts, which on account of their commonness and use we
are

are the most acquainted with of any, viz. Fountain-Salt, *Sal-Gem*, Sea-Salt, and Nitre. Concerning these, we would particularly inquire, whether they are produced by a combination of the Acid, into which they may be chemically resolved, with a fixed vegetable Alkali? Or whether, on the contrary, they are simple Bodies, just as nature has generated them, and by the action of the Fire are rather changed in their disposition, than separated into their proper constituent parts? The Chemists, certainly, especially after *Franciscus Trava-ginus* of *Venice*, and the famous *Otto Tachenius*, had published their Writings of Alkali's and Acids, have been of Opinion, that all these Salts were in reality originally compounded of an Alkali and an Acid that were before in being, and that they then first appeared in the Universe. After a good deal of consideration of this matter, however, it appears very probable to me, that the Salt in the Sea did actually exist before there was any the least sign of the acid Spirit of this Salt, or any fixed Alkali from burnt Vegetables to be found in the World. Nay, from Sea-Salt, no Mortal has been ever able by any Experiment whatever, to procure one Grain of a fixed Alkali. This, I myself, have sufficiently experienced. Take any quantity of the purest, driest Sea-Salt, and by long rubbing, mix it intimately with three times as much very dry common Bole: Urge it then in a very strong Fire in what manner you please, and it will yield but a certain proportion of acid Spirit of Salt; nor can you procure any more from it, tho' you increase your Fire to ever so great a degree. At the bottom of the Vessel, then, there will always remain the Bole, which will still continue Salt. Take this, and with Water wash out all the Salt, then filter it carefully, and form it into Chrystals; and what will you by this means be able to procure? For my own part, I can say, I never found any thing of an Alkali in it, but that it always still remained Sea-Salt. Besides, as far as I have been able to inform myself, no Person living has ever discovered any such thing as an acid Spirit of Nitre, or Sea-Salt, but what was produced by Art or Fire, from these pre-existent Salts: And when this is the case, it seems much rather to arise from a real change, than a proper separation of the concurrent parts. I confess, indeed, that these Acids, when they are poured upon alcalious Salts according to art, do produce regenerated Salts, which seem to come as near as possible to those Salts from which the Acids were drawn: But yet, still there is always some difference betwixt these regenerated Salts, and the native ones. These things, then, being rightly considered, make it plain, that we can't be so certain about the composition, and resolution of these Salts, as those Gentlemen wou'd persuade us. In the mean time, you observe, how cautiously we should look about us, when we make use of Alkali's in the solution of Bodies: For by the accession of something else to them, these Alkali's may be immediately changed into another Salt, and act no longer by that simple alkaline vertue, which it had when it was applied, but according to the disposition of the new Salt that is thus produced. But enough of this: Let us therefore proceed to something else.

In the seventh place, then, there is this very considerable in fix'd Alkali's, that when they are apply'd to certain Bodies that we wou'd have perfectly dissolved, they seem, indeed, at first to effect this, but are presently converted into Masses that are scarcely to be dissolved by any *Menstruums*, and which are in their nature

A fixed Al-
kali produces
Glaſs.

nature as far different from *Menstruums* as any thing can be. If, for instance, a hundred parts of pure Sand, or calcined Flints are reduced to a fine Powder like Flower, and then intimately mixed with a hundred and fifteen parts of a pure fixed alkaline Salt powdered likewise very fine; and this Mixture is then exposed to a moderate Fire in a Glass-house arch for the space of an hour, and kept constantly stirring, and afterwards, keeping it still continually stirring, to a stronger Fire for five hours more; you will by this means prepare a matter, which will have the dispositions necessary for making the choicest Glass. But if this, however, is then put up into a good dry Cask, and set in a dry warm place for four or more months, the combination of the Alkali and the Flints will be still farther perfected: If this Matter, then, thus prepared, is put into the Glass-house Pots, and exposed to the intense Heat of the Furnace, it will melt into a thick, tenacious, pinguious kind of a Liquid; and whilst it is boiling there, it will cast up a Scum to the Surface, which continually increasing more and more, rises often to a fourth part of the whole Mass. When this Scum now is carefully removed, till there appears no more of it, and the pure despumated Matter has been kept two or three days in fusion, what then remains in the Pot, the Workmen call the Metal, which when it comes to harden in the cold, produces the finest Glass. If this now was not evident from common Experience, what mortal living cou'd ever have imagined, that a solvent Alkali, spontaneously dissolving in the Air, cou'd, when it was rendered vastly active by the intenseness of the Fire, be converted with the Solvend into a metalline Mass perhaps, setting aside its want of malleability? This property, therefore, of Alkali's, must by all means be inserted in this account of the power of alkaline *Menstruums*. For here, when the Alkali, by the action of Fire is made to flow like Water, it hence becomes capable of dissolving the Powder of the Flints in the same manner, and by this very means becomes immediately so altered itself, that it retains nothing of its former disposition, but intirely acquires a new one. Hence, then, you see how *Menstruums*, and those very powerful ones too, may be joined in an indissoluble union with those Bodies which they have most intimately dissolved; which concretion is always so much the solidier, as the Solution is more perfect. We learn, therefore, from this Experiment, that Alkali's, whilst they perfectly dissolve other Bodies, are hence sometimes so altered themselves, that they absolutely lose the nature of a Salt; for if there is any substance in Nature, that is intirely different from Salt, Glass, certainly, must by every-body be judged to be such a one; notwithstanding it is near a third part Alkali. And in this Operation, is it not very remarkable, that this alkaline Salt, shou'd, in the very act of Solution, so immediately put off its alkaline Nature, as soon as ever it is converted into Glass? For of all the proper characteristics of an Alkali, there is not so much as one left. It has lost all its Taste: It does not cause an Effervescence with any Acid: It makes no alterations in Colours: It becomes exceeding soft, and perfectly free from any caustic Acrimony: Nay, it is much more fix'd in the Fire when it is turned into Glass, than it was before, when it existed in form of an alkaline Salt. But how very difficult is it now to be put into fusion, as it requires so strong a Fire applied to it for so long a time to make it melt? And which is still more surprizing, as soon as ever it begins to flow, and is converted into Glass, it becomes a tenacious Mass cohering together like
Pitch,

Pitch, and is so ductile, and pliable, that you may form it into whatever shapes you please: Nay, and if you thrust an Iron into it, it will so adhere to it, as to come out of the Melting-pot with it, and be retained upon it. But we still farther observe here with admiration, that from two Bodies exceedingly opaque, concreted into one solid substance, should be formed one so pellucid, that in the best sort of it we find the transparency of pure Water. And lastly, to detain you no longer, we see here a Body produced by solution, and that from a fixed alkaline Salt, which of all Salts is the most soluble, which itself cannot be dissolved by any known *Menstruum* whatsoever. Upon this, neither Water, Spirits, Oils, acid, alcalious, simple, or compound Salts, nay, nor the very *Spiritus Vini Philosophicus*, the *Sales Circulati Philosophorum*, nor even the *Mercurius Philosophorum* has any influence: For the Adepts *bona fide* assure us, that all these *Menstruums* are produced within glass Vessels: Nay, and they unanimously agree, likewise, that all their digestions, distillations, circulations, fixations and solutions of all Bodies whatsoever, they perform with their *Menstruums* in Glass alone. And, which is still more, even the secret Operations of the Alcahest itself, by which they tell us, all Bodies are converted into Water, are brought to perfection in glass Vessels, without their suffering from it any manner of alteration. Do not we, then, hence evidently learn, how difficult it is for a Philosopher to explain the origin of a given natural Body? How vastly hard to assign the Principles of which it was at first compounded, by plainly resolving it into those Principles, in such a manner, as by compounding them again certainly to produce the same kind of Body? If a man was perfectly acquainted with every other part of Natural Philosophy, but know nothing at all of the Art of Glass, what judgment, with all his skill and application, could he make of a piece of Glass that should be given him to examine? Certainly, as far as I am able to judge, he would not find the least indication by which he could possibly suspect that this Substance was concreted in an intense Fire, from an alcalious Salt, and calcin'd Flints? What a task then do the Philosophers undertake, when poorly furnished with Experiments, they dispute about the origin, nature, and principles of natural Chrystals, and even Gems themselves? We had better, certainly, in these cases, confess we are in the dark, than to hope such mighty things from our narrow capacities. For the difficulty of coming rightly at the knowledge of these things does not depend only upon the nature of the concurrent Principles, but also upon that surprizing effect of Fire, by which those very Principles are altered at the time they are coalescing into one Mass.

Having thus, then, examined into the origin and nature of alcalious *Menstruums*, and explained their effects upon various, and, indeed, the principal kinds of Bodies, we must observe, before we proceed, that from what has been said it appears, that more or less of the acid Salt contained in the Vegetables, by burning which the Alkali was produced, may still adhere to it; and, consequently, that this alkaline Salt will be of a different nature from what it would have been, had it been perfectly free from this Acid. And the same must likewise be conceived of the adhering Oil and Earth. Hence, therefore, according to the various proportion of these Principles, the common Alkali's will be very different. Nor for this reason is it at all a wonder, that

Difference of
Alkali's
with regard
to their
purity.

some writers should give us an account of Experiments performed by Alkali's, which, upon being afterwards tried by others, would not succeed; for it is not unlikely, but that the alkaline Salt they made use of was of a different nature.

From other
Bodies added
to them.

But there is likewise a very surprizing caustic, and consuming quality communicated to Alkali's, by mixing them according to art with Quick-Lime, made of burnt Oyſter-shells, or ſtony Sea-plants, but, particularly, of alcalious calcin'd Flints. For by this means ſuch a fiery, acrid, Alkali is produced, as being boiled with them, will ſoften and diſſolve almoſt all the Solids, both of Animals and Vegetables; ſo that here you have the moſt acrid, alkaline Solvent procured from the ſame matter, which, we obſerved before, produced mild, unactive Glaſs, viz. this *Calx* and an Alkali. Nay, and this Alkali, when it is thus rendered more acrid with Quick-Lime, and is dried with a pretty ſtrong Fire, will eaſily melt almoſt the Wax; and hence, if any Bodies are thrown into it, it acts upon, and diſſolves them in a very particular manner. Was this the ſecret which ſome of the ancient Alchemiſts made uſe of, when they tell us they performed ſome very ſingular Operations, by means of an Alkali that melted with a gentle Fire? Might not this poſſibly be their *Sal Tartari inceratus*, ſo called, becauſe, like Wax, it diſſolv'd ſo eaſily in the Fire?

Limits of an
Alkali.

We have now, I think, treated ſufficiently of Alkali's. In the mean time, however, it is neceſſary I ſhould juſt obſerve to you, that Alkali's act with no diſſolving power upon pure Mercury; for compound theſe two Bodies together in whatſoever manner you pleaſe, the Mercury is not found to ſuffer any alteration. And hence, therefore, upon thoſe Metals, which the Adepts tell us are made up of the pureſt Mercury, and an igneous, metallic, ſulphureous, fixed Spirit, with regard to the mercurial part, they are able to effect nothing by way of ſolution. Gold, therefore, and Silver, to the beſt of my knowledge at leaſt, ſuffer no alterations from Alkali's. Upon the other Metals, indeed, an Alkali is found to act with more efficacy; perhaps, becauſe theſe have ſome other Matter united with their mercurial part, which coming near to the nature of an Oil, or a Sulphur, is more expoſed to the action of an alkaline Salt. And as theſe external Sulphurs do not ſuffer themſelves very eaſily to be ſeparated from the metalline Glebe, with which they are concreted, hence it often happens, that whiſt alkaline Salts are acting upon the Sulphur, they ſeem to induce a change, likewise, upon the mercurial part which is cloſely united with it, though, in reality, they don't at all affect the nature of the Mercury. This I learnt evidently in melting common Antimony with Salt of Tartar; for the whole Subſtance, as well the mercurial part of the Antimony, as the ſulphureous, was diſſolved into one brown Maſs, without any *Regulus* ſubſiding. But if you take *Regulus* of Antimony, from which the external Sulphur is firſt ſeparated, and melt it with a fixed Alkali, then the Alkali, when it is in fuſion, ſwimming at top, will extract ſtill ſomething of Sulphur, and by this means tinge the alkaline Salt with a golden colour; and at the ſame time, the reguline, mercurial part of the Antimony which lies under it, will become purer, and of a finer Silver colour. Hence then the power of Alkali's, conſidered as *Menſtruums*, upon Metals, ſeems to be limited; for though you apply them even to calcin'd Metals,

Metals, they don't appear to be able, by the action of Fire, to penetrate into that Sulphur which fixes their Mercury into the form of particular Metals. Certainly, after all the contrivances that have been made use of, the production of a metallic Mercury, by the assistance of fixed Alkali's has not succeeded. Nay, the very greatest Masters of the Art, after so many Experiments made for this purpose, have declared, that they believe these Mercuries have been seen rather in idea, than in fact. For my own part, after taking a great deal of pains in this matter, I confess, the event has not answered, as has been promised. If, therefore, those things are true, which *Boyle*, *Tachenius*, *Homborg*, and others have wrote concerning the resuscitation of the Mercuries of Metals, there must be some secret method of making the resuscitating Alkali's penetrate even into their fixing Sulphur.

Passing these things by, therefore, the first and principal vertue of Alkali's Its Action. seems to be this; that if they can but be applied, and determined in their action upon animal, vegetable, or fossil concretions, whether fixed or volatile, so far as they are of an oily, balsamic, gummy, resinous, or gummy-resinous nature, and therefore howsoever concreted from oily substances, they intimately open, attenuate, and resolve them all, and dispose them to be perfectly miscible with Water, Alcohol, and Oils; the same effect, likewise, they have upon pure, proper Sulphurs, or these compounded and mixed with other substances. Hence Alkali's come to be the principal instrument in extracting what the Chemists call Tinctures. By the help of these are prepared, according to the opinion of these Gentlemen, at least, the most noble Medicines. Gum-Ivy, Juniper, Lac, Myrrh, and others, are not dissolved by Water, or Alcohol, without a great deal of difficulty; but if they are first properly prepared by these Alkali's diluted and heated, they dissolve in them very easily, and if they are then dried with a gentle Fire, they will excellently give out their vertues in solution. In the second place, when the elements of any Bodies are concreted together by means of a *Gluten*, or an Acid, interposed between them, then these Alkali's often bring about the Solution desired, by attracting into them the coagulating Acid, and by this means removing the *Vinculum*, and setting the Elements again at liberty. We are sensible, indeed, that these Acids are often so intimately united with some Bodies, that they won't be very readily, nor so perfectly fetched out the first time by these Alkali's; but still at last they generally yield to them: Mercury, when it is once accurately corroded by Spirit of Nitre, and then by the action of Fire converted into *Mercurius præcipitatus Ruber* does not, upon pouring on of Oil of Tartar *per Deliquium*, immediately return to fluid Mercury, but is changed into another Powder; but yet if this is put into a retort, and forced off from this alkaline Salt, with a strong Fire, the Mercury will leave its Acid united with the Alkali, and will recover again its pristine form. In the third place, if to some Bodies, when they are dissolved into their smallest Particles by an acid *Menstruum*, you apply pure Alkali's, these Alkali's often acquire a new vertue, by which being more intimately admitted to these Elements, they dissolve them much more efficaciously than if they had acted upon the same Bodies without this previous corrosion by the Acid. And hence we see, that in most of the methods by which the Alchemists have endeavour-

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A volatile
Alkali.

ed to procure fluid Mercury from Metals, they first order you to calcine them with Acids, and then mix and agitate them with Alkali's.

In the last place, now, it is necessary we should say something of volatile, alcalious *Menstruums*. Whether any volatile Alkali, then, ever naturally existed, as such, before the putrefaction or distillation of Animals or Vegetables, I won't pretend absolutely to determine. Some persons, perhaps, may be of opinion, that that singular Salt, which is found in chalybeate Waters, should be referred hither; but this I think must not be done without proper deliberation, as this cannot by any Art whatever be made to resemble the other volatile Alkali's, in all its characters; though it may be more properly, indeed, referr'd to these, than to Acids, as the famous *Hoffman* has elegantly proved in his writings upon this subject. The Bodies, however, of all Animals whatsoever, and those of Vegetables, that will putrify, are constantly so altered and disposed by putrefaction, as to have their saline Principle become a perfect volatile Alkali. The acrid Vegetables that we formerly mentioned will yield these Salts, by simple distillation; as do all Animals, likewise, that have been hitherto examined. And lastly, if the juices of Animals, not yet alcalious, are mixed with a fixed Alkali, they are so changed, that the other part being attracted into the fixed Alkali, they instantly send forth an alkaline Vapour, and by the action of the Fire yield immediately a volatile Alkali. This Salt, now, though produced after so many different manners, if it is perfectly purified according to art, will have exactly the very same appearance, and the same virtues: And these virtues are pretty nearly the same as those of fixed Alkali's, though in some measure, however, they differ from them in their effect, as plainly appears upon comparing them together. Volatile Alkali's, spontaneously, or in a very small degree of Heat, are always themselves in motion and action: Fixed Alkali's require a much greater assistance from the Fire, to make them efficacious. Volatile Alkali's soon fly off by Heat, and consequently from the Substance to be dissolved, if heated, and therefore do not continue applied to it in such a manner as to be able to exert its power upon it; whereas fixed ones, on the other hand, by means of the Fire that keeps them in agitation, persists to act constantly upon the Body exposed to them, if that is itself of a fixed nature, and does not quit them. When volatile Alkali's, however, are made to adhere to the solvend Body, they then, in a moderate Heat, become vastly efficacious, and that too very quickly. This appears evidently in the pure Alkali of Urine, which, if you apply it to the human Body, and cover it over with an adhesive Plaister, there instantly arises in the part, Heat, Pain, and an Inflammation, succeeded by a black, gangrenous Eschar, and an Erosion to the very Bones. These differences, then, being thus taken notice of, the other properties of volatile Alkali's may be learned from the History of the fixed ones. Let us, therefore, briefly take a view of,

Acid Menstruums.

Native, vegetable
Acids.

The physical character of an Acid has been given already; and upon examination it has appeared, that Acids rarely exist in a solid form, except in the essential Salt of acid and austere Plants, and in Tartar. But whatever Acids have been found in Vegetables, and Fossils, I have never yet known

any proper to Animals. Vegetable Acids are either native, or produced by the help of Fermentation. Native vegetable Acids, seem to owe their origin intirely to the Juices that the Plants draw out of their mother Earth; and hence, perhaps, all these may, in this respect, be look'd upon as of the nature of Fossils, especially as the Plants, that grow in the Sea, and have not their Roots inserted into the Earth at its bottom, consist purely of alcalescent parts, and in distillation yield an oily, volatile Alkali, as the illustrious Count *Marfilli*, in his Writings upon this head, informs us, he long ago observed. In some Vegetables the native Acids discover themselves evidently; as in Sorrel, the *Trifolium Acetosum*, and the Juice of all Fruits, whether the Pulpous, or Summer Fruits, especially before they are ripe, for afterwards, being concocted by the warmth of the Sun, they in some measure lose their acidity, and grow more mild. In the spring time, too, when Vegetables begin to put forth, and show again new signs of Life, the Juices often contain a perfect Acid, nearly like that of Vinegar. In other Vegetables there is likewise a true Acid, but it lies more concealed, as in Woods, and Aromatics. In Guaiacum, Sassafras, Cinnamon, and a vast many more, who would ever have expected an Acid, if it had not appeared so evidently by distillation? In the noblest Balsams, who would have thought of any such Acid as Turpentine, when it is distilled, yields so easily, and in such great abundance? These Acids, indeed, can scarcely be obtained pure, but are blended with other Bodies, and hence it is exceeding difficult to treat clearly of their proper action: The vertue of some of them, however, upon certain Bodies, is evident, as we see the fresh Juice of Oranges, Citrons, and Lemons, dissolves Lead, Tin, Copper, and Iron, and pretty strongly calcines them, as well as fossil Acids. These acid Salts, however, are formed into solid Globules, in a different manner from the other. *viz.* by taking the very thin, expressed, acid Juices, filtering them, inspissating them, and then letting them stand quiet, till they shoot into saline Chrystals; of these I have shewn you some every year procured from Sorrel, which are exceeding like Tartar, and have the true native vegetable acidity.

But fermentation seems more and more to exalt the latent Acid of Vegetables. For the Juices of Vegetables that are exceeding ripe, and sweet, appear to have hardly any thing of acidity in them, as we see evidently in the expressed Juice of Grapes, Cassia, Manna, Honey, and Sugar; and yet when these are rightly fermented, and set a working, an Acid may be presently drawn from them, but especially when the Wine begins to grow finer and more subtil. In ripe, mealy Corn, is there the least indication of an Acid? And yet when this has fermented but a very little while, it discovers an acidity. As these Acids, now, thus produced, are of a something different, and more subtil nature than the native ones; hence, to distinguish them, we may be allowed, for the future, to call them vinous Acids. These vinous Acids then are of two sorts; for either they are dispersed through the Wine, in form of liquid Acids; or else in time collect themselves together in the Wine, and fix themselves to the surface of the Vessel, in the solid form of Tartar. And these fermented vinous Acids have pretty nearly the same vertues as the preceding native ones.

Acids, liquid
and solid,
call'd vinous.

But

Acetose
Acids.

But the Acids of Vegetables, now, produced by a second fermentation, with your leave, I will call by the name of acetose ones. For if any known Wines are with acid, rough, crude ones, made to undergo again a proper acetose fermentation, they will be converted into (*Aceta*) Vinegars, will consume their proper Tartar, become much more acid, and will acquire a stronger and more durable Acid, which will remain even in distillation: Hence in Vinegars there is obtained a pure, active Acid, and then they are called pure, distilled, acetose Acids. These last, now, are of such incredible service and efficacy in the chemical art, that hence all other *Menstruums*, likewise, have been called *Aceta* too, as appears evident in the *Aceta Philosophorum*.

Fermenting
Acids.

But among these Acids, we must take notice, likewise, of fermenting Acids; by which we mean, vegetable Juices, that are in the very act of fermentation, and thus in a kind of middle state between their natural one, and that which they pass into when the fermentation is perfectly compleated; for during this time, the most elastic part of the fermenting Liquid acquires such a power as is not to be equalled by any thing I know of in all nature. For if this (*Sylvestris*) Sylvestrian, incoercible, explosive, acid Spirit, rising from a vast quantity of fermenting Vegetables, should pass through a very small vent-hole into the nostrils of the strongest man, it would strike him dead in an instant. If it does not act with all its force, it causes a sudden Apoplexy; if less powerfully still, a Childishness, with a *Paraplegia*; if very lightly, only a Giddiness. The truth of all this has been too certainly evinced by melancholy instances. Hence we come to have a more perfect idea of the more immediate cause of drunkenness, and the tremors upon the Nerves, that are a consequence of it. And hence we see the occasion of that surprizing *Phenomenon* mentioned by the illustrious *Cornaro*, in his noble treatise wrote in the praise of Sobriety, where he tell us, as he grew in years, he was annually, just before the time of vintage, troubled with a *Languor*, and lowness of spirits, which would not give way to any Medicine, or Regimen, but increased so as to become extreme, till, upon drinking new Must, he recruited his exhausted Spirits, and returned again to his former Vigour: This, then, he continued to enjoy till the Wine of that year began to grow old, and then relapsed into his usual debility, and was forced to wait for a fresh recruit of new Wine to set him to rights again. From all this then we evidently learn, what an incredible effect this fermenting Acid has upon the Bodies of Animals, either for their detriment, or their advantage. Whence does it happen, that the *Cholera Morbus*, in so short a time becomes so fatal? Certainly from Must, and ripe Summer Fruits, actually fermenting in the Stomach, and smaller Guts, and by the explosion of their Spirits, contracting the Muscles of these parts into spasms, that often prove mortal. Of this there is a remarkable instance in the *British Philosophical Transactions*, where that excellent Anatomist, St. Andrew, gives a very accurate account of the Body of a Man that fell into a *Cholera*, upon drinking a large quantity of bottled Ale, of which he died, in the manner there described. As by these accounts, now, the singular efficacy of such an Acid does evidently appear, so likewise it seems exceeding probable, that those Spirits, considered as a *Menstruum*, produce often upon other Bodies very surprizing effects. And I have sometimes doubted, whether this wonderful Spirit is not fixed in Tartar, and afterwards, when by the action of the Fire, in the distillation

distillation of this Salt, it is set at liberty, does not produce that elastic Vapour which the Chemists have always observed to be so vastly powerful, as to be able to burst to pieces all their Glasses, let them be ever so large. In the mean time, however, this is certain, that if Bodies that we want to be dissolved, are put into fermentable substances, in the very act of fermentation, they will be dissolved by them in a very different manner from what they would have been, had they been mixed with them, when they were not assisted by this fermentative power. This is evident in throwing green Herbs into Wine, or Ale, when they are working; for hence you have a Liquor in which all their virtues seem to be most equably united into one and the same Liquid, and afterwards to act with a joint efficacy. And thus the different ingredients in *Theriaca*, when they are mixed together with Honey, are reduced into one homogeneous Mass, and conspire together in the same operation.

But pure, thin, acetose Acids, are procured pretty much in their natural form, from Vegetables exposed to the Fire: For if you take a stick of Wood, a green one in particular, and lay it upon a clear Fire, in such a manner, that both the ends shall lie out, then the Fire acting upon the middle part of the Wood will fuse the humours that are contained there, and in form of Water drive them out of the extremities with a hissing and froth: And this Liquor, when it is examin'd, appears to be a pure Acid, has all the properties of Acids, and the dissolving qualities common to them. Hence, then, we learn, how the Smoke of Wood, that which is green in particular, makes the Eyes smart so violently, *viz.* by the acrid Acid which it disperses all about. This, likewise, when it penetrates into Flesh or Fish, that are hung in Smoke, tinges them with a red colour, and by its acidity prevents their growing putrid, or rancid. And this Acid is exceedingly like those that exist naturally in most Trees.

But again, there are discovered other very singular Acids, that are in some measure of a balsamic, and oily nature, which are drawn from Vegetables by Fire in a close Vessel, both *per adscensum* and *descensum*. Thus the Wood of Guaiacum, Juniper, Oak, and a vast many others, if you reduce them to dry Shavings, and carefully distill them in a Retort, yield a limpid, reddish Liquor, which is very acid, somewhat oily, and has a good deal the smell of a Herring dried in Smoke. And the Liquid thus prepared is strongly acid, especially if it is depurated by Filtration, and letting it stand quiet, called rectification; and the acid solvent virtue of this *Menstruum* is perfectly singular. In the human Body it produces wonderful effects, by attenuating, preserving, stimulating, and resisting putrefaction, and carrying off the noxious Matter by Sweat and Urine. If in these *Menstruums*, therefore, the medicated virtues of Plants are dissolved, the solutions become exceedingly efficacious; as they act by their very subtil, penetrating, singular Acid, and exalt the qualities of the Bodies dissolved in them. Of all these vegetable Acids, therefore, it is true, that they are capable of intimately dissolving many animal, vegetable, fossil and metalline Substances: By digestion and coction they dissolve the Horns, Hoofs, Bones, and Flesh of Animals: The Shells of Fish, and other Animals, they perfectly corrode into a pellucid Liquor: And Metals they dissolve, as I hinted before, except Mercury, Silver, and Gold.

Art, therefore, has sought out and discovered other Acids, which are able to dissolve Mercury, Gold, Silver, and other Fossils, which were unaffected by vegetable Acids, and hence were not easily managed by the power of human Bodies. For vegetable Acids may, by the action of a strong healthy Body, especially if assisted by a considerable motion, be so changed, as to lose their Acid nature, and be converted into another kind of Salt: But those Acids that we are at present acquainted with, which are capable of dissolving Mercury, Gold, and Silver, are not so easily subdued by the concoctive, animal powers, but being superiour to them, for the most part destroy them. And hence these become almost Poison to Animals, except in a very few cases, where a putrid Alcalescence prevails, as when alcalious Poisons are taken in by them, or in a putrid state of the Humours, as where the virulence of a Plague, or the sudden putrefaction of the Small Pox are to be dealt with.

Native, very rare.

Fossil, native Acids, now, are found to be very few, since it has been discovered, that the medicinal Waters once looked upon as acid, approach, in every character, nearer to an Alkali. There is often, indeed, a Vapour observed in Mines, which resembles a suffocating, sulphureous Acid, and by other marks demonstrates its acidity: But it is exceeding seldom that it is found alone, and very pure, in form of a Fluid.

Fixed ones, frequent.

But whenever it happens, which is very often the case, that it meets with a solid Body, that is capable of attracting that Acid, it then unites with it, and becomes fixed, and capable of examination: And when it is afterwards drawn out of that fixed Body, it then falls under the notice of our senses, and then, as far as one is able to judge of it, appears to be always one and the same.

In Sulphur.

For, as I formerly took notice to you, if it lays hold of a pinguious Fossil, it produces the various kinds of Sulphurs, which if they are burnt, emit Fumes, which being collected, refrigerated, and mixed with the humid Air, yield the Spirit, or Oil of Sulphur *per Campanam*. If you take this, now, and put it into a clean glass Vessel, and expose it a good while to the heat of boiling Water, you will distill from it a considerable quantity of pure Water, which, whilst the Sulphur was burning, had insinuated itself out of Air into the Acid; and there will then remain at the bottom a ponderous, thick, caustic Acid, which in every character resembles the purest Oil of Vitriol, except in this alone, that it contains nothing of a volatile Metal, which is always more or less in Oil of Vitriol.

In Alum.

But if this acid happens to get among Lime-stones, and corrodes them, it then produces Alums, which are of different kinds, according to the diversity of the matter that is mixed with them. All these, now, if they are first lightly calcined, and then with an intense Fire urged into Vapours, will by the condensation of these yield a Liquor, which, when it is purified according to art, is the very same with the former procured from burning Sulphur, without any difference at all.

In Vitriol of Iron.

Again, if you take native green Vitriol, and by the help of a moderate Heat reduce it to a dry, white Powder, and then by gentle degrees expose it to the Fire, till you come to the greatest, it will emit white, cloudy Vapours, which collected into a Liquor, and accurately depurated, is the very same again as was obtained from the Sulphur, and Alum.

The

The blue vitriol, likewise, if it is treated in the same manner, gives a liquid, which is the same with the former, nor can be distinguished from them, when it is rectified according to Art. All these acid Liquors, now, if they are urged with a heat of 560 degrees, boil, emit white cloudy Fumes, which disperse themselves about, and float to great distances, and destroy all Animals we are acquainted with, even Insects themselves. If they happen to be drawn into the human Lungs, in their full force, they presently excite an acute Cough, not to be removed, and then a suffocating, fatal *Dyspnœa*, with sudden death: Or if from some concurring circumstances they don't act so violently, they bring on a most troublesome Asthma, that continues during life. And the very same effect has Oil of Sulphur, Alum, Vitriol of Copper, and Copperas, as soon as ever, by the action of the Fire, they are raised into Vapours, by combustion, distillation, or ebullition. Nay, and take any of these Acids, which you please, unite it with a pinguious Oil, and it produces a Sulphur; with Lime-Earth, an Alum; with Iron, Vitriol of Iron; and with Copper, Calcanthum: From all these considerations, then, we are induced to believe, that the native acid, so ponderous, and difficult to boil, which is found in the fossil Kingdom, is always one and the same, that is to say, if you consider it as existing in form of a pure Acid. The properties of this Acid, now, are, first, that it is naturally the heaviest of all Acids. To Spirit of Nitre its specific gravity is as 11 to 9: To Spirit of Salt, as 11 to 8: To *Aqua Fortis*, as 11 to 9: And to distilled Vinegar, as 11 to 7, nearly, *Mem. de l'Ac. Roy. des. Sc.* 1699. p. 47. Secondly, it is of all Acids the most fixed; for in the heat of boiling Water it never emits any Fumes, except by means of the Water that adheres to it, not of the Acid itself: If you urge these Acids, however, with something more than 560 degrees of heat, they will then boil; and at the same time will send forth noxious Vapours. In the third place, these Acids, being perfectly freed from all their Water, by a strong Fire, and hence being rendered very pure, heavy, and acrid, very greedily attract into them Water out of the Air, and by this means dilute themselves, and increase their weight. Fourthly, the same thus rendered very pure, grow very hot immediately, upon the effusion of cold Water. In the fifth place, this Acid induces such an alteration on Sea Salt, Fountain Salt, and *Sal-Gem*, by the assistance of Fire, that in distillation they yield a Spirit of Salt; mixed with Nitre, it causes a Spirit of Nitre to rise from it; and if it is mixed with many other Bodies, dissolved by acid Spirits, it sets them free from their solvent Acids, by dislodging them, and rendering them volatile, whilst it often takes possession of their place itself. Upon this principle it is that Alum, and Vitriol, if they are first calcined, and then mixed with Nitre, yield *Aqua Fortis*; if with Sea Salt, Spirit of Sea Salt: For in the Colcothar there still remains a latent Acid of Vitriol, exceeding strong, and so fixed, that the Fire was not able to expell it, which being mixed with the Nitre, makes the acid Spirit of the Nitre rise into *Aqua Fortis*, which is the pure Spirit of Nitre, without any mixture of Oil of Vitriol; but at the same time, that part of the vitriolic Acid which remained in the *Calx* of the Colcothar, is left at the bottom with part of the Nitre, and produces there an exceeding fixed Salt, like *Nitrum Vitriolatum*. And the case is the same in the Sea Salt. In the sixth place, it readily dissolves Iron, Copper, somewhat slower, Silver with a good deal of difficulty, and Mercury not in less

than 560 degrees of Heat: Lead and Tin it don't dissolve at all. In other respects, this Acid agrees with the rest. It has this too in common with some, that it will perfectly dissolve Camphire into a liquid Oil, which by the effusion of a good deal of Water, may be recovered again into true Camphire.

Acid of Nitre.

But there is another sort of fossil Acid, likewise, that is procured from Nitre, nor ever was discovered any where, even in the smallest quantity, 'till it had been first drawn from that Salt. For if you take Nitre, and intimately mix with it three times as much Bole, Clay, Brick-dust, or any thing of the like nature, and urge it with a very strong Fire, a great part of it will be converted into red Fumes, which being collected into a Liquid, are called Spirit of Nitre. Or if you distill dry Nitre, with an equal quantity of Oil of Vitriol in the strongest Sand-heat, but gradually increased, you will then likewise from red Fumes have the same Spirit of Nitre. Or lastly, if you rub Nitre with an equal quantity of the *Calx* of red Vitriol, or Alum, and then urge it with a very great degree of Heat, it will then again emit the same Fumes, and from them yield a spirit of Nitre, which is as good, and as pure, as the former, but is then called by the Artists *Aqua Fortis*, *Aqua Stygia*, and *Aqua Docimastica*. This Spirit, now, howsoever prepared, is the same in every mark, and every property; for if there is any difference, it scarcely discovers itself by any Experiment. And it has this peculiar in it, that when it grows very hot in the Fire, it always sends forth very red Fumes, and dissolves Silver into very bitter caustic Chrystals; which Solution is proper to this Spirit, and can scarcely be effected by any other Acid, even pure Oil of Vitriol not doing it without difficulty. It dissolves Mercury, likewise, Lead, and Copper. Gold it does not affect; and scarcely dissolves Tin. This Acid, when it has dissolved its Metals, and intimately mixed itself with them, adheres to them with a considerable force, so as to remain united with them, in a pretty strong Fire. This appears evidently in Silver dissolved in this manner, which suffers itself to be melted into the *Lapis Infernalis*, without letting go its corroding Acid. *Mercurius præcipitatus Ruber*, too, when it is rightly fixed, how long will it resist an intense Fire, before it parts with the Acid that adheres to it?

Acid of Sea-Salt.

Sea-Salt, as Nitre, when it is pure, discovers no sign of an Acid, but if it is treated in the same manner we just now mentioned of Nitre, it is changed into a volatile acid Liquor. For if to prevent its melting, you mix it with three times its weight of Earth, and then urge it gradually till you come to the greatest degree of Fire, it will be dissipated into dense, white Fumes, that float about, are very volatile, and being collected form a Liquid of a golden or green Colour. If you distill it with Oil of Vitriol, you have the same Liquor, but more volatile. And if you mix it with the *Fæces* of distilled Alum, or Vitriol, and afterwards expose it to a very strong Fire, it will then likewise give out the same Spirit of Sea-Salt. And these Spirits, prepared in these three different ways, are intirely one and the same. Nay, and they will be the same, if you make them with *Sal-Gem*, Fountain, or Sea-Salt. This Spirit, now, has this peculiar in it, that if it is drawn from the purest Salt, and you repeat the distillation upon fresh pure Salt, when it begins through the violence of the Fire to grow exceeding hot, it emits white Fumes, and dissolves Gold, which

which no other Acid in nature is able to penetrate. It likewise dissolves Tin, Mercury with a flatulent noise, Iron, and Copper. Silver it does in no manner affect; nor perfectly dissolves Lead: So that this again is an Acid perfectly singular in its kind.

Hence, therefore, it appears, that Spirit of Nitre, and Spirit of Salt, are two perfectly distinct things, tho' at the same time they surprizingly approach to one another, and are converted into one another with wonderful ease. This certainly, then, in the History of *Menstruums*, ought well to be considered, and is as follows. If Spirit of Nitre is cohobated in a glass Retort upon Nitre that is exceeding dry, and purified with the utmost skill, so that there is not the least grain of Sea-Salt in it, you will then have the very choicest Spirit of Nitre, growing better and better upon every cohobation, and fitter for the Operations proper to this Spirit. But if this cohobation is performed upon common Nitre, which is not purified by chrySTALLIZATION, then the cohobated Spirit of Nitre will lose the nature of Spirit of Nitre, and will acquire the disposition of Spirit of Sea-Salt, or *Aqua Regia*, and will dissolve Gold. If we carefully examine, now, this extraordinary *Phænomenon* we shall easily perceive, that to this natural Nitre there must adhere somewhat of Sea-Salt, which intermixes itself with the nitrous Spirit in distillation, and thus from Spirit of Nitre produces *Aqua Regia*. And this again appears evident from the following Experiment. Take one part of pure decrepitated dry Salt, reduced to Powder, put it into a clean Retort, and pour upon it four parts of good Spirit of Nitre, or *Aqua Fortis*. Distill it then according to Art, to the utmost dryness, keeping your Sand-heat very strong to the last; and the acid Spirit which is thus procured, will be no longer *Aqua Fortis*, but *Aqua Regia*, which will dissolve Gold, but will not touch Silver. If you examine, then, the Salt, that remains at the bottom of the Retort after this Operation, by Solution, Filtration, and ChrySTALLIZATION, you will have a true, pure, inflammable Nitre. *Du Hamel. Hist. de l'Ac. Roy. des Sc. p. 158. Boyl. Or. Forms. p. 215.* Again, if you take one part of the purest Nitre, and two of the best Spirit of Sea-Salt, and distill them in a proper manner in a Retort, there will come off a Spirit which will dissolve Gold much easier and sooner, than Spirit of Sea-Salt. And the Salt now again that remains at the bottom after the strongest distillation, if you dissolve it in Water, filter, and chrySTALLIZE it, appears to be a good inflammable Nitre. *Boyle. Ib. from p. 215. to 224. Bohn. Chem. 35, 36, 163. Hoffm. Dissert. Chem. Phys. L. iii. Obs. 20.* Hence, therefore, it appears that *Aqua Fortis* becomes *Aqua Regia*, as soon as ever Spirit of Nitre and Spirit of Salt come to be mix'd together, in whatever manner, and almost in what proportion soever: Nay, and if to *Aqua Fortis* you add *Sal-Ammoniac*, *Sal-Gem*, Sea-Salt, Fountain-Salt, the *Sal Febrisugus Sylvianus*, or true Spirit of Salt, in all these ways there is constantly produced *Aqua Regia*.

Thus then we have given you the History of Acids as it stands at present. And in this, it is particularly remarkable in the first place, that Acids are so easily generated from Non-acids; as appeared above in the Acids of Vegetables. Wine too, not at all acid, has, by being close stopped up in a clean Bottle, and tied to the Sail of a Wind-mill, been converted in three days into good Vinegar, according to the Observation of Monsieur *Homborg. Mem. de l'Ac. Roy. des Sc. T. II. p. 11.* But in the second place, it deserves well to be taken notice of, likewise,

likewise, that Acids, when they are once produced, will bear the Fire for a long time and be scarcely altered: For *Aqua Fortis*, *Aqua Regia*, Spirit of Nitre, Spirit of Salt, and Oil of Vitriol, being included in Glasses hermetically sealed, and exposed for four years to the equable Heat of an Athanor, retained the same dissolving power: Vinegar only was grown insipid, and had acquired an aromatic Smell; and the Spirit of Salt had begun to corrode the Glass. In the third place, however, these same Acids lose their acid nature, whilst they act as *Menstruums* upon solvend Bodies. This Monsieur *Homborg* very ingeniously inferred from a tedious Experiment performed with Mercury and Spirit of Nitre. *Du Hamel. Hist. de l'Ac. Roy. des Sc. p. 442, 443.* Hence, therefore, it appears, that the strongest acid *Menstruum*, is, by dissolving its object, converted into an insipid, unactive Fluid, not unlike Water, and deprived of the proper solvent Power which it had before: And hence, perhaps, it is not improbable, that these Acids are generated, and perish. For what Person living has ever discovered any Spirit of Nitre in the World, which was not first procured from pre-existing Nitre? And yet Nitre is produced from Earth, filled with animal Excrements Lime and an Alkali, and Air; or from pure Spirit of Nitre attracted into a pure Alkali, particularly a fixed one. Rich and fruitful Lands too, defended from the Rain, and perfectly prevented from consuming their strength by nourishing of Vegetables, are all found by length of time to be impregnated with a fruitful Nitre, if you take care that no Sea-Salt shall come at them. *Boyl. Scept. Chem. p. 177.* Hence, then, it is evident, that the acid Spirit of Nitre is, by the sole action of the Fire, produced from pure Nitre, altered; whereas native Nitre is produced without any such Spirit first existing. In the fourth place, therefore, these Acids, whilst they dissolve Bodies, become concreted with them, are changed, and converted into new ones, and thus from one, give rise to a great variety: For Spirit of Nitre dissolves Silver, Lead, wonderfully changes Tin, Copper, Mercury, Nitre, Antimony, Zincq, and Emniery, and with them forms new Bodies, that are different in Taste, Smell, Colour, Density, and all their effects. *Boyl. Mec. Qual. 118, 119.* In the fifth place, all these Acids agree in some particulars, but differ in others.

The agree-
ment of A-
cids.

They agree, with regard to the Effervescences they excite by being mixed with Alkali's, and the production of new Salts that arise from this combination. As likewise, in their composition with Chalk, Corals, Crabs-eyes, Pearls, Mother of Pearl, the Shells of Cockles, Limpins, and Oysters, Stones, Bones, Hoofs, quick and flaked Lime, Iron, and Copper: For all these are generally dissolved by all sorts of Acids sooner or later, whether it is effected quietly, or with a great *impetus*. These Bodies, now, when they are thus dissolved, always attract into them the acid of the Solvent out of the Water, in which that Acid was before diluted: And the dissolved Matter being by this means united with its solvent acid Salt, may afterwards be diluted in Water like a Salt, so long as its Acid adheres to it; tho' these Bodies before this Mixture were no ways dissoluble in Water. But when this Acid is again by any method removed from the dissolved Matter, then this constantly appears again in form of an Earth, which most strongly resists a Solution in Water. Hence, then, it appears, how very much we may be imposed upon by Water, whilst judging of it by its appearance, we make use of it in our Operations for pure elementary

mentary Water; whereas, in reality, it may contain in it various kinds of dissolved Bodies, together with their Solvents. And hence it comes to pass, that Effects are frequently supposed to be produced by simple Water, which in fact, are owing to these latent Solvents and *Menstruums*. And this, indeed, happens the more easily, because, Metals excepted, Acids in general, when they are accurately united with the Bodies abovementioned to a perfect Saturation, they lose all their Acrimony, and for the most part all their Taste, and thus lie perfectly concealed. * With of Spirit of Nitre, dissolve 4 drachms and 9 grains of Crabs-eyes, as it generally will, and let the Solution be carried accurately to the point of Saturation, and you will have a limpid, and almost insipid Liquor; let this then be diluted with very pure Water, and filtered, and let it stand for some time in a moderate Heat, and it will appear like clear Water; and yet, if you drop into it a strong fixed Alkali, the dissolved Body will all precipitate to the bottom, which a Person not apprized of the contrary, might suspect to be produced from the Water itself. These Acids farther agree in this, that by dissolving Bodies, they not only become united and concreted with their Solvents, but are likewise at the same time changed in their own nature: For it is demonstrated by undeniable Experiments, that the most acid Acids, whilst they corrode their Objects, are truly changed by them, and put off the disposition, not only of an Acid, but a Solvent likewise. Thus Spirit of Nitre, for instance, when it has corroded Mercury, and is separated from it again, presently loses the power of dissolving it any more. Another property of Acids in common, is their turning vegetable Juices of a red Colour, as appears in the Turnsole, Roses, and Violets. And again, they all agree in this, that they do not so much alter the Bodies they dissolve, as they are altered by them themselves. This is found to hold true in almost every case. Vinegar in dissolved Lead, does not continue Vinegar there, nor is separated Vinegar again; but the Lead is recovered perfect Lead. Spirit of Nitre dissolves Mercury, and the Mercury is procured from it again exactly the same; but the Spirit of Nitre, when it is separated, is nothing like what it was before. Hence, therefore, lastly, this likewise is common to all Acids, that many of them are continually destroyed.

But these Acids, now, on the other hand, differ very widely first of all, in the proportion between their true Acid, and the Water it is mix'd with. Thus in an ounce of the best Vinegar, there are 18 grains of pure Acid, and all the rest Water: In an ounce of Spirit of Salt, 73 grains of true Acid, the residue pure Water: An ounce of Spirit of Nitre, gives 2 drachms and 23 grains of Acid, the rest Water: The same quantity of *Aqua Fortis*, 2 drachms 26 grains: And, lastly, an ounce of Oil of Vitriol yields 4 drachms and 65 grains of Acid, according to the Observations of Monsieur *Homborg*. *Hist. de l'Ac. Roy. des Sc.* T. L. p. 52. In the second place, this same Acid, when it is pure in every particular sort, differs surprizingly in its dissolving power: For the Acid of Nitre boiled with Gold, has scarce any effect upon it, except changing it black; whereas it dissolves Silver presently: And the contrary is true of *Aqua Regia*. Hence then it appears, that the Acid does not act there as

Difference of
Acids.

* The quantity of Spirit of Nitre is not added, and our Author says it is not necessary; nor indeed is it absolutely so, as it will be determined by the Saturation: But then why he should mention such an odd quantity of Crabs-eyes, as 4 drachms 9 grains of Crabs-eyes, and add *ut solet facere*, I can't imagine.

an Acid in general, but as a Body endued with a peculiar vertue. In the third place, Acids differ likewise in this respect, that whilst they dissolve their Objects, some of them are changed a great deal more than others. Spirit of Vinegar, for instance, in dissolved Lead, becomes an oily pinguious Spirit: But Spirit of Nitre, whilst it corrodes Tin, is not altered in this manner. Fourthly, the same Acid is very much changed by acting upon some particular Bodies, but very little or nothing if it acts upon others. Thus distilled Vinegar, in the Solution of Lead, is altered in the manner I just now observed; if it corrodes Iron, it loses all its former nature, nor can be ever recovered from it again; but if Copper is corroded by it into a Mould, and then dissolved into a green Liquor, and from this you procure Chrystals, these Chrystals will contain an exceeding strong Vinegar, and if you distill them in a Retort with a great degree of Fire, you will have a very strong acid Spirit of Vinegar, scarcely at all altered, tho' it adhered so tenaciously to the Copper. Hence, therefore, it appears, what different changes are induced upon Acids by being united with different Metals; which is true in other Bodies likewise. All Acids in general, now, may be diluted in Water. They may be mixed with Spirits, as Spirit of Nitre with Alcohol, with a prodigious Heat, very red Fumes, and an Effervescence which almost bursts out into Flames. They may be combined likewise with Oils; Spirit of Nitre, sometimes, with such an agitation as excites Fire; for the most part with an intense Heat. Oil of Vitriol likewise, mixed with Alcohol, and Oils, makes the Compound vastly hot. But whenever Acids are intimately united with Oils, they almost always produce somewhat of a bituminous, pitchy, or sulphureous Substance; whence often arise very extraordinary changes. Thus, then, I think I have laid before you such an account of acid *Menstruums*, as is sufficient to enable you to judge of their action. We must now, therefore, briefly take under consideration those called the *Neutri*, *Hermaphroditi*, *Compositi*, and *Enixi*.

Of neutral Salts, as Menstruums.

Sal-Ammoniac a Menstruum.

And here let us first examine *Sal-Ammoniac*. This is very easily diluted in Water, nay and in a moist Air dissolves into a very acrid, and surprizingly penetrating Brine, which most happily attenuates, incides, opens, and resolves the thick, viscid, pituitous, and pitchy concretions formed in animal Bodies, and then expells them by Perspiration, Sweat, Urine, and *Saliva*, and excellently too resists putrefaction. And for the same reason, if this Brine is boiled, or digested, with the Gums, Resins, or Gum-Resins of Vegetables, it intimately resolves them, and disposes them to be conveniently dissolved in aqueous, and fermented spirituous *Menstruums*. Upon Metals, likewise, it has beautiful effects. If you boil Filings of Iron in it, they are surprizingly dissolved, and converted into an excellent restorative aperient Medicine. If you boil or digest it with Filings of Copper, it gives a Liquor of a beautiful Colour, a few drops of which taken in a morning fasting, has often done great things in the Epilepsy, and Worms. On these accounts, this Brine affords a noble *Menstruum* in the Animal, Vegetable, and Fossil Kingdom. But when the exceeding pure dry flowers of this Salt are rubb'd for a long time, and accurately mixed with Fossils, and they are afterwards sublimed together in a Sand-heat, and in a close Vessel, they then, as a *Menstruum*, acquire inimitable

ble vertues. Hence the Chemists have called it the *Aquila Alba*, and the *Pistillum Sapientum*. Sulphurs, sulphureous Substances, Semi-metals, and Metals, treated in this manner, are vastly attenuated, opened, rendered volatile, and perfectly altered: And hence are prepared such excellent Medicines, as can scarcely be equalled by any other Art; witness the flowers of the *Lapis Hæmatitis*, the *Ens Veneris*, and *Ens Martis*, not to mention many more. What is more surprizing, than the various changeable Colours of Antimony thus produced from a black one? Let it suffice to take notice only, that many of the Philosophers have called this Salt, the Key, that is to admit us into the more profound parts of chemical knowledge. It has certainly this excellent quality, that it is scarcely altered at all by sublimation, except by means of some other Bodies joined with it. If it is mixed with *Aqua Fortis*, or Spirit of Nitre, it immediately converts these Liquors into *Aqua Regia*. If with fixed alcalious Salts, it is instantly changed into a very pure volatile Alkali, acting afterwards in that character, and into a new Salt pretty much resembling Sea-salt. From Spirit of Sea-salt perfectly saturated with a pure volatile alkaline Spirit, *Sal-Ammoniac* is produced; as it is likewise from Sea-salt, Urine, and Soot mixed together. Hence then it appears to be a true semi-volatile Sea-salt; and on his account its whole power, as a *Menstruum*, may be reduced chiefly to that of Sea-salt. Hence too it can never be made better than by subliming it some number of times in a Vessel accurately closed, from the purest, driest, decrepitated Sea-salt; for by this method are prepared the choicest flowers of *Sal-Ammoniac*.

Sea-salt comes next in order, which, as I have often taken notice of already, Sea-Salt a Menstruum is not only found in the Sea, but is dug likewise out of Pits, and procured too from Fountains: These three sorts, therefore, being perfectly the same, I shall describe them altogether under the name of Sea-salt. This Salt being, either by means of the Sea, Fountains, or Pits, distributed all the World over, proves a universal preservative against putrefaction. It readily dissolves in Water, and in a moistish Air spontaneously runs into a very strong Brine, which gives us the most beautiful, and defecated *Menstruum* of Sea-salt, the Effect of which, with regard to chemical purposes, is almost the same as has been ascribed to the Brine of *Sal-Ammoniac*, and which therefore may be applied to the same uses. This Sea-salt being set upon the Fire, will decrepitate, and then, in a dry, hot Vessel, may be readily reduced to a Powder, and melted in the Fire, at which time it will easily insinuate itself through the Pores of the Vessel it is fused in, and so disappear in the Fire. But when with this Salt thus in fusion, you mix Fossils, Metals, and Semi-metals, there are very strange alterations produced, peculiar, and different from all others. I took myself 8 ounces of moistish Sea-salt not decrepitated, and 2 ounces of common Antimony reduced to a Powder; and after they had been accurately mixed by rubbing them a long time together, I put them into a Crucible, which I covered with another inverted, and closed them together with a strong Lute. These being thus prepared, I put them in the Fire for four and twenty hours, and then urged them with such a Heat as to melt the Salt, after which the Crucible being opened, I found a blackish-brown Mass, at the top of which there stood up some white *Spicula*. I reduced the whole again to Powder, and luted the Crucible as before, and then obtained a reddish-brown Mass at the

bottom of which there was somewhat of a more metalline nature. I repeated the same again a third time, and when it came to melt, almost all the Salt ran through the Crucible, and at the bottom I found a Mass of Antimony, which was of a reddish-yellow, and surprizingly changed. By this instance, then, it appears, how this Salt, as a dry *Menstruum*, acts with the assistance of Fire. There are an infinite number of other Operations, to which it may be applied with a very different effect, than what wou'd be produced by any other Salt. Hence in Cementations, this Salt mixed with Brick-dust in a dry form, is made use of to many beautiful purposes in the exaltation, separation, and maturation of Metals, concerning which *Paracelsus* wrote so largely in his Works, what other Persons since have found to be true. Among other things, we may take notice, that if dry Sea-salt is mixed with Brick-dust, and exposed to the Fire, it will be converted into a volatile acid Spirit resembling *Aqua Regia*, which will then act upon metalline Glebes like *Aqua Regia*, and hence perform very singular Operations. *Vid. Paracels. de Cæmentis, & Gradationibus.* But when by the method above-mentioned in the description of the acid spirit of Sea-salt, this Sea-salt is converted into a Spirit, and this Spirit again, by distillation, is drawn off from some of the same pure, decrepitated, dry Salt, and cohobated a good many times, you then obtain a singular and wonderful solvent of Sea-salt. These are tedious Labours, I confess, but they are usefull ones; and therefore, if you have a mind to repeat them after me, you may do it in the following manner. In two pounds of spirit of Sea-salt, by adding a little and little at a time, I dissolved as much fine dry powdered Sea-salt, as it wou'd possibly take up. This Liquor, by letting it stand quiet, and filtering it, I made exceeding pure, and then put it into a tall Bolthead, and fitting another smaller one into it, luted them well together, and exposed them to the Heat of the Sun, from the tenth of *May* to the tenth of *July*. I then distill'd this Liquor in a Retort with a gentle Fire, till there remained at the bottom a thick pinguious Liquid, that appeared like a thinner kind of an Oil, in which there were hard Chrystals of Sea-salt. When this was done, I poured the distilled Liquor back again, and repeated this three times, constantly drawing off the same quantity I put on; and at last there was left a spongy, oily, pinguious Salt at the bottom. This Operation I afterwards repeated with all possible care and accuracy for five and twenty times more, and then took what came off upon the last distillation, and poured it back again upon the *residuum*, and let them stand thus mixed together for five months. I then, with a very gentle Fire, drew off a Phlegm that was almost insipid, and when I perceived a very acid Spirit begin to rise, I fixed on another Receiver, and urging it with a little stronger Fire, there came over a very acrid, acid, heavy Oil of Salt. This I set aside by itself; and after all these distillations, the Salt that remained at the bottom of the Retort, was still very acid, and considerably fixed. This I then put into a glass Plate, and exposed it to the Air in a subterraneous place, where it run *per deliquium*. * When this

* It's pretty remarkable here, that our Author does not say that he actually did depurate this Liquor, &c. and then procure from it this noble Solvent; but says, when it is depurated, &c. such a one may be procured, and refers us to *Paracelsus*. Nor in the next sentence, tho' he says he took all this pains to learn whether what *Paracelsus* said was true, does he tell us whether it is so or no.

Liquor is afterwards depurated by filtration, and mixed again with the Phlegm, Spirit, and Oil of Salt, that came off first, there is produced, upon a new distillation, a Liquor of those solvent vertues, that fully answer all our trouble. *Vide Paracels. x. Archidox. C. 4.* I was willing, Gentlemen, to take all this pains, to learn, if I could, what truth there was in what *Paracelsus* had asserted. Mr. *Boyle*, after a proper and long protracted digestion, by a moderate sand heat, procured from Sea-Salt, without any thing mixed with it, a Spirit, without any Phlegm, and before any Phlegm arose. Nine parts of Sea-Salt being dissolved, filtered, depurated, and chrystallized, yield one part not to be formed into little Glebes, which is rough, austere, and saline: This being separated, the Salt becomes purer. *Du Hamel. Hist. de l'Ac. Roy. des Sc. p. 16, 17.* If a person then considers all these things, he won't wonder, that the greatest Masters have ascribed such extraordinary vertues to Sea Salt chemically prepared, both in *Menstruums*, and Medicines: Every one will see what method it ought to be prepared by.

Our Nitre, procured from animal substances, an Alkali, and Lime-Earth, and afterwards purified, hence easily becoming alcalescent, and fixed, and being as readily again convertible into a volatile Acid, is of a pretty singular nature, considered as it acts upon Bodies, as a *Menstruum*: And its operations, indeed, are often so intricate, that it is scarcely possible rightly to comprehend them; which happens chiefly from its being so mutable in the Fire itself, when it is mixed with other substances. If it is exposed to the Fire, pure and dry, as it so soon runs with other Bodies like Water itself, hence, though they otherwise would not melt without a great deal of difficulty, it wonderfully promotes the fluxing them, and attenuates, divides, and mixes them together, even though you suppose it to act here with no other vertue. For this reason, persons who are employed in fusing of Metals, make use of Nitre for forwarding their work. But in the second place, if there is any thing in the substances mixed with it of an oily, pinguious, sulphureous nature, this immediately, in a melting Fire, detonates with the Nitre, with a great *impetus*, takes fire, instantly excites a prodigious Heat, greatly raises the strength of the Fire, applies it more violently, and hence vastly changes, divides, melts, and separates Bodies, and in a very different manner from what can be effected by any other contrivance. But at the same time, the Nitre itself likewise loses the nature of Nitre, and acquires that of *Sal-Polychrest*, which has quite another dissolving power from what the Nitre had from which it was produced. Hence, therefore, there are three various actions of Nitre upon Bodies in the Fire; one before it deflagrates with them; a second during the time of deflagration; and a third when it is perfectly over. In the third place, when Nitre is melted with Vegetables that turn to a Coal, it then, likewise, is put into a very great motion, violently agitates and dissolves the solvent Bodies, and at the same time sends forth wonderful active Fumes, which being assisted by the Fire, penetrate, and dissolve every thing. And lastly, when it is thus converted into a fixed Alkali, it won't then melt without the strongest Fire, and has then acquired the quality of an acrid, penetrating Alkali, though always of a particular nature; and hence again it begins to act as a fixed, alkaline *Menstruum*, and thus obtains and exerts a new dissolving power: But this was treated of before in our History of alcalious *Menstruums*. In the fourth place, if the same Nitre fus'd

Salt of Nitre
a *Menstruum*.

with its solvend Bodies, happens to meet with any Earth, Stones, Alum, Vitriol, Brickduft, or the like, it is immediately converted into a very acid, volatile, sharp Salt, which being agitated with so great a Heat, penetrates, dissolves, and induces prodigious changes upon the Bodies it is mixed with, acting in this case like *Aqua Fortis*, with one part, whilst the other part that remains at the bottom acquires a new, and very different solvent power. Hence, therefore, we see how wonderfully efficacious this Salt must be, when it is used like a Cement with metalline Glebes; for then it is converted into such corrosive Spirits, which at the same time make great alterations in the Metals. But this I have sufficiently explained in our account of Acids, to which, therefore, give me leave to refer you. Again, in the fifth place, if pure Nitre is fused in an intense Fire, and is kept in the Fire with the reguline part of Antimony, it becomes a perfect caustic Stone, which acts in a manner that cannot, as I know of, be imitated by any other Salt: For this Salt is exceeding fixed, vastly difficult of fusion, and of an uncommon, igneous acrimony. Hence, therefore, it appears what a wonderful dissolving efficacy this Salt must have, when, together with *Regulus* of Antimony, it is applied to Bodies in the Fire. Sixthly, if upon Nitre, when it is in fusion in a clean Crucible in the Fire, you throw powder of *Sal-Ammoniac*, it will take fire in the same manner as if a live Coal was thrown into it, but somewhat softer; and it is by this means altered every moment, and becomes of another nature, 'till at last, being perfectly saturated, it will not take fire any longer upon throwing in of the *Sal-Ammoniac*, but is converted into a new kind of Salt, which at last grows reddish, is of a singular nature, though but little regarded or known amongst the Chemists. When Nitre and *Sal-Ammoniac*, therefore, are thus mixed together with other Bodies in the Fire, a different kind of solution will happen every moment, and consequently new effects will be continually produced, whilst these thus remain in the Fire together. To these things the Operators very seldom sufficiently attend, and hence it comes to pass, that they frequently meet with *Phænomena* they were not aware of, which disturb their Operations, and render the success of their Experiments uncertain. In the seventh place, if to the Solvend you add one ounce of Sea-Salt, and two ounces of Spirit of Nitre, or *Aqua Fortis*, the Liquor that is expell'd with a moderate heat will be an *Aqua Regia*, and act only with the power that that does; whilst the Salt that remains at the bottom will be Nitre. Hence, therefore, it appears, that in the latter part of the Operation, when it comes to be dry, it will act like true Nitre; whereas, at the beginning, the Liquor that was separated had the efficacy of *Aqua Regia*; and it is likewise as evident, how various the effects may be in different parts of the time that any given *Menstruum* continues in action. In the same manner if upon one part of very pure Nitre, you pour two of Spirit of Sea-Salt, they will yield in distillation a pure *Aqua Regia*, perfectly so in every property and very strong; but if you then increase your Fire, and proceed to distill to a perfect dryness, you will find again at the bottom of the Retort a true Nitre in all respects. Hence, therefore, we see how cautious we ought to be, that we are not deceived in our *Menstruums*. And again, if Spirit of Nitre, and a proper quantity of any Alkali are mixed together, with the solvend Bodies, they soon return into a Nitre, and therefore act like a Nitre in the last part of their Operation. And if what *Glauber* says is true, that Sea-Salt, a fixed Alkali, and

and Quick-Lime, mixed together, and ustulated till they are red hot, and then exposed to the Air, and thence moisten'd, will produce a true Nitre, then certainly if these materials are made use of together in cements, they would have a very different effect from what one would at first imagine. These things, then, if a person rightly considers, and at the same time adds what we have already said of the conversion of Nitre into an Alkali, in our History of alcalious *Menstruums*, and into an Acid, in our account of acid ones, he will sufficiently understand its efficacious and various dissolving power.

Native Borax, the produce of the *East-Indies*, *Persia*, and *Transylvania*, being dissolved in Water, filtered, and chrystallized, is of a bitter sweetish taste, and neither acid, nor alcalious. In distillation it yields a mere Water, and a Glass; which Glass may be afterwards dissolved in Water. If it is mixed with Sand, and urged with the strongest heat, it affords no acid Spirit. It exceedingly promotes the fluxing of Metals, and by thus fusing them, unites them thoroughly together, and by this means produces many effects which could not be accomplished in another way, without a great deal of difficulty.

Borax as a
Menstruum.

Whoever, now, is properly acquainted with what we have delivered concerning saline *Menstruums*, will readily conceive, how, by the various combinations of these Salts with one another, may be produced a vast number of new saline *Menstruums*, every one of which will presently acquire new and different dissolving vertues. This composition, now, is sometimes effected by art, and with design; at others, it happens accidentally, and without being foreseen, and so comes to be reduced among other chemical observations. And from these two fountains have there risen a vast quantity of *Menstruums* which have been described by the Chemists. Thus, for instance, if volatile Alkali's are united with fixed ones, then the volatile, by the action of the Fire, are always rendered stronger, harder, and more volatile; whilst, on the other hand, the fixed attracting the Acid, perhaps, from the volatile, as likewise the Oil, and Earth, become always differently compounded, and have not the same efficacy they had before. Fixed Alkali's, mixed with native, vegetable Acids, produce a wonderful compound Salt, which is soft, aperient, and diuretic: This we see in *Omphacium*, or Juice of Lemons, or the like, mixed with a proper proportion of Salt of Wormwood; for the Salt arising hence has very different solvent powers from what the Principles have from which it is made, or than any other Salts have. If you mix volatile Alkali's with these Acids, you have then another compound Salt, as different as possible from the former with the fixed ones. If you rightly combine fixed Alkali's with pure, fermented, vegetable Acids, you procure, after many surprising *Phænomena*, a saturated Salt, which is volatile, soft, penetrating, saponaceous, melts easily in the Fire, and possesses very extraordinary vertues. Here the Vinegar returns into its proper *Matrix*, Salt of Tartar, and impregnates it with its own peculiar Acid, which was acetose; for the Chemists call Vinegar fluid Tartar; and hence they have given to this Salt the name of regenerated Tartar. Others have called the Mixture prepared in this manner (*Acetum radicum*) radicated Vinegar; as it appeared to return into its proper (*Radix*) Root. And having myself often experienced the beautiful effect of this Salt, both in the animal, vegetable, and fossil Kingdom, I have been in doubt, whether this is not in reality the *Sal Tartari Volatilis* of *Helmont*, which the author so highly extoll'd for its vertues. Be this as it will,

Compound,
saline *Men-*
struum.

this

this I can safely affirm, that in the whole class of *Menstruums* there is scarcely one that deserves examination, and application, better than this does. This I could make appear by an infinite number of examples; but let one suffice. That noble Gum, Myrrh, cannot, without a vast deal of difficulty, be so dissolved by Alkali's, or Acids, as to be rendered subtil enough to penetrate into our Veins, if it is taken into the stomach; but if you digest it according to art with this Salt, it melts, and in an inimitable manner dissolves into a thick, homogeneous, medicinal Mass. This Salt, if it is made very accurately, will very intimately unite with Alcohol of Wine, and thus yield a *Menstruum*, which no person will repent making, though it costs him a great deal of pains. Hence, therefore, we see how much some of the more modern Chemists are in the wrong, who, making Alkali's and Acids the grand principles of Bodies, assert, that these can't be mixed together with any propriety, nor without acting contrary to true chemical knowledge, intimating, that by this means the noble virtues of the Alkali's are destroyed by the Acid, and what remains is of no efficacy, as *Zwelfer* in his works so often inculcates. But these Gentlemen may know, that if the purest Alkali of Tartar is united, according to art, with the volatile Acid of Tartar converted into Vinegar by a double fermentation, then the Alkali, and its proper virtue, being destroyed, as well as the Acid of the Vinegar, and its proper virtue, there arises a new neutral Salt, the efficacy of which is much more excellent than that of either the Alkali, or the Acid. And when a pure volatile Alkali is accurately combin'd with a very pure, strong Spirit of Wine Vinegar, so that you nicely obtain the very point of saturation, you have then a limpid Liquor, very little Salt, without any remarkable acrimony or smell, considerably volatile, and compounded of the lightest Alkali and Acid. And this possesses a very peculiar, dissolving power, which in vain you will seek any where else; for it is capable of penetrating into almost all kinds of Bodies, and resolving them without any great apparent agitation. Hence the Physicians have valued this Water exceedingly for removing diseases of the eyes and ears, arising from any preternatural concretions. And for the same reason, among all the secrets for discussing, and resolving glandular tumours, nothing hardly is found more efficacious than fomentations with putrified Urine and Vinegar, if the part is first well rubb'd, and they are then applied hot. From these observations, now, we may likewise understand, what will be the consequence of combining fixed or volatile Alkali's with fermenting Acids; for at first they will cause a sudden effervescence, then put a stop to the fermentation that was begun, and produce Salts, very much resembling those that have been described. And the same kind of Salts are produced, likewise, by mixing Alkali's with those Acids that are separated from Vegetables, whilst they are burning, or with those that are drawn from them by distillation. But if you combine fixed Alkali's with the native Acid of Fossils, there then again arise new Salts, but those vastly different too from one another. If, for instance, you dissolve the purest Alum in clean Water, and heat it, and drop into it hot Oil of Tartar *per Deliquium*, 'till it is perfectly saturated, they will precipitate a chalky *Calx*, and the limpid Liquor swimming at top, and consisting of the native Acid of the Alum attracted into the Alkali, being defæcated, and filtered, will yield a Salt like *Tartarus Vitriolatus*, but free from any suspicion of a metalline taint, whose virtues are excellent in Chemistry as a *Menstruum*, and are very effi-

cacious

cacious in medicine. In the same manner, if you take either the white, blue, or green Vitriol, and dissolve it in four times its weight of Water, filter it, and drop into it hot, a fixed, hot Alkali, till you come to the point of saturation, you will thus again have a compound Salt arising from the Alkali, attracting into it the Acid which had corroded the Copper, or Iron, in the Mines: So that here again you have a natural, vitriolated Tartar, which differs from the common, in this particular, that its Acid has not been exposed to so strong a Fire, and hence has more beautifully retained its natural virtues: And besides, it will more perfectly deposit its metalline parts, except it be the true *Calcanthum* of Copper, for then, indeed, part of the Metal remaining in the solution, will discover itself in the Salt, by a blue colour. But farther, whenever you intimately mix a fixed Alkali with any true Sulphur, then the fossil Acid is attracted into the fixed Alkali, and if nothing else prevented it, there would be produced a Salt like the former: But we find, however, that it is in some measure of another nature, as appears from the saline *Spicula* that are formed from it. And this seems to happen, because the pinguious, oily Matter, which is mixed with the Sulphur, unites itself with the fixed Alkali, as well as the acid does, and thus prevents the pure saline parts concreting together, and by its interposition forms a decompound Salt, of a very different smell, taste, and efficacy. From what has been said, then, it appears what will be the consequence of mixing Vitriolic, or Alum Waters, or their inspissated, pinguious *Residuum*s by what name soever distinguished, with these fixed Alkali's; for by this means the metalline and terrestrial part, which these contained in them, will be separated, and the solvent Acid will unite with the Alkali into a vitriolated Tartar, whose dissolving Power will be singular, and different from that of all other Salts: This the application of it to Metals, Semi-metals, Sulphurs, and other fossil Glebes generally evinces. And it commonly too retains its virtues longer without alteration, than any other compound Salt; for it has its Acid more strongly combined with a very fixed Alkali, into an exceeding fixed Salt: Nor is there any known Acid in Nature, which, if poured upon vitriolated Tartar, is able to dislodge the Acid that is united with it, though the native Acid of Vitriol expels the Acids from all other compound Salts, as has already appeared. But on the other Hand, if with native, fossil Acids you mix pure, volatile, alkaline Salts, there then arise particular kinds of *Sal-Ammoniac*; and as these are compounded of a fossil Acid, and a volatile Alkali, perhaps, for distinction sake, they may be, not improperly, called Semi-volatile, vitriolated Tartars. And these, likewise, deserve to be well considered by the Chemists among their *Menstruums*, on account of their remarkable dissolving power; and by the Physicians for their noble efficacy in opening, attenuating, resolving, and stimulating. What then will be the effect of mixing common *Sal-Ammoniac* with Vitriols, and then exposing them to the Fire? Why, the Acid of the Vitriol being attracted into the alkaline part of the *Sal-Ammoniac* will expell thence the acid Spirit of the other part of the *Sal-Ammoniac*, render it volatile, and separate it, and then from the conjunction of the Acid of the Vitriol, and the Alkali of the *Sal-Ammoniac*, there will be produced a semi-volatile, vitriolated Tartar, such as was just now described, and the remainder will be a metalline Mass, which existing before in the
 Vitriol,

Vitriol, is now precipitated from it, and separated in the Form of *Fæces*, or, being again corroded by the Spirit of the Salt, produces a new kind of dissolved Metal. Hence, then, you have a true method of judging what will be the consequence of combining fixed or volatile Alkali's, with all native, fossil Acids, though these often lie very closely concealed in Metals, Earths, Oils, and other Salts; for the effect will be always the same, and for this reason may be foretold. And, indeed, these Experiments are so certain, and hence so entertaining, that they cannot be recommended too much; especially if we consider at the same time, that they are of excellent service both to Chemistry and Physic.

But before we quit this doctrine of *Menstruums*, it is necessary we should take likewise into consideration those *Menstruums* which are produced by the combination of fixed Alkali's with the fossil Acid procured by Fire. A pure, fixed Alkali, therefore, when it is perfectly saturated with the Acid of Sea-Salt, Fountain Salt, or *Sal-Gem*, gives a regenerated Salt, which resembles true Sea-Salt in almost every quality. If it is saturated with Spirit of Nitre, it forms a Salt that in almost every character resembles Nitre. If it is properly united with the Acid of Alum, burning Sulphur, or Vitriol, it makes the *Tartarus Vitriolatus* before described. On the other Hand, when a pure volatile Alkali is in the same manner combin'd with Spirit of Sea-Salt, *Sal-Gem*, or Fountain Salt, there then arises the genuine common *Sal-Ammoniac*. If it is united with Spirit of Nitre, or *Aqua Fortis*, it produces a semi-volatile Nitre. If with the acid Spirit of Alum, burning Sulphur, or Vitriol, it gives a semi-volatile, vitriolated Tartar, the same which we above described. These things then evidently inform the Chemist, how many, and what surprizing actions may be often excited in *Menstruums*, purely from mixing and uniting certain Bodies together, and then exposing them to the Fire, as a common moving cause; for it's incredible, what a prodigious alteration often arises from the accidental or designed addition, but of one single Body. And yet without an accurate knowledge of all these things, the chemical Doctrine of *Menstruums* will never be compleat. The Experiments I have made to inform myself in this matter have given me a great deal of Pleasure, as it does now to communicate the success of them to you. But there still remain to be considered the actions of those *Menstruums* where pure simple Salts are united with others. But this, from what has been already laid down, is almost evident of itself. If a pure Alkali is united with Sea-Salt dissolved in Water, the Brine grows turbid, an Earth is precipitated, and the Salt then properly procured by chrySTALLIZATION, is a pure Sea-Salt. A fixed Alkali put into a *Lixivium* of Nitre, makes it turbid and whitish, precipitates an Earth, and produces the most pure Nitre we know of. The same mixed with the Brine of *Sal-Ammoniac* attracts its Acid, by this means sets free its Alkali, expells it, and at the bottom produces a pure, fixed Sea-Salt, the volatile Alkali being dissipated into the Air. A pure, volatile Alkali put into a Brine of Sea-Salt, makes it turbid, depurates the Salt, and then flies off. If it is mixed with dissolved Nitre, it does the same, and purifies the Nitre. If you put it into *Sal-Ammoniac* well diluted with Water, it effects the same depuration there likewise, but it does not at all alter the nature of the *Sal-Ammoniac*, which continues exactly of the same vertue it was before. Vegetable Acids mixed with

with Sea Salt, Nitre, and *Sal-Ammoniac*, make but little alteration in them. And the same Acids, fermented, or rendered purer by distillation, mixed with the same Salts, don't change them a great deal. What alterations are produced in *Menstruums* by the artificial mixture of fossil Acids, with the Salts just mentioned, I gave you before, when I treated of those Acids and these native Salts. In a very few Words, therefore, I just repeat, that in Alum and Vitriol calcined to a dryness, there remains a good deal of a fixed Acid, which is exceeding strong, and has this peculiar property, that when it is rendered active by the Fire, it will expell all other Acids from any Bodies that were dissolved by those Acids, provided those Bodies are of such a nature, that they may be dissolved by this Acid of Alum, Vitriol, and Sulphur; and by this means it produces very particular effects, as a Solvent. Give me leave to illustrate this by an Example. Take Vitriol calcined to a dryness, rub it with Sea Salt, and put them together into a Retort, and with a Fire gradually increased to the greatest degree, distill them, and there will rise a pure Spirit of Sea Salt: For the Acid of the Colcothar being superiour, expells the volatile Acid of the Sea Salt, takes possession of the other fixed part of this Salt, and from these two concreted together, produces a kind of *Sal Mirabilis Glauberi*, but which, at the same time, contains the metalline *Fæces* that were in the Vitriol. But this, indeed, I explained to you before. Again, if you take Mercury, and rub it with calcined Vitriol, 'till it is thoroughly divided, and then to this Mixture add decrepitated Sea Salt, and put this Compound into a Glass Cucurbit, and very gradually urge it with a sand heat, then the Acid of the Vitriol converts the Acid of the Sea Salt into a Spirit, which being agitated and heated, dissolves the Mercury, as usual, and then carries it up in form of a pure *Mercurius Sublimatus*; which is nothing else but the very pure Spirit of the Sea Salt, attracted into the Mercury, and united with it into a homogeneous, vitriolic, mercurial Mass. But there are an infinite number of effects, and those very surprizing ones too, that may be understood from these principles in the History of *Menstruums*. Hence, from Alum, or Vitriol, calcined, and mixed with Nitre, is distilled *Aqua Fortis*, in which there is nothing of the Acid of the Vitriol, but which is pure Spirit of Nitre. If they are treated in the same manner with Sea Salt, you have a Spirit of Salt. If with Nitre and Sea Salt together, in distillation there arises an *Aqua Regia*. Hence, if Nitre and Colcothar are exposed to an open Fire in a Crucible, the Acid of the Nitre is dissipated, and there remains a kind of *Nitrum Vitriolatum*. And Sea Salt calcined in this manner, leaves a kind of *Sal Mirabilis Glauberi*. But it will be more entertaining to you, from the principles I have laid down, to carry these Experiments farther yourselves, than if I should lay them before you too particularly. I have but one thing more, therefore, to add, and that is, that by combining Salts with Salts in any manner whatsoever, there always arise new Salts, and new *Menstruums*. By this means, therefore, the Chemical Science is continually advanced; and hence now, appearances perpetually offer themselves to our observation, which are very agreeable, promote the knowledge of natural Philosophy, and often furnish us with new and very useful discoveries.

But in the last place, there arise new *Menstruums*, likewise, and those of different vertues, from the combination of various *Menstruums* with one another: And

here there is room for infinite application ; as there is also in reducing of any sort of *Menstruum* to its greatest purity ; and the attenuating any one into the least Particles, which it is possible either for art or nature to reduce it to : For in these three particulars seem to have consisted the peculiar and excellent knowledge of the top Masters of the Art. But it's impossible to deliver here what might be said upon this Head : Let one Example suffice. I want, for instance, the purest, strongest, and most subtil, vegetable Acid. Take, then, the best Verdegrease, which is Copper finely corroded by a fermenting, exhaling Acid, and pour upon it twenty times as much of the strongest Spirit of Vinegar that can be procured by distillation : Digest these, that the Verdegrease may be dissolved into a very green Liquor, which depurate accurately by letting it stand quiet, and filtering it, and then with a gentle Fire inspissate it till a pellicle is formed on the surface : Then let it be set by in a quiet place, and it will shoot into Chrystals, like Emeralds, consisting of the Acid of the Vinegar, and the corroded substance of the Copper. Decant the Liquor, collect the Copper Globules, and inspissate the Liquor again to a pellicle. Take out again the new-formed Chrystals, and proceed in this manner, 'till no more Chrystals appear. If you then dry this Copper Mould, thus saturated with the Acid, very gently with a moderate warmth of the Air, and then very gradually urge it in a glass Retort, you will have an incorruptible, vegetable Acid, exceeding strong, nor affected with any metalline taint from the Copper. If you attempt this with Lead, Tin, or Iron, it will never succeed : Copper only answers the end, by attracting the Acid, separating it from its Water, and returning it back again, without any alteration ; whereas the others attract it indeed, and separate it, but never part with it again pure. As from malt Liquor, now, fermented Manna, Honey, Sugar, Cyder, and Perry, such Vinegar may be prepared, from these, likewise, by the help of Copper, may be procured such a strong Acid. Hence *Zwelfer* falsely imagined, that he was in possession of the famous Alcahest, for which he was sharply handled by the shrewd *Tachenius*, who strenuously insisted upon it, that it was nothing but strong Vinegar. But there are infinite numbers of *Menstruums* that may be still found out : And hence almost every Artist boasts of some particular *Arcanum* ; nay, and indeed is able generally by the assistance of it, to do something more than any body else can possibly do, who is not acquainted with it. But here, it's true, the usefulness of the discovery is often not so much to be extoll'd, as the vanity of the possessor of the secret is to be blamed ; as no body who is expert in the art will ever be at a loss to find out new *Menstruums*, if after that he has by his art prepared Bodies, he will but apply them to others. And hence, perhaps, the Solvents proper to every kind of Body, and therefore to the human *Calculus*, might by this time have been discovered, if the Chemists had but applied all their Liquors to this Stone, as there are often effects produced in this manner, which could not possibly be foreseen : Thus, if a person was acquainted with all *Menstruums* whatever but Spirit of Bread, the efficacy of that in dissolving many Bodies would appear to him quite incredible. But by mixing one *Menstruum* with another, there often arise new ones, and those too very beautiful. Thus, for instance, *Tartarus regeneratus*, if it is rightly prepared, may be intimately united with the purest Alcohol of Wine ; and then you have a vegetable *Menstruum* composed of

of a vegetable Alkali, Acid, and Sulphur, exceeding subtil, and very closely combined together; and hence it is of mighty efficacy, made use of either as a *Menstruum*, or a Medicine. Again, if the purest, most saturated, alkaline Spirit is united with the purest Alcohol, it becomes the *Offa Helmontiana*, and makes a noble *Menstruum*. This very nicely dissolves distilled, vegetable Oils, and hence arises a *Menstruum* consisting of a genuine Sulphur and Alkali, concerning which one may doubt, whether there is any thing more excellent, either in Medicine or Chemistry. In the same manner, if the best Spirit of Nitre is perfectly saturated with an alkaline Spirit of *Sal-Ammoniac*, we obtain an almost volatile Salt of Nitre; and hence may be prepared that so much wished for volatile Nitre, which whether or no it answers the great Expectations formed of it, may then be easily tried by Experiments. In the cultivating and improving of these studies some Chemists have employed an Age, and have thought the pleasures that arose upon their new discoveries a sufficient recompense for all their labour. And let me advise you, Gentlemen, to apply yourselves to these inquiries, noting down whatever new you meet with, that thus, from a sufficient number of Observations collected together, you may, at last, with caution, be able to draw some Rules that shall be of a more general nature.

The doctrine of *Menstruums*, then, being thus dispatched, let us proceed to deduce some Corollaries from what has been delivered. First, then, it is not yet certain, whether any *Menstruum* has such an innate power, that it is able to act upon its solvend object without the least assistance of Fire. Nor, indeed, is it possible to make any Experiment that shall be able to determine this, as in every place there is Fire, and that a pretty deal too, from which it cannot possibly be freed. Nay, in fact, almost all the *Menstruums* that we are at present acquainted with, if they are quickned with a certain degree of Heat, perform their Solution so much the better. 2. *Menstruums* scarcely become efficacious, till they are reduced to a fluid form, or one very near it. And this, Fire, Air, Water, and Attrition, in particular, bring about; which four causes likewise generally excite *Menstruums* into action, though before they lay quiet. 3. Some *Menstruums* seem to have a power implanted in them, by the efficacy of which they produce a motion, depending only upon the nearness of the Bodies to which this motion relates. If a very good Loadstone, suspended by a Thread and at rest with respect to its poles and those of the World, should be absolutely without motion, one would be led to think, that it had no active power: But if in the very greatest degree of cold, a piece of Iron, or another Loadstone should be brought within the sphere of its activity, there would immediately be generated a motion in them both, which would last till they came into contact, and then being joined together, they would both be at rest. This power, therefore, spontaneously, and without the assistance of any sensible Fire, generates motion, not seeming to be excited by motion, itself. In the same manner, the best Spirit of Nitre, though it's kept close stopp'd up, will for years continue to emit a red Fume, which hanging over the surface, keeps in continual motion, and rises out of the mouth of the Vessel as soon as ever you take out the Stopper. The same thing is true, likewise, in an alkaline Spirit of *Sal-Ammoniac*, which, as far as I have been able to observe, is never at rest. And as for that Spirit which is distilled from *Sal-*

Corollaries.

Ammoniac, with Quick-Lime, that is still much more agile. Such Bodies, therefore, both excite and preserve motion in a wonderful manner. That such Vapours, now, may be perpetually floating about in the subterraneous parts of the Earth, 'till they light on some certain Bodies, in which being afterwards fixed, and united, they form variety of compound Bodies there, who will deny? In all these cases, however, this must be considered, that even in the greatest degree of Cold, the Air is in a constant oscillatory motion, which is often the cause by which those motions are likewise excited. By this motion, now, proper to *Menstruums*, and arising from them, solutions are often brought about immediately, which could not be effected by the greatest degree of motion excited by any other cause. If you have a mind to see an instance of this, take only a piece of *English Chalk*; let it be calcin'd in the intensest Fire, nay, even *Tschernhausen's Focus*, and it will scarcely be altered in this vast motion; expose it to the hottest, coldest, calmest, or most stormy Air, and it will remain just the same; keep it ever so long in boiling Water, it will not be dissolved; boil it in a *lixivium* of Salt of Tartar, and it will still be chalk: And yet put it only into cold Vinegar, and it will dissolve and disappear. Hence, therefore, it is evident, what a prodigious difference there is between that motion which is excited by the reciprocal action of the *Menstruum*, and Solvend, and that which is produced by Fire, Air, Water, and Impulse. 4. That which we call acrimony, therefore, in a *Menstruum*, because it corrodes our Body, and gives us pain, does not render such a *Menstruum* fit to dissolve other Bodies: This we see evidently in Oil of Vitriol, Spirit of Nitre, Spirit of Salt, and *Aqua Regia*, which though they instantly consume any part of us, are not capable of dissolving Wax, and Sulphur, which are so easily dissolved by our Humours. 5. Many *Menstruums* cannot naturally dissolve certain Bodies; and yet if these Bodies are first dissolved in some other *Menstruum*, they will then be disposed to be dissolved in those very *Menstruums*, which before they absolutely resisted. Boil, for instance, common Sulphur in Alcohol, as long as you please, and it will no more dissolve in it, than a Stone will in Water; but melt this Sulphur with Salt of Tartar, and it becomes a redish brown Mass, and then pour Water upon this, even in the cold, and the Sulphur will be very readily and intimately dissolved: Boil Powder of Antimony in Alcohol, and it has no effect upon it; but boil the same in an alkaline Salt dissolved *per Deliquium*, till it becomes a dry Mass, and then pour Alcohol upon it, and you will soon have a golden Tincture. And, indeed, such a well-managed, successive application of different *Menstruums* to Bodies, the greatest Masters in the Art have laid so much stress upon, that *Boyle*, *Homborg*, and *Tachenius* have told us, that even Metals themselves may by this means be intimately resolved into their two constituent Principles, a fixing Sulphur, and a regenerated Mercury. For they assert, that if Silver is dissolved in Spirit of Nitre, and then digested for a long time in a pure, fixed Alkali, and afterwards sublimed a good many times with *Sal-Ammoniac*, it will at last yield a fluid Mercury; and at the same time they call these, resuscitating Salts. Thus Acids procure an entrance for fixed Alkali's into the inmost parts of Metals; and then the fixed Alkali's assist the volatile, alkaline Salts to penetrate them, which otherwise they had not been able to effect. This is what these Gentlemen assure us. If you ask me whether

I believe that Metals may thus, by the assistance of Salts, be reduced to Mercury? I can't tell what to say to it. For my own part, I frankly confess, I have taken a great deal of pains upon this head, but have never yet been able to effect any such thing: Conscious, however, of my own inferior abilities, I would by no means go about to detract from the capacity or credit of others. 6. Some *Menstruums* dissolve certain Bodies, which before the Experiment was made, seem'd the least in the World fitted for such a solution, whether you regard either the *Menstruums*, or the solvend Bodies. Thus, for instance, the tenacious, viscid, native Turpentine becomes so penetrating in the human Body, that in a very short time it gives a violet smell to the Urine, changes its colour, and heats the whole Body; if it is mixed with Oils, it dissolves them; as it does perfectly Refins in a small degree of Heat, tho' they dissolve with so much difficulty: And it has the same effect, likewise, upon Gum-Resins, which can scarcely be dissolved by any other method; as Gum-Copal, and others. But what must we think, again, of the Yolk of an Egg? If one may be allowed to speak by analogy, it is the *Placenta* of the Chicken, an organical Machine, whose infinitely subtil structure eludes the most acute, microscopical observation, and the most curious anatomical inquiry. Is it not a viscid, tenacious, unactive Substance, without Smell, taste, or any the least degree of Acrimony? And yet if this is rubbed in a gentle Heat, according to art, with any gummy, oily, resinous, or balsamic Substances whatever, it does more than can be effected by any other *Menstruum*; for it destroys their viscidty, and renders them dissoluble in Water, and Spirits, and very easily miscible with the animal juices. Here then we must allow, that Nature furnishes us with a *Menstruum*, that can scarcely be equall'd by any production of the profoundest Art. The very bitter, yellow Bile too of any sound Animal, Fishes in particular, that have no Lungs, and are voracious, have almost the same effect upon balsamic, gummy, resinous, tenacious, teribinthenaceous, viscid Substances, which they happily dissolve by being gently mixed with them. Manna, Honey, and Sugar, with warmth and rubbing do the same. I might here take notice, likewise, of the White of an Egg: When this is hardened by boiling, well separated from the Yolk, and distilled in a *Balneo Mariæ*, it yields a clear Water, that has no considerable Smell, or Taste, is neither saline, acid, or alcalious, and yet whose efficacy is so great and peculiar upon Metals, that both *Paracelsus* and *Van Helmont* agreed, that this alone was proper for the preparation of their medicated Mercury, of such excellent vertues. And if you take the hard White of an Egg, put it in a clean Vessel, and in a Cellar expose it to the Air, you will have from it a very insipid Liquor, which, if it was offered one, one would take to be pure Water; and yet this Water will penetrate Myrrh, which is so hard to be dissolved, in such a manner, that it will be better resolved by this, than by any other *Menstruum* whatsoever. To persons, now, not acquainted with these things, there is nothing seems more surprizing, than that Bodies should be dissolved by the very softest *Menstruums*, which are affected by scarcely any other. 7. I assert, therefore, that neither acidity, a lixivious acrimony, or saline disposition appearing physically to be present in any *Menstruums*, does ever demonstrate, *a priori*, that such a *Menstruum* will dissolve any given Body; but this certainty must always depend upon some Experiment, by which it

it has appeared that this Solution will happen, if this *Menstruum* and that Body are mixed together. For if simple Sulphur is put into any known Acid whatever, from the mildest to the strongest, even tho' it is assisted by Fire, the Sulphur will remain unaltered as Sand in Water. So Spirit of Nitre, howsoever it acts upon other Metals, has no effect upon Gold. It is idle, therefore, to say in general, that Acids dissolve Metals; for this or that Acid only, dissolve such and such particular Metals. If a Person, after he had in many instances experienced the corroding quality of the strongest caustic Alkali, should hence begin to believe that this power would extend itself to all other Bodies; how much would he be deceived, when he saw plainly that Mercury, Gold, and Silver, suffered nothing from this Solvent. And the same thing we observe holds good in Salts: For if Silver is boiled with Salt of Tartar it grows white, tho' it does not do so at all if it is boiled with Sea-salt. We must not therefore, pretend to say, that Alkali's, Acids, or saline Bodies, are solvents in general, but only in a limited sense, with respect to their particular objects: If we offer to proceed any farther, the nature of the thing is against us. 8. On the other hand, a prudent Chemist would not presently conclude, from seeing any Body dissolved, that the cause of this Solution, was an acid, alcalious, or saline Body, if there were not some other circumstances, that might more certainly determine it. And yet this error, the modern Chemists have often fallen into, who, being too prone to run into generals, have from any observed Solution presently imagined, that they knew the Solvent. But suppose, now, that in a given case, a Person was sure that Gold was there dissolved into its smallest Particles, and at the same time knew perfectly well that Gold is not dissoluble by any known Salt except Sea-salt, and what is produced from it: Yet even here, one cou'd not certainly conclude, that because Gold was here dissolved, therefore Sea-salt was the Solvent; for if the purest Mercury is rubbed upon the cleanest Gold, it will penetrate, corrupt, and dissolve it. In all nature, now, we don't know any Body, that is less acid, alcalious, or saline than Mercury; no Body in which there is less Acrimony than in this, as it gives no pain, tho' it is applied to the Eye, or the bare Nerves: And yet this we see dissolves Gold, which Sea-salt excepted, resists every acid, alcalious, saline, acrid Body that we are acquainted with. 9. But I assert farther, which is still a greater paradox, that all that physical Power, which we generally call corrosion, or corroding Acrimony, is, absolutely considered, nothing at all, but relative only between particular corrodents and corrodends, and not between every corrodent and all other Bodies: Hence, if a Person, after he had, in an infinite number of instances, experienced the corrosive Acrimony of *Aqua Fortis* upon Animals, Vegetables, and Fossils, shou'd thence hastily conclude, that therefore this very corrosive Liquid wou'd much easier corrode any Bodies that were softer, he wou'd soon find himself mistaken by putting into it the softest Wax, or the brittlest Sulphur. 10. Nor, on the contrary, will it at all follow, that because any particular Body is very soft, with regard to our senses, nor corrodes and resolves the Animal Fibres, it has not, therefore, a dissolving Power: For a Person, without any inconvenience, might take a considerable quantity of sweet Oil of Olives; and yet Sulphur, which resists every corroding Acid, may soon be entirely dissolved in it; as may Wax likewise, which corrosive Acids do not affect. Even melted Wax, which is so soft and unactive, is said to extract a

Colour from Coral, gently indeed, but very efficaciously; and yet the same Coral would bear the extreme violence of the Fire for a long time, without being altered; nor be affected by any Alkali's. This no-body could easily have believed *a priori*, but must first be convinced of the truth of it by particular Experiments. Those Bodies, therefore, which appear to us to be exceeding hard, and are found to be so in the Fire, do not hence, in order to their Solution, require Solvents which have given any proofs of their being very acrid. And hence, upon these principles, it won't seem impossible to be found out in Art or Nature, a Solvent that shall be suited to any given Body scarcely dissoluble by any thing else, which *Menstruum* at the same time shall not be able to corrode other Bodies, that are much weaker and softer. And the only way here, if one would do any good, is successively to apply all the *Menstruums* we know of, to the Body whose Solvent we want to discover: For very often that which seems most unfit for the purpose, answers it better than any other whatsoever. Consider, for instance, the Stone in the Bladder, and Cancers. These we have not hitherto been able to cure; but yet we ought by no means to despair of finding out a Remedy, which may be able to dissolve the Stone without hurting the Bladder, which from what has been said, we see wou'd not necessarily follow. Spirit of Rye-bread, has a wonderful power of dissolving almost any Stones, and yet does not by any corrosive quality hurt the human Body. The Water drawn from the hard Whites of Eggs, may be dropp'd into the Eye without any pain; and yet with regard to many things, has a dissolving virtue. 11. Most *Menstruums*, at the very same time that they dissolve, and change their objects, are perfectly likewise changed by them, so that the action between them is reciprocal. This appears to be true in almost all *Menstruums*. Water, Alcohol, and Mercury, indeed, are less altered than others, but those likewise are changed by degrees. For tho' the Alchemists say that the purest Mercury never suffers any alteration; yet this by the admixture of other Bodies is altered by concretion: And as that itself is often rendered impure by other Bodies, it must then be in some measure altered by them; even when by transmutation it is converted into Metals. 12. It is a very great mistake to imagine, that all *Menstruums* will constantly perform their Solutions so much the more efficaciously, as they are more depurated, and reduced to their greatest degree of strength; for very often their virtue decreases in proportion to their strength and simplicity. If you want, for instance, a Vitriol of Lead, and for this purpose dissolve it in *Aqua Fortis*, you will always find the Solution more difficult in very strong Spirit of Nitre, than if it is diluted with a sufficient quantity of Water. The same is true in Iron, which dissolves in Oil of Vitriol mixed with four times its weight of Water, whereas if it is thrown into the purest Oil of Vitriol, the Mass in an instant becomes almost immovable. Hence the purest Alcohol coagulates a great many things which common Spirit of Wine dilutes and dissolves: This appears evident in human Blood, which is coagulated by the former, but diluted by the latter. Hence the greatest simplicity of a *Menstruum*, or its utmost perfection in its kind, does not always increase its dissolving power upon particular Bodies. But on the other hand, it is true likewise, that if the same *Menstruum* is applied to other Bodies, it often requires the exactest purity to be able to act upon them as a Solvent. If we want, for instance, to dissolve distilled Oils accurately in Spirit of Wine, it must

must first be reduced to the purest Alcohol, or it will have no effect at all. In the same manner, if you wou'd dissolve Amber in Spirit of Wine, you must make use of the most rectify'd Alcohol possible. So that here again we can't pretend to pronounce absolutely of *Menstruums*, whether they are required pure, or diluted, to induce such and such changes upon Bodies, unless it has been first precisely determined by Experiment. 13. But in this Doctrine of *Menstruums*, there is nothing more remarkable, than that in Solutions performed by them upon their object, there often arises a new power in Nature, which neither existed in the *Menstruum*, or Solvend, before the Solution, but depends intirely upon this union of them together. A Child, for instance, may without any inconvenience, take 3 grains of Crude Mercury, and so it may 7 or 8 grains of Spirit of Sea-salt; and yet when from these prepared together, you have 4 grains of *Mercurius sublimatus corrosivus*, if the Child should take this, it would prove a most violent Poison. So one may safely give a Child 30 grains of Crude Antimony powdered, and as many of Nitre properly diluted; but if these are reduced to a Powder, mixed together, and then set on fire, you have in an instant a *Crocus Metallorum*, of which no-body wou'd give a Child 6 grains, that did not design to destroy it. I wish, therefore, the Chemists wou'd hence be cautioned for the future, not to believe that the productions of their Solutions are always good Medicines, or at least not hurtful to the human Body, because the Simples which produced the Compound had medicinal vertues, or else were innocent. Certainly, the greatest miscarriages that have happened in the Art, and have often brought it under such disgrace, have risen from this precipitancy of the Artists. And, indeed, nothing has ever more surprized me, than to see the unlimited liberty that both the Chemists and Physicians have taken in determining the medicinal vertues of every Body which they have by their Art prepared. Examine *Basil Valentine* only, in his *Currus Triumphalis Antimonii*, and you will see a flagrant instance of it. For my own part, I have often thought with myself, that a Carpenter, Mason, or any other handicraft, might as well cry up every thing in their way, as these Persons do in theirs. But you, Gentlemen, who will make truth, and the good of mankind your study, will always remember, that this itch of commending every thing must be prudently restrained; and that if you shou'd meet with any new thing that you have a mind to make trial of, it is proper to begin with a very gentle dose, and proceed gradually, carefully attending to every effect it produces: And if it is made use of with this caution, the Doctrine of *Menstruums* will open a way to the understanding the most excellent things that belong to the Art. For if you examine the *Classes* we have described, and the Objects that properly belong to every one of them, and consider carefully the true marks assigned, you may then at length make use of this Doctrine in such a manner, as to be able, as much as possible, to determine *a priori*, what will happen upon the application of one Body to another: But here, however, you will continually meet with new appearances which you were not acquainted with before. As far as I have been able to let you into the Knowledge of these things, I have done it with pleasure, and must now pass on to something else, viz. the consideration of

The universal Menstruum or Alcahest.

Whoever, therefore, carefully considers what has been hitherto delivered, will easily believe, that all chemical solutions of Bodies, except a few purely mechanical ones, are the effect only of attraction, and repulsion, between the Particles of the *Menstruum* and those of the Body dissolved; hence, therefore, that all the action here depends upon the relation betwixt these two; and of consequence, that according to the known rules of art there cannot be assigned any Body, either natural, or artificial, which, without any distinction, would dissolve all Bodies whatsoever: Nay, and farther, that it is impossible to deliver any physical method, by which the resolution of all Bodies promiscuously may be obtained. Nevertheless, after *Van Helmont* the Father had published his Writings, there was a report went about in the Chemical World, of a secret, universal *Menstruum*, which *Paracelsus* was said to have possessed, and which he, according to his manner of writing, called the *Alcahest*. If any such thing, now, as *Helmont* solemnly swears, was ever known to any mortal, it certainly ought to be looked upon as the most excellent favour, that the Divine Being ever indulged Mankind with, either in the Chemical, or any other Art. This, without dispute, would be vastly more valuable than any Philosopher's Stone, and much more to be wished for, as by the help of it might easily be obtained the most certain means both of Health and Riches. This, with a great deal of reason, was the opinion of Mr. *Boyle*, who yet, after an infinite deal of Pains, and with all the skill that he by this means acquired, was never able to come at the discovery of it, nay, upon the best foundation, scarcely believed, that there ever, in reality, was any such thing. Designing Men, however, have made a handle of it to satisfy their avarice, by imposing upon such persons as they found fond of such kind of *Arcana*: Prudent Men have always remained in suspense, not daring absolutely to pronounce any thing in it. For these reasons, therefore, I was willing to give you an historical account of this Affair, just as it is, that is to say, as it may be collected from the Writings of those Authors who alone have wrote of this *Menstruum*; that thus at least we may know the opinion of those Persons, who tell us, they have possessed, and made use of this *Arcanum*. Every thing, however, that has been said upon this head, by other People, has been borrowed from *Helmont* alone; for from what *Paracelsus* himself wrote of the *Alcahest*, no mortal would ever have thought of any such thing, had not *Helmont* given the hint, that such great mysteries were couched under this uncommon Word. As for my part, I confess freely, I am not master of this secret of the Fire; and therefore I can do no more than by carefully examining, and faithfully comparing one thing with another, lay before you what is to be found in these Authors. And if these persons were really acquainted with any such thing, and were willing that one who studied their Writings attentively should find it out; I know no better way of coming at it than what I have proposed. By this means a person who is disposed to set about this grand work, may know what Matter he must make use of, by what Instruments he must operate, and in what method he must proceed, that so he may not lose both his labour and his money. And it will farther, too, have this great advantage, that it will secure us

from being imposed upon by the tricks of Impostures, whose boldness and knavery make them formidable, but who don't know themselves what they pretend to; for these Fellows may be easily detected by any person who is acquainted with the doctrine of *Paracelsus*, and *Van Helmont*. This I myself have sometimes found excellent use in, when I have happened to have to do with these vain pretenders. Let us, therefore, with a great deal of caution, proceed.

First, the
Name.

And in the first place, let us consider the name, which is *Alcabeſt*. This word, before *Paracelsus*, no body ever made use of, no not even among the Chemists. And even he himself, as far as I have been able to discover, never used it, but in one passage, which you have in his Treatise *de Viribus Memororum*, Lib. II. C. 6. where there are these words. *And the Liquor of the Alcabeſt is exceeding efficacious in the Liver, to comfort and strengthen it, and to preserve it from a Dropsy, and all the Diseases that have their rise in it. And its process is, to be resolved after Coagulation, and coagulated into a transmuted form. This appears in its process of Coagulation and Resolution. And then if it overcomes (sui simile) that which is like it, it is a Medicine for the Liver above all Medicines. Nay, though it were consumed, it would supply the place of an intire Liver, as though it were not consumed. All you, therefore, that make Physic your Study, ought to know how to prepare the Alcabeſt, in order to remove a great many Diseases that have their seat in the Liver.* So that *Paracelsus* never made use of this word but twice, and that only in this place; nor is there the least Mention of any such thing, either before or after, as I informed myself by a careful examination of all his works. No mortal, therefore, from what he said upon this head, would ever have thought of this grand secret, had not *Helmont* afterwards added his interpretation.

Secondly, its
Etymology.

The derivation, therefore, of this new word, thus coined by *Paracelsus*, was examined into. And upon considering, that it was usual with him to conceal common words by the transposition of their letters, it was imagined that was the case here; though sometimes too he formed strange words by joining the beginnings of different words together. Thus when he would have you make use of (*Tartarus*) Tartar to resolve the *Saburra* in the Spleen, he says, take *Sutratat*. L. II. *de Vir. Membr.* C. 7. And again when for diseases proper to the Kidneys he prescribes Saffron, which from its golden Colour the Chemists called *Aroma Philosophorum*, he says, these Distempers are cured by *Aroph* L. II. *de Viribus Membr.* C. 10. Hence, therefore, some persons have thought, that *Alcabeſt* signified *alkali est. Rolfinc. Eph. Germ.* D. 12. Ann. VI. VII. p. 193; *Rulandus* in his Lexicon; and hence supposed that it has always an Alkali for its basis, which is then saturated with a proper Acid. Others have been of opinion, that it was called so *quasi Staltzgeist* because if the *Alcabeſt* is the same with the *Circulatum*, they imagined it was made from Sea Salt, coagulated, resolved, and coagulated into a transmuted form. But again, others suspected, that it was called *Alcabeſt, quasi Algeist*, or a perfectly pure simple Spirit: This they thought its process of coagulation, resolution, and coagulation, seem'd to teach us. And lastly, there is *Faber's* opinion, who says, it is a pure, mercurial, metalline Spirit, which is so united with its own proper Body, that hence two become one Body, that is inseparable, and indestructible. *Eph. Germ.* D. 11. Ann. 8. App. III. This, then, being

being all we can learn from the etymology, let us pass on to the synonymous terms, and see if by comparing them together we can get any farther light into it. *Paracelsus* himself has left us no synonymous name, but *Helmont* has a great many, and therefore these we will now examine. And in short we have no other assistance besides the authority of *Van Helmont* alone, who declares that the very same bottle was given likewise to him.

In the first place, then, he calls it simply, *Water*; telling us, p. 88. § 27. that he knew a *Water* which he must not discover, by the mediation of which all Vegetables might be transmuted into a distillable Liquor, without the least *Fæces* remaining at the bottom of the Vessel. And in the same place § 29. he says he mixed together a certain *Water*, and Coals made from Oak, in an equal quantity, and digested them with a bath heat in a Glass hermetically sealed. And there he calls the same a *thick Water*, whilst he writes § 28, that in the second Book only of the *Maccabees*, Chapter the first, there is mention made of a *thick Water*, which was a perpetual Fire, and perhaps not unlike his *Water*. And in another place he calls it a *solvent Water*, as p. 628, where he says, the Liquor *Alcabeſt* is an immutable, *solvent Water*. But he came still nearer the matter, when with one word he called it (*Ignis-Aqua*) *Fire-Water*, for whilst p. 337. § 3. he is giving an allegorical account how he came by his knowledge, he pretends he received a bottle in which there was *Ignis-Aqua*, of one word only, a name perfectly simple, singular, indeclinable, inseparable, and immortal. And again he calls it a *Latex* reduced to its least Atoms possible in nature. p. 94. § 28. But he very frequently calls it a *Liquor*, p. 85. § 6. By the addition of the *Liquor Alcabeſt* of *Paracelsus*, he asserts, that all Bodies may be converted into *Water*, p. 119. § 89. And that by the *infernal Fire*, which is the *Liquor Alcabeſt* of *Paracelsus*, may be known how much any Vegetable contains of either Luminary. p. 265. § 11. p. 384. § 43. p. 419, 628, 700. § 23, 700, § 2. p. 706. § 10. 714. § 27. 776. § 11. 60. And he calls it, likewise, the *solvent Liquor* p. 88. § 29. All these things, therefore, seem to intimate, that this *Arcanum* was of a moist, liquid form, like a kind of a *Water*. In another place, as a synonymous term, he makes use of *the Fire of Hell*; for he says expressly, § 28. p. 119. by the *Fire of Hell*, which is the *Liquor Alcabeſt* of *Paracelsus*. And again, p. 45, 15. Original Sand resists both Art and Nature, nor can by any means be made to recede from its constancy, except by an artificial, *infernal Fire* alone, in which artificial *Fire Sand* becomes Salt. If *Helmont*, therefore, in this appellation has followed *Paracelsus*, by this we may know what the *Alcabeſt* was, because *Paracelsus* himself has wrote of this *infernal Fire*: But of this by and by, when we come to speak of the *Alcabeſt* itself. Afterwards, *Helmont* says, this is a most happy and perfect Salt, which has arrived to the utmost degree of purity and subtlety that Nature is capable of. § 24. p. 384. And for this reason, he seems to call it, the *Ens primum Salium*, p. 419; the *Sal Circulatus*, and the *Sal Circulatus Paracelsi*, § 11. p. 43. § 49. p. 374; the *Circulatum majus*. Ibid. *Sal Circulatum*, p. 576. *Sal Circulatus*, p. 628; *Sal Circulatus Paracelsi*. § 23. p. 700; of which he made mention in his Book *de Renovatione & Restauratione*. If, therefore, *Van Helmont* has acted candidly and honestly in this affair,

Thirdly, the
Synonyma's.

affair, we may from these synonomous terms, and the writings of *Paracelsus*, make an attempt towards a discovery of this wonderful *Menstruum*.

Its origin.

But before we proceed to this, we must in the fourth place consider its origin. First then it is never found spontaneously in Nature; for here Nature is deficient, § 12. p. 56. where he expressly asserts, that part of Earth may be homogeneously reduced into Water by Art; but strenuously denies, at the same time, that this can ever be effected by Nature alone, because in Nature the agent is wanting by which true Earth may be reduced into Salt and Water. Nor is this produced except by the chemical art, which alone discovers a *Latex*, which cannot be transmuted, being reduced to the smallest Atoms that are possible in Nature. § 27, 28. p. 94. Nor is this to be effected by vulgar Chemistry, but by the labour of Wisdom. *Ibid.* § 23. p. 700; and that, as he expressly asserts, as its ultimate and most perfect production. And lastly, he says, Chemistry, as its most excellent effect, prepares a *universal Solvent*. § 65. p. 387. Nay, and in the whole Art there is not any operation more difficult than the preparation of the *Alcabeft*; nor is there in the whole Art any thing more laborious. Nor can the knowledge of this Operation be acquired either by reading, or meditation, but by a fulness of science, and that too doubly confirmed; and hence very few are acquainted with it. § 23. p. 700. And for this reason this *Liquor*, whose Operation is vastly tedious, cannot be obtained by human understanding; For though a person should have so much skill in the Art as to be properly qualified to come to the knowledge of it; yet unless the Most High, by a special favour, leads him to it, he will never arrive at it; for he must be chosen by a particular privilege, whoever becomes Master of it, § 27. p. 714. For God alone is the dispenser of it, for reasons which are known to the Adepts, § 2. p. 704. From this origin of it, therefore, thus delivered by *Helmont*, we may see how much they are mistaken, who idelly imagine, they shall be able to prepare it with a little trouble. These vain boasters certainly thus discover both their ignorance and their dishonesty. Nor let them impose upon you, by pretending to more things of the same nature; for *Helmont* absolutely refutes every thing of this kind, by plainly asserting, that as in the whole compass of nature there is but one Fire (*Vulcanus Ardens*) a burning Fire, so there cannot be but one Liquor, which will dissolve all Bodies into their first Matter, without any alteration in itself, or diminution of its strength; as the Adepts know and testify, § 6. p. 677, 678. Being secured, therefore, by this doctrine, I have been able to silence many illiterate persons, rich in promise and expectation, and sometimes crafty Foxes too, by only asking them one or two questions, by their answers to which I soon perceived how little they understood of what they boasted of.

Fifthly, its
Vertues.
First, with
regard to its
Object.

But let us now proceed to examine into the stupendous vertues that are ascribed to this wonderful, and almost tremendous *Arcanum*. This *Menstruum* then can efficaciously exert its dissolving power upon all sensible Bodies whatever, whether Simple or Compound, Volatile or Fixed, Solid or Liquid, Animal, Vegetable, or Fossil; nay, upon Gold and Mercury themselves, upon which nothing else can act to their intimate parts. Thus hear him speaking himself. (*Nostre Mechanica*) Our Mechanics have discovered to me, that all Bodies, whether rocky, stoney Substances, or Gems, Flints, Sand, Mercasites, Clay,

Clay, Earth, Bricks, Glafs, Lime, Sulphur, &c. may be transmuted into an actual Salt, æquiponderant to the Body from whence it is procured: And Vegetables, Flesh, Bones, Fish, and every thing like them, I have known to be reduced by it into their three mere Principles: Metals, however, on account of Anatic Commixture of their Seed, and Sand, are reduced to a Salt with a great deal of difficulty, § 11. p. 43. For Sand, or original Earth, resists both Art and Nature, nor will by any helps of Art or Nature be made to recede from its primitive constancy: But under the power of the Artificial *Infernal Fire* alone, Sand becomes Salt, and at last Water, §. 45. p. 15. Again, The *Alcabest* of *Paracelsus*, by subtilizing them, transmutes all natural Bodies, §. 7. p. 57. And in another place, all Bodies are easily reduced to Water by the application of the *Liquor Alcabest* of *Paracelsus*, §. 6. p. 85. Even those that otherwise refuse to be resolved into their three Elements, *Ibid.* By the help of this likewise, all Vegetables are commutable into a Liquor, which may be distilled without any *Fæces* remaining at the bottom of the Glafs, §. 27. p. 88; even oaken Coal itself, *ibid.* §. 29. For one and the same Liquor, *Alcabest*, perfectly reduces all tangible Bodies in the Universe to their first Life, §. 11. p. 266; even all Poisons themselves, §. 49. p. 374. And which dissolves every thing besides itself, as warm Water dissolves Snow, §. 24. p. 380. §. 65. p. 387; Oil itself, and Spirit of Wine, p. 576; Cedar Wood, p. 634; All kinds of *Elixir Proprietatis*, 635; The *Ludus* likewise of *Paracelsus*, p. 700; Mercury, §. 10, 11. p. 776; Gold itself, §. 10. p. 706, which cannot by any other Solvent whatever be radically destroyed into its constituent Principles, as it is much easier to make Gold out of what was not Gold before, than to produce any thing from Gold which shall not be Gold. To this agree all the whole Tribe of Adepts, who unanimously assert the truth of it.

In the sixth place, let us consider the manner in which the *Alcabest* exerts its power upon these its Objects. And here we find its efficacy is always excited by Fire, and this applied only in a gentle degree, whether it acts in digestion, distillation, or cohobation. For he mixed the *Alcabest* with Coal made from Oak in equal parts, and digested them for three days in a Bath-heat, in a Glafs hermetically sealed, and the Solution was then compleated, §. 29. p. 88. The *Sal-Circulatum*, by digestion only, reduces every sort of Oil, and Spirit of Wine, into a prodigious different form, from what they were in before, p. 567. If the *Alcabest* is mixed with an equal weight of Cedar-wood reduced to small pieces, and is exposed to a kindly warmth in a sealed Glafs, the whole Wood will, in a week's time, be reduced to a milky Liquor, p. 634. Sometimes too, the work is done by one simple distillation: For if the *Liquor Alcabest* is distilled once only from common Mercury, it leaves it at the bottom coagulated, and pulverizable, and neither increased nor diminished in its weight, p. 628; which is effected in a quarter of an hour, p. 776. But sometimes a cohobation is necessary, in order to accomplish your design. For frequently, when Bodies are converted into a Salt of the same weight they were of before, they must be cohobated some number of times with the *Sal-Circulatus* of *Paracelsus*, before they will intirely lose their fixity, §. 11. p. 43; which happens chiefly in Metals, Gold in particular, on account of the perfectly equable commixture of its Seed, *ibid.* On the other hand, if by one distillation only it is drawn off from the *Ludus*, or *Cevilla* of *Paracelsus*, this

Sixthly,
with regard
to its method
of acting.

distillation,

distillation, in so small a space as that of two hours, it converts the whole Stone into a Salt of the same weight. As for any other manner of applying this universal Solvent, I can find none, nor does it appear by any argument, that a greater degree of Fire is necessary for the operation. By a gentle agitation of its parts therefore, excited by the Fire, it is capable of dissolving all Bodies. For the *Alcabeft* itself rises in distillation with the second degree of a Sand-heat, § 29. p. 88. But it does not ascend with a Bath-heat, § 29. p. 88. 634.

Seventhly,
its effects.

But farther, there was nothing ever observed in all Nature, or even related, that is more surprizing than the physical effects which these Authors ascribe to the action of this *Menstruum*: For it intirely converts the whole Body of its Object, into a Matter which has neither gained nor lost the least weight during the Operation; and this transmuted Matter seems always to be liquid or saline. In this affair, however, there is some variety: For Mercury, by the action of the *Alcabeft*, is reduced to a fixed Powder, which is pulverizable, resists a Wind-Fire, and remains fixed if mixed with Lead. § 10, 11. p. 776. Almost all other Bodies are converted into a Salt æquiponderant to their former Mass, § 11, 15. p. 43. § 12. p. 56. An oaken Coal is soon changed into two diaphanous Liquors, which differ in situation and colour, § 29. p. 88. Cedar-wood is converted into a milky Liquor of equal weight with it, and then farther into a twofold Oil, which afterwards, by simple digestion, are changed into a pure Salt, so that it may be mixed with Water, p. 634. But the *Ludus*, or *Cevilla* of *Paracelsus*, which is a Stone found at the bottom of the *Scheld*, near *Antwerp*, is within the space of two hours only, converted by a gentle distillation into a Salt æquiponderant with the concrete, which being exposed to the Air, dissolves, and runs into a Liquid, without leaving any *Fæces* at all, § 23. p. 700. From this whole account, then, it is evident, that this Solution at the beginning is performed after different manners, but that at last, however, it reduces all Bodies into a kind of Salt that may be dissolved in Water, Mercury alone excepted, which on account of its perfect simplicity, which renders it more pure than Gold, and exceeding like pure Water, refuses to be converted into a Salt; and hence it radically resists all division possible to be effected, either by Art or Nature, and for this reason is perfectly indestructible, § 8. p. 55. § 10. p. 705. These Bodies, however, after they are by the help of the *Alcabeft* reduced to an æquiponderating Salt, still retain their proper vertues, which depend upon the feminal property of them, and which therefore are peculiar to them, and not common to others. This very remarkable circumstance is described, § 7. p. 55. where he says, the *Alcabeft* of *Paracelsus*, by subtilizing them, transmutes all Bodies in Nature; for Bodies, when they are reduced to their utmost possible subtility, at last pass into another substance, with a retention of their feminal Properties. And § 65. p. 387. By the universal Solvent, all things return back to their *Ens primum*, and exhibit their native qualities, whence they have an opportunity of acquiring great and unlimited powers. But more plainly still, § 6. p. 677, 678. while he asserts that this Liquor alone dissolves all Solids into their first Matter, without any diminution, or alteration of itself. And therefore, he cries out, get but acquainted with this homogeneous, immutable Solvent, which resolves all its Objects into their first liquid Matter,

and then you will be able to look into the intimate essences of things, and examine their qualities, § 25. p. 780. By this means, therefore, all these Bodies are converted into a saline volatile Matter, which still retains their particular *Spiritus Rectior*. Hence it may be intimately mixed with any Humour of the human Body, with that circulate through all its Vessels, and in its whole passage every where exert those powers which are proper to it, with regard to our Body. These, therefore, they called Potables. Hence, then, we see, what the Adepts meant by potable Gold, and how vain and deceitful the boast of those Persons is, who pretend to be Masters of it. Gold, when it is corroded by Acids, will still give you again its actual Particles of Gold, tho' they then lie concealed in the Acid: But the philosophical potable Gold, is a saline Liquor æquiponderant to the Gold, without any *Menstruum* whatever united with it, being only the pure simple first Matter of the Gold, or its *Ens primum*. See in particular § 23. p. 700. Here, therefore, above all, it is particularly remarkable, that the *Alcabeſt*, whilst it thus dissolves, never mixes itself at all with its Solvend, but remains perfectly separate from it. Hence, therefore, it neither increases nor diminishes the substance of the Body dissolved, but leaves it exactly the same as it found it. This you evidently see, § 28. p. 88. where he says, that the two Liquors of the dissolved oaken Coal, which were different in Situation and Colour, rose with the Warmth of the Bath, whilst the solvent Liquor remained at bottom, of the same weight it was before. For it finds no Body with which it can be joined, itself being too pure and subtil, and reduced to its least Atoms, and hence disdaining all ferments, and always remaining single, § 27, 28. p. 94. Hence it acts only by an external action, not concreting with its transmuted Object, as the purest Fire uses to act upon its Object, as warm Water melts Snow, § 24. p. 380. § 6. p. 677, 678. For this Liquor leaves nothing of itself mixed with its Solvend, § 10, 11. p. 776. Hence, therefore, besides others, this *Menstruum* seems to have two excellent advantages above all others: In the first place, that it does not act by attraction, or repulsion, but only by a mechanical dissolving Power, contrary to all others that we are acquainted with, Fire, perhaps, alone excepted: And then, secondly, that it always preserves intire the native Powers of its Solvends, and yet whilst it resolves Poisons, it deprives them of their violent and deadly quality, and gives them the most excellent medicinal virtues, by reducing them to their *Ens primum*, § 49. p. 374. which, however, it must be allowed, is very difficult to comprehend. When Bodies, now, are by the help of the *Alcabeſt* reduced into their saline volatile *Ens primum*, retaining at the same time all their seminal qualities, if they are then urged any farther by the action of this Solvent, they are perfectly deprived of their proper seminal virtue, and from every one, how different soever, there is produced the same unactive, inodorous, insipid, simple, elementary Water; so that by too great an application of the very same *Menstruum*, whatever excellence was produced before, is now destroy'd. It appears, therefore, that the ultimate matter of all tangible Substances is Water, upon which the *Alcabeſt* itself can act no farther, but which being again impregnated with the seminal fecundity of any Seed, may be converted again into any new Bodies whatever. Hear what he says himself! Every Body is transmuted into an actual

actual Salt æquiponderant to the Body from whence it is made; and this Salt being cohobated some number of times with the *Sal-Circulatum* of *Paracelsus*, loses intirely all its fixity, and is transmuted into a Liquor, which itself likewise at last becomes an insipid Water, of the same weight with the Salt from which it proceeded, § 11. p. 43. Original Sand, by the artificial *Infernal Fire* alone, is changed into a Salt, and then a Water, § 15. p. 45. And I know a *Water* by the mediation of which, all Vegetables are converted into a distillable Juice, which rises without leaving any *feces* at the bottom of the Glass; and which Juice being distilled with Alkali's, is totally reduced into an insipid elementary Water, § 27. p. 88. An oaken Coal turned into two Liquors by the *Alcabeſt*, and then mixed with a little Chalk and distilled, rises with almost its former weight, and has all the qualities of Rain Water, § 29. p. 88. And then they all become so volatile, that they rise with a Bath-heat, and fly off from the *Alcabeſt* which remains at the bottom, § 29. p. 88. § 24. p. 380. p. 634.

Eighthly, its
proper im-
mutability.

But what is much more surprizing than all the rest, is in the eighth place, that this *Menstruum*, whilst it operates so wonderfully upon all other Bodies, is not in the least lessened, altered, or weakened in its efficacy by any of them: So that in this respect again it resembles Fire, and is with a great deal of reason compared to it. By a very expressive Phrase, therefore, it is said to act, by its power of acting upon all sublunary Bodies, without reaction, § 15. p. 45. And that after it had dissolved the oaken Coal in so extraordinary a manner, the solvent Liquor remained at the bottom of its former weight and strength, § 29. p. 88. For its transmutation is despaired of, as it cannot find any Body worthy enough to be wedded to, and is single with regard to every commiscible ferment, to which it might be in subjection: And hence it cannot die, § 27, 28. p. 54. In its most perfect action, therefore, it reduces every tangible Substance to its middle life, without any change in itself, or diminution of its strength, § 11. p. 265. It is immutable, therefore, and immortal, § 3. p. 377. This alone, by operating, is not altered, § 24. p. 380. § 6. p. 628. 634. 677, 678. It acts, therefore, without any re-action of the Patient, or depauperation of the Agent, § 27. p. 704. § 10, 11. p. 776. For this Dissolvent is homogeneous and immutable, § 25. p. 78. and being the same both in number, weight and activity, it is as efficacious, the thousandth Operation, as it was at first.

Ninthly, its
Volatility.

But among other things remarkable in this *Menstruum*, is, in the ninth place, its degree of Fixity or Volatility in the Fire: And this again is exceedingly surprizing. For after it has rendered all Bodies, the most fixed not excepted, so volatile that they will rise with the gentle heat of a Bath, yet itself remains fixed at the bottom, nor ascends with them, § 14. p. 56. § 27. 29. p. 88. § 10. p. 634. 700. 776. In the mean time, however, the *Alcabeſt* itself is so volatile, that it rises in distillation together with the Bodies it has dissolved in the second degree of a Sand-heat, § 29. p. 88. And hence it may, by distillation, be drawn off from common Mercury, which it fixes, and coagulates, p. 776. 628. Hence, therefore, the compass within which the whole power of this *Alcabeſt* exerts itself, is accurately determined.

In the tenth and last place, before we quit this subject, we must observe to you, that this *Solvent*, that thus remains intire in all its Operations, nor is ever overcome, or fatigued by the resistance it meets with from any thing, does yet acknowledge one Body in Nature with which it may be so united, as to be brought into Wedlock with it. This appears evident, by considering the Text of the Author. § 27, 28. p. 94. Chemistry was solicitous about finding out a Body, which should have so great a sympathy of purity, that it should not be dissipated by any corruptent. And at last Religion was astonished to see a *Latex* discovered, which being reduced to the least possible Atoms in Nature, remained single, and disdained to be wedded to any Ferment. Its transmutation therefore was despaired of, as it could not find any worthier Body with which it might be united. But the labour of Wisdom found out an anomalous Body in Nature, which rose without any commiscible ferment different from itself. This Serpent bit itself, revived from its Poison, and afterwards knew no Death. So that we see here the conjunction of two things which were in some measure different. But he intimates this still more plainly and distinctly, § 11. p. 265. where he says, that one and the same Liquor, *Alcabeft*, reduces all the tangible Bodies in the Universe to their first Life, without any alteration in itself, or diminution of its strength, but is brought under the yoke, and altered by its equal alone. And in another place he comes still nearer the matter, § 14, 17. p. 56, 57. telling us, that when Mercury is perfectly freed from the original Sulphur, which intimately adheres to it, it is not afterwards mutable by any Fire, but immediately destroys all other Seeds, except its equal.

Thus, Gentlemen, I have faithfully laid this affair before you. Concerning any thing of this nature, I have not, to my knowledge, read a Word any where but in these Authors. Neither the ancient Philosophers, nor any other Chemists or Physicians ever mentioned, or heard of any such thing; and yet, of every thing we want in Physics, it is vastly the most to be wished for. You will, no doubt, therefore, be mighty solicitous to know in what kind of Matter it ought to be sought; for which reason I will add a few words upon this head, having tried a vast variety of things myself, which I have sometimes repented of with indignation. *Paracelsus* then had a Liquor which he prepared by an infinitely tedious circulation from Sea Salt, in which Nature has placed the greatest perfection. This by an indefatigable application he still advanced to a perpetual Oil; and then he called it the *Ens Primum salium*; *Oleum Salis*; *Liquor Salis*; *Aqua Salis*; *Circulatus Sal-minor*; *Circulatum minus*; L. IX. *Archid.* under the remedy *ad Maculas*. In his Treatise *de Sale*, C. IV. *in correctione & additione*. Lib. *de Renovatione* Arch. IV. Cap. 4. *Essentia de Salibus*, Archid. L. VIII. Cap. *de Elixire Salis Quintæ Essentiæ extractio de salibus*, Archid. X. Cap. 2. And the preparation of this *Sal Circulatus*, which is vastly troublesome, is there described, nor is there any thing obscure in it, except that we don't know what the Spirit of Wine is, that is there required to separate the impure from the pure. This now agrees exactly with the Opinion of *Van Helmont*; for he says, that the Salt of Bodies being some number of times cohobated with the *Sal Circulatus* of *Paracelsus*, is converted into Water, § 11. p. 43. And hence to the *Primum Ens Salium* he ascribes the virtues of the *Alcabeft* itself, p. 419. And

Tenthly, its submission to one certain thing.

Of the Matter of the *Alcabeft*. Sea Salt for the *Circulatum minus*.

says, that by the *Sal Circulatus* all poisons die, § 9. p. 374. And hence he calls it the most happy, perfect Salt, which is reduced to the ultimate degree both of purity and subtilty, and hence pervades every thing, that alone remaining immutable during its operation, by which it readily dissolves every thing else, § 24. p. 380. This *Sal Circulatum* acts wonderfully upon Oil, and Spirit of Wine, p. 576. This *Sal Circulatus* reduces Bodies into the Liquor of their concrete, p. 628. And with that may be prepared the *Ludus*, § 23. p. 700.

And Mercury to be united with the *Circulatum minus*.

But *Paracelsus* had another Solvent, much more powerful than the former *Circulatum minus*, and much more difficult to be come at, which, therefore, he called his *Circulatum majus*, *Archidox.* x. C. 4. And hence in the same place he calls it, likewise, the *Materies Mercurii Salis*; and afterwards, *Living Fire*, *Archid.* x. C. 5, 6. In common Mercury he supposes there is a most perfect Fire, and a latent, celestial life, and that the quintessence of Mercury is celestial Fire, if it is dissolved with its Mother, viz. an *Arcanum* of Salt, *Archidox.* x. C. 6. When these two, therefore, by a true adunation, are intimately united together, and together rendered pure, subtil, and volatile, then seems to arise that wonderful mercurial Water, which he describes in the Chapter *de Corrodente specifico*, where he says, that Gold so dies there, that it continues to be Gold no longer; whereas in all other corrosions of Gold, the Gold is only divided into very small Particles, but still remains the same true Gold, and by an artificial reduction may be always recovered again. By this art, therefore, there is a perfect union of Water with Water: For there is a two-fold Water, viz. a common one, which is in Salt, and a metalline one, which is in Mercury, both which, however, have the same Root. All this now seems to have been understood by *Van Helmont* exactly in the same manner, and therefore in a few words I shall just add what he has said upon it. Please therefore to hear him speaking, § 8. p. 55. The internal Mercury of Metals, perfectly freed from every taint of a metalline Sulphur coheres together with an indissoluble union, so that it radically resists all possible division either by Nature or Art. Nor could I learn the nature of Water, except under the Rod prepared from Mercury's Wand. And I found the nature of Mercury adequate to Water: For it does not contain the least Earth in it, but is always the Son of Water alone, § 10. p. 56. 705. And he says with all the ancient Alchemists, if I had not seen that Mercury eludes all the labour of the Artists so, that it either flies all off from the Fire still intire, or else all remains in it, and both ways retains its immutable identity, and the anatic homogeneity of its identity, I should say that that art was not true, which is true without any falsity, and by far the truest of all. So that what is above is like that which is beneath; and the contrary. And hence it is absolutely impossible either for Art or Nature to find any different parts in the homogeneity of Mercury, not even by the *Alcabeft* itself, as Mercury is more simple than even Gold itself, and formed with a greater anatic identity. And hence, therefore, there is in Mercury the *Ratio proxima* of indestructibility, as in the Elements themselves. Hence all sublunary things are too weak to subdue pure Mercury, or to penetrate, alter, or defile it. It remains secure in Air, Fire, and the acrid Liquor. It is not affected by any Solvent, much less penetrated through by Air. And, there-

fore, there is nothing in Nature like this pure Mercury, no not at a distance, § 17. p. 670. It resembles, therefore, the *Ens Metallicum*, and comes very near it, § 4. p. 705. And at length, actually existing simple, and not as a constitutive part of things, § 17. p. 670. From these principles, then, we know, that it is brought under the yoke, and changed by its equal alone, § 11. p. 265. For this anomalous Body in Nature, rose without any commiscible ferment different from itself; but it bit itself, revived from the Poison, and afterwards knows no death. Thus, then, Gentlemen, you have the History of the *Alcabest* of *Paracelsus*, and *Van Helmont*, which I have extracted from their own Writings, and laid before you with the utmost fidelity. Here, therefore, you see at once, that it is in vain to seek for this *Menstruum* in human Urine, or any of its productions. Nor can it ever be found in Tartar, or any of its Preparations, tho' this may be substituted as Regent to the Prince, § 25, 26. p. 780. Nor can Phosphorus ever be reduced to it: The properties that have been proposed won't admit of it. *Glauber* too is mistaken, when he seeks it in the fixed Alkali of Nitre: As *Zwelfer* is in hoping to find it in the most acid Spirit of Vinegar distilled from Verdegrease. Nor does the famous *Guernerus Rolfincius* seem to have had a right notion of it, when he supposed it to be threefold from a fixed Alkali as the *Basis*, viz. in Fossils from an Alkali of Tartar, and Vinegar of Antimony; for it is a mere vitriolated Tartar that is thus produced: In Vegetables from an Alkali of Tartar saturated with Vinegar; for this gives a mere tartarized Tartar: In Animals from the same Alkali saturated with the acid Whey of Milk; for hence arises a tartarized Tartar, but a more valuable one: Nor does the addition of *Sal Ammoniac* much alter the case, *Eph. Germ.* D. I. Ann. 6, 7. p. 193—196. App. And indeed, no-body in the description of the *Alcabest* has come nearer to the Sentiments of *Paracelsus* and *Van Helmont*, than *Peter John Faber*, in his Manuscript concerning Alchemy, to the most serene Duke of Holsace, which is printed in *Eph. Germ.* D. II. Ann. 8. App. p. 111. 117. out of which these remarkable words confirm my opinion. The Liquor *Alcabest* is a pure mercurial metalline Spirit, so converted to its proper natural Body, that these two become one inseparable indestructible being, destroying every thing else, and converting them into their first Matter. It is the true *Mercurius Philosophorum*, prepared from the Mineral Kingdom, joined to its own Body, inseparable from it, being a milky, buttery Liquor, penetrating and dissolving every thing. This, now, is of two kinds, Simple and Compound: The Simple is made from a pure metalline Acid, and a pure metalline Salt, rendered volatile with its Spirit; and the Preparation of this is exceeding difficult: That, however, of the Compound, is still far more so; for this is prepared from a mineral Acid, and a pure animal and vegetable Salt. The Liquor *Alcabest*, or the perfect pure *Mercurius Philosophorum*, is like Fire of an incorruptible unalterable nature, reducing every thing to its first Matter. And the very sagacious *Joachim Becherus*, in his *Subterranea*, is almost of the same Opinion: For he asserts, that he has discovered in Sea-Salt, a certain arsenical and mercurificating Power, which was it but separated and pure, would be the *Alcabest* itself, which, however, would be perfectly distinct from the *Mercurius Philosophorum*. Hence Mercury itself, he looks upon as a sulphuro-metalline Substance, which of itself would be solid, and receive all its Fluidity from an arsenical Sulphur of com-

mon Salt. This very subtil conjecture, I wish he had more clearly demonstrated. The sum of this Gentleman's Argument is this: The purest Silver, corroded by Spirit of Nitre, and precipitated by Spirit of Sea-Salt, becomes volatile, and then easily disposed to part with its Mercury; and therefore Sea-Salt can transmute the purest Metals from their fixed Nature into true Mercury. Perhaps, now, at last you may be willing to know my Opinion of this matter, and whether I believe that any of the Chemists were ever Masters of this grand *Arcanum*. To this I freely answer: *Van Helmont* complains, that the Bottle was once given him, but that it was taken away again, and therefore he could not make many Experiments with that Liquor: And *Paracelsus* does not say so many, and so great things of his Solvent, and therefore, I really don't know what to say of it. This, however, I'll venture to say, and would advise you to try it, that if you will but examine Sea-salt, and Mercury, in every chemical Method you are acquainted with, you will never repent of your Labour.

Of Chemical Vessels, and the Furniture of an Elaboratory.

As the business of Chemistry is concerned in producing and observing the changes of Bodies, and as these changes are particularly effected by the application of Fire, hence the Operators necessarily stand in need of Instruments and Vessels, without which it is impossible for them to exercise their Art. By a Vessel, now, I mean every hollow Body, in which the Matter to be chemically changed, or actually changed, is contained, as likewise the changing Body or Solvent. An Instrument, I shall call every body that has that strength, size and figure, as to make it fit to apply the changing causes to the Bodies to be changed in such a manner, as by means thereof, to excite such a motion as the rules of Art determine, and by the assistance of which, the Operator shall be able to manage both those causes, and those Objects. In general, then, your chemical Furniture must consist of Bodies to be changed by Art, of causes capable of effecting such changes, of Vessels, Instruments, and Bodies actually prepared by the chemical Art, if you would have your Elaboratory complet.

Chemical
Vessels.

Chemical Vessels, to which the Objects to be changed are committed, must be able to contain such Bodies, and their solvent causes, and at the same time to bear the Fire that acts upon, that they may not prove defective in the middle of their Operation. It is necessary, therefore, that these should be very strong, and of such a nature, as not to taint their Contents: And these one may call containing Vessels. And those on the other hand, that receive the Substances after they are changed by their causes, which are almost always separated by the force of Fire from the Body, which in the containing Vessel either does then bear, or has born that force, we may call Receivers: And in these Vessels we have particularly to consider, the Matter, and the Figure.

The Matter
of the Vessels.

The Matter of the Vessels, is either Wood; Clay; Stone; Metal, or Glass.

Wooden Vessels, made of dry Wood, not oily, or painted, are reckoned best for keeping Salts, saline Bodies, Limes, and calcined Substances, if they are put in them, when they are both very dry, and the Vessels are then stopped very close: For in this manner those Bodies use to keep, which in almost all others

others melt from the Moisture of the Air. Mortars and Bowls too, turned out of Wood, are used to advantage, particularly for rubbing Metals with Water that are dissolved in Mercury, for which purpose they are better than any thing else. These too are of service in reducing melted Lead and Tin to Powder, if they are first rubbed over with Chalk: And these are the chief Uses they are put to.

Vessels made of Glass are of excellent service, because they neither change, add, or take away from the Bodies they contain; and whilst they are exposed to the action of the Fire, they suffer nothing to transude through them from within, nor admit any thing from without, except Fire, and Magnetism, containing and bearing even the *Alcabeſt* itself in the Fire. In every Experiment, therefore, we want to make, and in every chemical Operation, these, and these only ought to be made use of, when there is not required a greater degree of Fire than Glass is able to bear without melting. And as the *German* green Glass which least of all affects the contained Bodies, is the most incorruptible, and bears the Fire a long time without being fused; hence that is preferable to every other sort for these purposes. As for the white, which is almost like Chryſtal, and easily flaws, and sweats out its Alkali, that must be rejected here, because it melts too easily, and communicates its Alkali to Bodies, as appears too evidently. The green Glass, I mention, will bear more than 600 degrees of Heat before it is put in fusion, but how much more exactly, I don't yet know: In the greatest Sand-heat, however, I have brought it to melt. It is evident, therefore, that this can bear a considerable compass of Fire, without any inconvenience, tho' beyond certain limits, it can sustain it no longer. It were much to be wished, therefore, that *Van Helmont* had acquainted us with that secret Lute, with which a glass Vessel being coated, it would bear the strongest open Fire of a Wind-furnace, without melting, so that he cou'd with Glass distill the igneous Oil of Vitriol. This Crust is said neither to split, crack, fall off, nor vitrify. And thus in the greatest intensity of the Fire, this Coat is said to incrustate the Glass internally, *Helm.* § 19. p. 707. If this was true, then all Operations might be performed in Glass; but, I confess, I know of no such coating, nor have ever met with any body that did.

The third sort of Matter made use of for chemical Vessels is Metal. Of Metals, now, Iron melts with the most difficulty; and hence a great many Vessels are made of Iron. All metalline Vessels, however, have two inconveniencies, the first that they are corroded by Salts when they come to be red hot, and hence both spoil their contents, and are themselves destroy'd: The second, that they melt in the Fire. This I myself have had experience of; for I got some iron Long-necks made of cast Iron, in order to distill Phosphorus from Urine, but they melted long before the Operation was finished.

In the fourth place, therefore, the Chemists make use of Vessels likewise, made of Potters Clay. But these too, when they are made of a fat clayey Earth, vitrify when they come to be exposed to the greatest degree of Fire, and thus prove deficient. The best, therefore, are those made of a poorer Earth, such as the *Hessian*, and the like, which are made of crucible Earth; for these bear the most intense Fire. But these, too, as they are porous, transmit some saline Particles, especially when you make use of them in the distillation of acid Spirits. Of this variety of Vessels, now, it is evident what sort are the most proper

proper for any particular Operations: Pure aqueous Liquors, for instance, and perfect fermentative Spirits, may be distilled in Metal: Acetose, distilled, fermented vegetable Spirits conveniently enough too in Tin: Other saline Substances require Glass. The spiral Tubes made use of in the distillation of acetose Liquors, are made of Tin; but it's best always to make the Head of Glass, for the reasons just mentioned. Earthen Vessels are never made use of, but where there is required a very great degree of Fire, and then, that they may transpire less, and be not so apt to crack, they should be always coated with a proper Lute. When you are perfect Masters then of this affair, before you begin any chemical Operation, you must consider the nature of the Matter to be operated upon, and the degree of Heat it will require, and hence you will easily see what kind of Vessels are fit for your purpose. And here, where one is perfectly at one's liberty, one wou'd always prefer Glass, if it was for no other reason, than that one can here look into the Vessel, and observe all the *Phænomena* that happen to the Bodies within, during the Operation; which setting aside the gratifying one's curiosity, is of excellent service both in Chemistry and Philosophy, as by this means we come at the origin of a great many appearances. The *Indian Potters Earth*, of an ash colour, is like *China*, and is, perhaps, a *Species* of it. The Potters make Vessels of this Earth of all sizes, in which they put up their Pickles and Sweet-meats, to send abroad. These are neither corroded nor penetrated by Acids: And hence your Distillers of *Aqua Fortis* make use of them, to keep their acid Spirits in.

The best Figures of Vessels for keeping Bodies.

Vessels, now, let them be made of what Matter you will, may differ vastly in their Figure; of which, with regard to chemical uses, I shall just add a few words. Those glass Vessels that are designed for putting volatile Liquors, and Salts in, are best, I think, made with a plain bottom, hollowed inwards, the sides rising cylindrically, and terminating at top in a narrow cylindrical Neck. The mouth of these must be secured with a glass Stopple, ground nicely to the concavity of the Neck: And the larger that part of the concave Surface is, that the Stopple is in contact with, the more nicely it will answer the end. But those Vessels out of which Liquors are to be dropped, should be made with a spherical Belly, and the Neck of these too should be cylindrical, and the Mouth of them produced into a Rim, which on the upper part should be a little hollow. These may be stopped with a Cork, or if you keep volatile acid Spirits in them, with the Gardiners yellow Wax. The Figures of these you see in Plate IX.

For chemical Operations.

Other Vessels which the Artist wants for the separation of Bodies by Fire, which is generally done by distillation, require different Figures according to the different ends to be answered. And here it is necessary that these should be of two Sorts, one for containing the Body to be changed, and bearing the Fire necessary for the Operation; the other for receiving what is separated out of the other by the action of Fire; which are almost always colder. I shall now then consider the Figure of each of these.

Crucibles and other melting Vessels.

If the Body to be changed and separated in the Fire, is to have nothing but its fixed part preserved, then the Figure of the Vessel made use of, is almost always an obtuse Conoid with its *Base* at the top, and truncated *Vertex* at the bottom: And these are varied through all the degrees, from this conical Figure, to a concave spherical Segment. Thus the melting Pots called Crucibles

are

are conical, but the smelting Vessels used for ustulation, and calcination are concave parts of a spherical Segment. In these Vessels, the effect of their Figure is this, the shallower the Vessels are, and the more they diverge from the bottom, the more easily will the volatile Matter fly off from the fixed, and the Fire will be applied to a larger Surface both of the Matter to be separated, and that which remains fixed; and hence for ustulation, the lowest, and openest Vessels are always made use of.

But when the volatile Matter, separated from the fixed, is to be saved as well as the fixed, then the containing Vessel has a three-fold Figure, *viz.* either a cylindrical one, a conical one, converging upwards, or a conical one, converging downwards. The cylindrical, by its sides only keeps in the volatile Bodies, but neither forwards or impedes their ascent: The whole difference, therefore, in this sort, arises from the height; and hence, as is the height, so is the diversity of the operation. In order to separate the most volatile Bodies from the less volatile ones, these cylindrical Vessels must be very high; and the contrary, when you want to separate Bodies that are almost fixed, from those which are perfectly so. But when from a narrow bottom, the Vessels are expanded upwards, as in the Hemispherical Cupels, or those that are only the segment of a Sphere, then it is plain from Hydrostatics, that every point of the concave base will sustain an incumbent column of Liquor, whose height is measured by a line drawn perpendicular to the horizon from that point to the surface of it. Hence, therefore, it is plain, that the columns will be always so much shorter, the nearer you come to the edge; for which reason this diverging figure wonderfully forwards elevation; and on this account exhalation is effected by it most expeditiously. Thus then we have an idea of the Vessel called a Retort; for it is a hollow Sphere terminating in a cylindrical neck, whose upper horizontal line is a tangent to the upper point of the Sphere, whilst the inferior one produced, forms a diameter to the Sphere parallel to that tangent. Such a Vessel, therefore, easily determines the separated Matter into the cylindrical Aperture, and thence, into the Receiver, which is here very easily raised by the Fire, and confined and repelled by the arched figure of the Vessel. This Vessel, therefore, is fittest for separating by distillation those parts which are very fixed from those which are absolutely so; as in the distillation of Oil of Vitriol, Spirit of Nitre, *Aqua Fortis*, Spirit of Salt, Spirit of Alum, and the like. But the Workmen generally bend the neck downwards, and draw it out into an open conical end, that the Vapours which are propelled into the first part of the neck, may afterwards spontaneously run down, and distill; and with this view are made all your common Retorts. But for very tedious distillations, where a long continued application of the Fire is requisite to raise and expel Particles that very strongly resist such an elevation, I got some cylindrical Vessels made, which when they were placed in a horizontal position, in their upper horizontal part opened into a horizontal neck, as you see Plate X. with these are most conveniently distilled Phosphorus, and all Liquors that rise with a great deal of difficulty; and if you will try them, you'll be pleased to find some very difficult Operations rendered much more easy. When I distilled however yearly before you such large quantities of Oil of Vitriol, and fossil acid Spirits, in my private Lectures, you remember I always instead of Retorts made use of cylindrical, earthen Long-necks, which open with a large, circular

Distilling
Vessels.

Pl. X.

lar mouth. These, when they are placed horizontally in the Furnace, are the best kind of Vessels, for these distillations; for cylindrical Segments being at one end inserted into the Orifices of these Pots, and at the other, into large glass Receivers, placed horizontally, likewise, and then well luted, furnish us with the safest method of distilling these acid Spirits. These all you may examine in the figures annexed Pl. X. which will readily bring to your mind what you have so many times seen, and help you to conceive properly of those you never saw before. Thus then I think we sufficiently understand the fundamentals of the Doctrine of the figure of containing Vessels in the distillation of Bodies that rise with difficulty. And if we consider what follows from this Doctrine, we shall find this observation generally true, that with the more difficulty any thing rises in distillation, the more necessary will be the figure and disposition of these last Glasses: But on the other hand, when the Matter to be sublimed is very mobile, and in its degree of volatility differs but little from the Body from which it is to be separated, then Vessels of a contrary figure best answer the purpose. Those in the first place then are conical, which because they somewhat resemble *Hercules's* Club, are by the *Germans* and *Dutch* called (*Kolven*) Clubs, as on account of their likeness to a (*Cucurbita*) Gourd, they have obtained the name of Cucurbits; but the ancientest Alchemists, as *Lully* and others most frequently called these Vessels Urinals. And here it is very easy to conceive, that when the Liquors in these Vessels are raised by the Fire, they must run against the converging sides of the Vessel, and being there stopp'd in their ascent, will be repelled and turned back again. If there is any thing therefore that is raised with difficulty by the degree of Fire made use of, that rarely ascends so easily in these Glasses, but is rather repelled back again, and remains at the bottom. In these Glasses, too, this is to be observed, that the greater the latitude of the bottom where it is widest, is in proportion to the aperture of the upper orifice, through which the sublimed Liquor must pass, there the impediment and repulsion of the elevated Matter will be greater, too, so that by this means the perfectly volatile part alone may be nearly separated from that which is not so much so. And lastly, the height of these Glasses must be taken into consideration, likewise, for the greater their altitude is, the more difficult will be the sublimation of those Bodies that are less volatile. A proper regard to these three circumstances has given rise to a very beautiful invention, by the assistance of which you may with a little Fire, Trouble, and Charge, distil a large quantity of simple Alcohol, or the same impregnated with the most subtil, vegetable Spirits; and it is done in the following manner. Make a conical, tin Vessel, the Base, of what size you have a mind, 6 inches, for instance, in diameter; and let the diameter of the upper orifice be one inch, and the height be 4 feet. At the top let it be bent downwards in a cylindrical form, and at the bottom let this Cylinder be turned up again, that it may be inserted into the Mouth of a cylindrical, spiral Tube, commonly called a Worm. Then if you put some Spirit of Wine in a Cucurbit, that stands in boiling Water, and fit on such a conical Vessel to it for a head, and then distill through the spiral Tube and the Refrigeratory, you will the first time have a very strong Spirit, which upon a second repetition of the operation will come off pure Alcohol. From the same Principles we understand the nature of the (*Pbiala Chémica*) Chemical Vial, as it is called, which is a spherical

spherical Body, from whose *Vertex* there arises a long cylindrical Neck, open at top: These are generally called Matraffes, or Boltheads. These, now, are of incredible use in Chemistry, in some of the nicest Operations; for as the Neck may be made of what length you please, as may likewise the proportion of the capacity of the Neck to that of the Belly, hence it is very evident, that you may give the Liquor contained in the Belly so great a degree of resistance, with regard to its ascent, that if you digest it with a gentle Fire, there shall scarcely any thing come out of the orifice at top. But in this kind of Vessels I have observed particularly, that the column of the Atmosphere that rests upon the aperture of the Neck, surprizingly compresses the Liquors that are contained in the Belly, and are agitated by the Fire, and serves as a kind of Stopple, to close up the aperture of the Neck, being at the same time kept in *æquilibrio* with the *impetus* of the Liquors that endeavour to rise; for whilst the Air being rarified by the Fire endeavours to elevate the whole superincumbent column of the Atmosphere, it meets at the same time with just the same resistance from the renitent weight: Hence then the liquid particles that are contained in this rarified Air, are repelled to the bottom of the Vessel, by which means it comes to pass, that when they are agitated by the Fire, they are strongly applied to those Bodies that lie at the bottom of the Glass. This you see evidently with the naked Eye; for if you put some Alcohol of Wine into one of these Boltheads, that has a very long, small Neck, and hold it cautiously over the Fire, when it begins to be so hot as to be ready to boil, you will perceive Vapours ascending into the cavity of the Neck, and falling down again, like little, floating Clouds. Hence, therefore, with these Glasses, the digestion of *Menstruums* with their proper Solvents, is most happily effected, without loss either of the *Menstruum*, or the Body to be dissolved; which has been of excellent service to me in performing a great many experiments, which otherwise I could not have made. These tall Matraffes, farther, are particularly serviceable in separating the very volatile, pure, alkaline Spirits, and Salts, from their volatile Water, Oil, and Earth, from which it is so very difficult to separate them by other methods. These Vessels, however, have this one inconvenience, that when the Liquor at the bottom comes to boil, as it cannot rise up high enough, it leaves the top part of the glass Neck cold, and hence, if the boiling Vapour ascends at once, by the sudden heat it is apt to make the Glass fly in that place, especially if it is in the Winter, and freezes. And then, again, the Drops that are collected upon the cold part of the Neck, and hence are cold themselves, often run down among those parts that are vastly hot in the Belly or Neck of the Glass, and burst the Vessel to pieces. This I once experienced myself, to my cost, whilst I was digesting some Mercury with this *Apparatus*. From what has been said, then, we conceive sufficiently of the efficacy of the figure of Vessels, and the necessity there is of such and such particular Forms, to answer different ends proposed. The figure of Receivers, particularly if they are large ones, is two-fold; either they are made with a spheroidal Belly; or else in form of a Cucurbit. Supposing, however, the capacity of both to be the same, then that, like a Cucurbit, is preferable to the spherical, because it being longer, the bottom is farther from the mouth of the exhaling Vessel, and hence gives the Liquors coming very hot from the Fire, a more convenient space to grow cool in: This observation I have found of

service. It's very often necessary, however, to increase the distance betwixt the containing Vessel, and the Receiver; and this I told you before might be done by putting a cylindrical Tube between them, and then luting it to the Mouth of them both. But in the more nice distillations, of Mercury in particular from Metals, we are forced to make use of another contrivance to increase the distance to a proper length; which is done by the help of the Glasses you see here, which being made to fit into one another, form one continued Vessel of what length you please; their junctures at the same time being secured with a proper Lute. A Retort, Receiver, and these prolonging Vessels, which I have given you a Figure of Pl. XI. would be sufficient for all distillations, if we did not often want to separate Bodies that are very volatile from other volatile ones: But as this is daily the case, here again we are obliged to make use of tall, upright Vessels, which must have a Head fitted on to them, called by *Dioscorides* an ἀμβίξ, where he writes of the sublimation of Mercury, whence by an *Arabian* variation 'twas call'd an *Alambic*, or *Alembic*, under the *Rostrum* of which you place the Receiver. You will easily perceive, now, where it is proper to make use of a Cucurbit with a Head, and Receiver, and where a Retort and Receiver. This, the easiness with which any Bodies rise, and the consideration of their being mix'd with others that are very volatile, from which they are to be separated, will sufficiently point out. You perceive too at the same time, that the principal inconvenience of this last *Apparatus* is this, that as the Alembic must be luted to the Cucurbit, and its *Rostrum* to the Receiver, you must by this means have two Junctures, which, take all care you can, will transmit some of the subtil Vapours through the cracks of the Lute. But there is often necessary, likewise, a continual reasfusion of the volatile part, upon the fixed *Residuum* from which it was separated. This the Artists generally call Cohobation, *Paracelsus*, formerly, Circulation; and this operation has the most beautiful effects of any in the Chemical Art. As the Operators, therefore, saw the great necessity of it, and at the same time found, that every time they opened their Vessels, they lost some of their Liquors, by thus pouring them back, exposed to the Air, they on this account contrived a Glass Vessel, consisting of a Cucurbit and an Alembic, the two *Rostrums* of which being turned back into the Cucurbit, perpetually return into its Belly the Liquors that are collected in the Alembic; and thus, the Vessel being perfectly secured above, the loss of the Liquor is prevented, and the trouble very considerably lessen'd: This they called a Pelican, which is so much the better, as the Tubes brought from the vertex of the Alembic are longer. But as these Vessels are not very easy to be procured, the same effect may be obtained in a simpler manner, and that is, by putting the Matter you are going to work upon into a Bolthead, with a pretty long Neck, and then fitting the Neck of a less into the Mouth of it, and securing the Juncture with a proper Lute. You must observe, however, to heat the Glasses first to such a degree as will be necessary for the Operation; for then the Air, being heated, will be proportionably expell'd out of the Vessels, after which you may lute it, make your Fire, and proceed without any danger. In this *Apparatus*, however, it sometimes happens, that the Liquor which is collected at top, and grown cool, falls down upon the hot bottom, and makes it fly: Being thus cautioned, therefore, you will take care to guard against this inconvenience.

And

And thus we have sufficiently considered Vessels for any Chemical Operations.

Of LUTES.

By a Lute, the Chemists mean a ductile, tenacious Mass, growing hard when it's dry, which serves to secure the junctures of their Vessels, that no Air may pass in and out, but particularly, that the Corpuscles, when they are carried up by Fire in the distillation, may be kept in, nor suffered to escape out of the Vessels. It is evident, therefore, that the Lutes must be different, according to the nature of the Bodies to be distilled.

If then it is an aqueous Body you are operating upon, you need only take the flower of Linseed, from which the Oil has been express'd, and with a little White of an Egg, work it well into a Paste, and it will be sufficient; for if you put this in betwixt the Cucurbit and the Alembic, and lute with it the juncture of the *Rostrum* of the Alembic, or the Retort, with the Receiver, it will grow hard with Heat, and if it cracks, may be mended by an addition of more of the same. And in the distillation of all fermented inflammable Spirits, and volatile, alkaline, and alcoholisated Salts, the same Flower will serve if it is well work'd with clean cold Water.

But in the distillation of Acids, either acetose, or other, this Lute won't do, because in this case it will be corroded, dissolved, and soften'd, and thus will suffer the Spirits to escape. For this purpose then, you may take an Ox's or Hog's Bladder that has been macerated in Water, 'till it begins to grow glutinous, and, as it were, semi-putrid, and fasten it round the juncture, and it will answer the end excellently well.

But again, when with a very strong Fire you distill the corrosive acid Spirits of Vitriol, or fossil Salts, you must then have a Lute, which after it is applied, will harden like a Stone; and hence this has been called the *Lutum Sapientie*. You make it best in the following manner. Take the Colcothar that remains after the distillation of Oil of Vitriol, and boil it in Water, which renew till the last does not appear to be at all salt; and then let it be dried, and kept carefully in a close Vessel. When you want your Lute, take some of this sweet, dry Colcothar, and rub it well with an equal quantity of the best Quick-Lime, and then with a little beaten White of an Egg, work it presently into a Paste, and apply it immediately to the juncture of the Vessels, which must be dry, and something warm. This Paste then will very soon dry, and harden like a Stone, and like Glass is capable of confining any Salts. Without all this trouble, however, I prepare a Lute of the same nature, in the following manner. With a quantity of Potter's Clay, I mix so much of the purest Sand, that the Mass, if it is work'd with Water, won't stick to the Fingers any longer; and to this I then add a fourth part of common Mason's Lime, so as to reduce it to a pretty stiff Paste. And the drier this is when it is made use of, the better, if it does but remain ductile: When this then is applied to the junctures of the Vessels, it grows hard, and excellently answers the purpose. If in a very intense Fire it should happen to split in the distillation, the crack may be soon made good again with some of the same. It has this convenience too, that it may be easily procured, whereas good Quick-Lime is sometimes difficult to come at.

Coating of
Vessels.

But in distillations, particularly in the hottest Furnaces, where the Vessels are red hot, it sometimes unluckily happens, that when you throw in new Fuel, either the cold Air, or the coldness of the Matter thrown in, strikes upon the Surface of the red hot Vessel, which then easily flies, and bursts asunder. Hence it is absolutely necessary, that these Vessels should be coated over with some proper Matter, in order to secure them from the ill effect of this sudden Cold. And this must sometimes be done likewise, when you distill with glass Vessels in the strongest Sand-heat, where the Glass is ready to melt; for by this means the Glass will be fixed as it were by this Crust, and be prevented being put in fusion. In order to make this in the best manner, take some Potter's Clay and Sand, reduce them to a Powder, and with some Water work them thoroughly into Paste, that is no longer tenacious, and then at last add a little Mason's Lime, and mix them well together. When you use it, warm your Vessel, hold it over the Vapour of Water, that it may be slightly moisten'd all over; then cover it intirely with this Paste, and by working it with your hands, reduce it every where to such an equal thickness, as you shall see convenient: This being done, sprinkle it over with hot dry Sand, and then set it by in a cool place, that the Coat may dry very slowly. If it should happen to get any cracks whilst it is drying, they may be stopp'd up with the same Matter. When these Vessels are prepared in this manner, they will bear a very intense Fire.

Of FURNACES.

Various Fur-
naces.

There is now, Gentlemen, but one thing more left to finish our Theory of Chemistry, and that is, a short consideration of Furnaces, which we shall now proceed to. And here we don't propose to describe all the Furnaces made use of in the management of Metals: Nor, indeed, is this necessary, since what the incomparable *George Agricola* has done upon this head is sufficient, who has explained this matter in the most elegant Style, and illustrated it with very accurate Cuts. If you will consult *John Rudolphus Glauber* too, upon Furnaces, you will find some particular contrivances for rendering some of the ruder Operations of Chemistry more easy. Of these things, therefore, I need say nothing. But it's my design here to explain to you those Furnaces, which a person will have occasion for, who has a mind to exercise himself in the practical part of Chemistry, according to the method of our processes.

The end
they answer.

A Furnace, then, is a Machine, by means of which, the Fire may be contained, confined, and applied to the Vessels, in which the Matter to be chang'd by the Fire is expos'd to it. In a Furnace, therefore, in the first place, there is required a *Focus*, or Fire-place, in which the Fire may be lighted, kept up, and determin'd. And as the Fire, which must be fed with proper Fuel, requires a Chimney to carry off its Smoke, and a Draught for the Air, and a Door to throw the Fuel in at, it appears in what manner these ought to be contriv'd. In the second place, in building a Furnace, we ought particularly to take care, that the direction of the Fire be so managed, that it shan't spend itself to no purpose, but shall be determin'd towards that part where we have occasion for it. And in the third place, it must be so built, that the Vessels containing the Bodies to be operated upon, may be so conveniently dispos'd,

as

as to be equably affected with any degree of Heat necessary, till the Operation is compleated.

That Furnace, therefore, will be best in its kind, which will perform the desired effects, with the least Expence, for the longest Time, and with the greatest Equability, and be managed with the least trouble and attendance of the Operator. The first of these ends will be answered, by contriving it in such a manner, that the whole Heat of the Fire, without any loss, may be apply'd to the Body under Examination. This will be obtained by building the Furnace of solid Materials, and forming the internal Surface of such a figure, as is proper to determine the strength of the Fire to the place designed: And this contrivance will have this advantage too, that the frequent attendance of the Person that keeps up the Fire will be less necessary. The second end will be answered, by chusing out such Fuel as will consume as slow as possible, so that it will but, at the same time, keep up such a Heat as is necessary for the Operation. And this is effected in particular by observing a proper proportion between the Fire-place, the Chimney, and the Air-holes: Upon which Principles, your skillful Operators will at once lay on such a quantity of Fuel, as will last for a very considerable time. The third circumstance, however, is the most necessary of all, *viz.* That the Fire may be kept up to the same degree, without any increase or diminution of its strength. For it appears by chemical Observation, that a determined degree of Heat produces upon every Body a certain effect; and hence, when the action of it grows either stronger or weaker, the effect will be different from what it was before. For this reason, therefore, there often arises a confusion among our chemical productions, when in the same Operation, we promiscuously make use of a greater or less degree of Heat. And besides, it is particularly to be observed, that such a variation of the Fire, makes Bodies of quite another disposition, with regard to any particular degree of Heat: For if in two chemical Operations, we make use of the same Fire, but let the degrees of Heat succeed each other in a different manner, we shan't be able to produce the same things from the very same Body; which has often prov'd a very detrimental error. In building of these Furnaces, therefore, the Workman must always consider first the quantity of Fire, which the Fire-place of the Furnace must receive, contain, and keep up. Secondly, the kind of Fuel to be made use of to answer the purpose; upon which head, you may consult what has been laid down from p. 168, to 214. In the third place, he must have a regard to the strength of Fire necessary for every particular chemical Operation: For the very same quantity, of the same Fuel, in the same Fire-place, may produce such various Heats, that by means of it, every intermediate degree, from the gentlest to the most intense, may be excited and continued: In the fourth place, therefore, he must always have a particular regard to the easy access of the Air to the Fire-place; and should take into his computation too, the strength with which the Air tends to the *Focus*, either by Blast or Draught. Nay, and he ought to consider too, the various states of the Atmosphere, with regard to Heaviness, Lightness, Moisture, Dryness, Heat and Cold: For when the Barometer is highest, and it freezes hard, and the Air is dry at the same time, the same Fire will burn brightest and strongest. But in the fifth place, he ought above all to attend to the course of the Fire that is kindled in the Fire-place: For if there

The quality
of the best
Furnace.

there are any large passages, by which it can make its way out into the Air, it will be dissipated, and lose its strength; whereas, if its united action is determined to that particular place where the Operator wants it, it will best of all answer his ends. These, then, are the fundamental Principles upon which depends the just construction of Furnaces. I shall, now, therefore, proceed to describe those Furnaces which I here make use of before you, and which a Person ought to have in his Elaboratory, if he wou'd be furnished with such as may enable him to perform all the Operations of Chemistry. To begin, therefore, with the most simple, which I contrived for my own use above forty years ago, when I was making great numbers of Experiments in a Study not very large, and that had but a small Chimney, for which I had occasion for a good many Furnaces.

The most
simple Fur-
nace.
Pl. XIII.

This then is made in the following manner. With the best and driest Oak a hollow Prism is formed upon a square Base, 9 inches broad, and 14 inches high. Within this there is fixed a square Partition made of the same Wood, and an inch thick, which must be placed 5 inches from the bottom, and will by this means divide the Furnace into two parts, the lower of which will be 5 inches high, and is the *Focus* or Fire-place; the upper 8 inches, in which are placed the Retorts, or Cucurbits, for distillation. This middle Partition, which represents a kind of Diaphragm, has in the middle of it a round Hole of 5 inches diameter, in the hollow of which may be placed the round bottom of the Cucurbit, or Retort. And this too has four more round Holes in it, of an inch diameter each, that the Heat may rise out of the bottom-part into the top. The Fire-place has on one side a Door with Hinges, which is as big as the side of the Fire-place, viz. 9 inches wide, and 5 high, that it may be opened at pleasure, or shut close as there is occasion. The whole internal Surface of the Fire-place is lined with thin Plates of Iron or Brass, that so the Wood may be in some measure defended from the Fire. The Door likewise has four round Holes in it, each an inch in diameter, for the free admission of the Air into the Fire-place, to which there are fitted four cylindrical Stoppers, by the help of which you may let in more or less Air, as you find it necessary. And here the Carpenter must be particularly careful, that the Door be made of very dry Wood, and so fitted, as to shut the Fire-place up exceeding close. As for the upper part of the Furnace, the side contiguous to the Door below, has a Hole cut out in the middle of it, and reaching to the top, which is $4\frac{1}{2}$ inches square. On the inner edge of this Hole, the Wood is cut away all round to the breadth of half an inch, and to half the thickness of the Board of which the Furnace is made, and then on every side there is fastened a slip of Wood in such a manner, as to form a groove with that hollow. There is then cut out of the same Wood a Board an inch thick, and exactly of the same size with the Hole cut in the side, but that has likewise on its inner part a rim on all three sides, half an inch broad and thick, in order to slip into the groove formed on the edge of the Hole, that thus this Board being every way secured, may shut up this Hole exactly, when you have a mind to distill in a Cucurbit, digest in a Bolthead, or exhale in an open Vessel, and be removed again when you want to distill in a Retort: For which purpose you must have another piece made exactly in the same manner as the former, but only with a circular Hole in the middle of it, of $2\frac{1}{2}$ inches diameter, to transmit

mit the Neck of the Retort. The top of the Furnace consists of two folding Doors, which in their middle are cut out into an orbicular Hole of 5 inches diameter, to let through the Cucurbit, or Neck of the Bolthead: And lastly, there is a round wooden Cover made fit to this Hole to stop it close, when you distill with a Retort. When you want to set it to work, take a square earthen Pan with 3 feet, $\frac{1}{2}$ an inch high, whose bottom must be plain, and its sides on the outside $5\frac{1}{2}$ inches wide, and the height of the whole Pan, from the bottom of the feet to the edge of the Pan, 3 inches and a half. On the bottom of the Pan, spread lightly some sifted Ashes to the height of a quarter of an inch, and then upon this lay a Live-coal of *Dutch Turf*, perfectly red quite through, and not at all smoaky; and then this, if it is lightly sprinkled over with the same sifted Ashes, will keep up such an equable Heat for near four and twenty hours, as the human Body is capable of bearing. But here you must take notice, the thinner the Coal is covered with Ashes, the greater will be the Heat, but then it won't last so long. In this Furnace, now, you have neither Smoke nor Smell. And it maintains such a very soft equable heat, that I can't think but that Eggs might be hatched in it. But in this too we can raise as great, nay and greater degree of Heat, than that of boiling Water. In this, therefore, conveniently, safely, and with little expence, may be performed all Digestions, distillations of Waters, spirituous Liquors, volatile alkaline Salts, and all volatile aromatic and oleose Salts, as well as all Preparations of Tinctures. All exsiccations, and exhalations for the formation of Chrystals, may be affected here likewise. Nay, after *Glauber's* manner, I have prepared in it Spirit of Nitre, and Spirit of Salt, to the great surprize of an old experienced Chemist. This therefore I call the (*Furnus Studioforum*) Student's Furnace.

But when you want a Furnace that will yield a greater Heat for distillation in Sand, then the following seems to me the best fitted for this purpose: And as the portable ones have this convenience, that they leave the common Fire-place free, I'll describe one of that sort. With a very thin Plate of Iron, make a hollow Cylinder 17 inches in diameter, and 19 inches high. Let the bottom be closed with a Plate of the same kind, and the top be open. Let it be supported at bottom with 3 iron Legs 12 inches long, and let the inside of the bottom be covered with a copper Plate, that the Salt of the Ashes mayn't too soon eat away the Iron. Within the Cylinder, you must fix a Grate parallel to the Base, whose upper surface must be 4 inches above it. Let this Grate be surrounded with a thin Rim $3\frac{1}{2}$ inches broad; and let the Bars be $\frac{1}{2}$ an inch square, and stand an inch from one another; or let the diameter of the circle of the Grate be so divided as to place six such iron Bars in it. This Grate is placed within the iron Cylinder at 4 inches distance from the bottom, where it must have three pieces of Iron standing out to support it. Let your Door then to this Ash-hole be 4 inches high, and 6 wide, and made to fit nicely, that it may shut it up very close upon occasion. Three inches above the upper surface of your Grate make the opening of your Fire-place, which must be 6 inches wide, and 4 and a half high. With the *Foci* then 15 inches distant, and a perpendicular from the *Focus* to the Circumference of 5 inches, describe an ellipse; and then by this make a solid wooden Semi-ellipse, cut off at the *Foci*; by which model you must shape the internal surface of your Furnace, which must be built with Bricks, so disposed, as to form such a concave surface,

Second Furnace.

Pl. XIV.

surface, and so contrived, that the edges next the internal part may come as close to one another as may be, so as to leave but small spaces, which must be filled with Mortar made of Lime and Sand. But before the Bricklayer can do this, you must have a Stopper made to the Fire-place. This must be made of a plate of Iron, the same of which you make your Furnace, and with the same cylindrical surface. As for the size of it, it must be made in such a manner, that when it is applied to the opening of the Fire-place, it may reach an inch beyond it on every side, that it may thus intirely close it up. Upon this Cover, then, you must erect a hollow Segment, cut out of this Cylinder to the size of the opening of the *Focus*, the sides of it tending towards the center of the Cylinder, and the top and bottom being parallel to the Base of the Furnace, that the internal surface of this Stopper may be made to answer to the concave, elliptical figure of the Furnace. Let the Bricklayer, then, fill this hollow with Brick and Mortar, and so form and smooth its internal surface, that when it is fixed in the hole it may make one continued, uniform figure with the surface of the Furnace. When this is made, build your internal Furnace with Brick and Mortar, in the manner before directed. At the upper part of the iron Cylinder, and on that part which is near to the door of the Furnace there must be a Segment cut out, 3 inches broad, and 2 deep, that the Neck of the Retort may be placed there in a declining position, when you have occasion to distill in such Vessels. And last of all, in the upper part of the Furnace an Iron Pot must be so firmly fixed in with Mortar betwixt the Bricks, that the Fire shan't be able to make its way through, but at the same time, about the edge of the brick-work, at top, there must be left 4 holes, shap'd like a Half-Moon, an inch broad, and two inches in curvature, which may serve as a vent for the Smoke and Fire. A Furnace built in this manner is fit for distillation with a Cucurbit, Retort, and Bolthead, and as it is portable, it is convenient for a great many purposes.

A Third
Furnace.

Pl. XV.
Fig. 1.

The third Furnace which an Elaboratory cannot be without is a *Balneum Mariæ*. This consists of the same Furnace as the preceding, except that the surface of the Grate is only 8 inches distant from the bottom of the brass cylindrical Vessel. The brass Vessel which is for the Bath, and is set with Mortar within the upper part of the Furnace, is 12 inches deep. This is of a cylindrical form, and at the top has a horizontal Rim an inch broad, by which it rests upon the top of the Furnace, and above that, another of the same breadth rising perpendicularly. There is then another Vessel made, in such a manner, that when it is placed within the former, it may stand an inch distant both from its bottom and sides, and may reach 5 inches above the top of the furnace. At 12 inches distance from its bottom, this Vessel has a rim on its outside, which runs a little declining, and when it is just broad enough to cover the aperture left between the two Vessels, is turned perpendicularly downwards, that it may be received exactly within the erect, perpendicular Rim of the former, and thus the cavity between them may be perfectly closed. In the broad, lateral Rim of this Vessel there is a hole made for pouring Water into the Bath Vessel, that by this means it may be contained betwixt that Vessel, and this internal one. The Neck of this second Vessel receives into it an Alembic, whose *Rostrum* may be inserted into a Tin Worm, in a Refrigeratory. To this likewise may be fitted that sort of Alembic, which is produced into a tall, cylindrical Tube, and then turned down again, for the

distillation

distillation of Alcohol, which we have already described. And lastly, there may be made a Cover to the Bath Vessel, to fit into the perpendicular Rim, as the former did, and close it in the same manner. And the Neck of this Cover, too, may admit an Alembic, in order to distill with a Worm. This Furnace, then, thus compleated, we may make use of first, for the common distillations of all Vegetables with Water; and of all Resins, Balsams, and Gums with Water, into their essential Oils. Secondly, for distillation of Vinegar; and very conveniently for distilling any thing whatever either in *Balneo Vaporis*, or *Maris*, in any determined degree of Heat, as far as the degree 212. And thirdly, this is of excellent service in the preparation of Alcohol at once, with a good deal of ease, and in a large quantity, which otherwise requires so much Time, Fire, Labour, and Charge. For these reasons, I have in Plate XV. given you a very exact description of it, with its whole *Apparatus*.

But there is still wanting a Furnace, in which may be raised a very intense Heat, for fusing Bodies that require a very strong Fire. And this is best built in the following manner. In the first place, let there be raised a stone Base, arched at top, and 3 feet high; for this Furnace must have the Door of the Fire-place at such a height, that the Operator may look into it as he stands upright. Upon this Base let there be raised an Ash-hole 5 inches high, and over this a Grate, with Bars almost an inch thick, and near an inch from one another. Let the Base of the Ash-hole, and the Grate above, be of a circular figure, and 12 inches in diameter, and above the Grate let the Cylinder be continued to the height of 6 inches. Upon this Cylinder let there be erected a paraboloid Cone, whose *Axis* must be 8 inches, and lowest ordinate 6, whence its Parameter will be 4 inches and a half, and its *Focus* one inch and $\frac{1}{8}$ from its *Vertex*. When this Paraboloid is built to 6 inches height above its cylindrical Base, raise a cylindrical Chimney over it 2 feet high, whose diameter will be 3 inches. In the fore part of the Fire-place 2 inches above the Grate, let there be a door 5 inches wide, and 6 high, and arched above with the arc of a circle of 12 inches diameter. At an inch distance above the arch of the door let there be a conical hole in the Furnace of 2 inches aperture, that you look down through it into the Fire-place if you want to see whether the Matter is melted in its Vessel; and make a Stopper to put in or take out of this hole at pleasure. This Furnace must be built of very good Bricks and Mortar, its walls must be 5 inches thick, and its internal surface must be smooth'd over with very dry Lime. This, when it is once hot, raises a prodigious Fire, especially in the middle of the *Axis*, and the upper part, as is demonstrated geometrically with a great deal of ease. The iron door must be let in so as to shut very close; and the bottom of the Ash-hole must be a plate of Iron, that if any thing happens to fall through the Grates it may readily be come at again.

Fourth Furnace.

Pl. XVI.

But a chemical laboratory must be still furnished with another Furnace for the distillation of acid Salts, from Nitre, Sea-Salt, Fountain Salt, *Sal-Gem*, Vitriol, Copperas, and Alum. This then, after having tried various sorts of them, we build after the following manner. Upon the pavement under the Chimney let there be erected a Parallelipiped, the breadth of it in the front 20 inches, and length 38; and the breadth of its cavity in the front 12 inches, and its length 22; whence the thickness of the Wall is evident. Let this Pa-

Fifth Furnace.

Pl. XVII.

U u u

parallelipiped

paralleliped be raised 11 inches high. In the middle of the front let there be an opening carried from the Pavement 11 inches high, and 4 broad, round the edge of which let the brick-work be let in a little, that a door, made of an iron plate may be received into it, when you want to stop it close: This is for the Ash-hole, and draught to the Furnace. Here, instead of a Grate, let there be fixed some prismatical iron bars, an inch square, 14 inches long, and an inch distant from one another, and let them lie parallel with the breadth of the Ash-hole. Upon the upper hollow of the Paralleliped let there be described an Ellipsis, whose *Foci* must be 22 inches distant, and transverse Diameter 12, and then the breadth of the Fire-place at the beginning and end will be nearly 10. With this elliptical Figure then let there be a cavity formed, within 4 inches and a half deep, and let the external parts be compleated in a parallelipedal form. In the front Wall, directly over the Ash-hole, let there be an opening into the Fire-place, 7 inches broad, and 9 high; and let this Hole have its lower edge declining inwards 1 inch and a half, and have an iron Door made exactly to fit it. Let the lower part of the Door be 3 inches above the upper part of the Ash-hole. In the other longer side there must be an arched aperture, whose lower limb must be placed 10 inches above the Grate. The length of this Limb must be 20 inches, its height 12, and the Arch must be an Ellipse, whose *Foci* are 20 inches distant, and has a transverse Diameter of 24. At this aperture are put in the long Necks. On the inside of the Wall, opposite to this aperture, and 9 inches above the Grate, there must be raised a Ledge of an inch and a half breadth for the Vessels to rest upon during the distillation; and in the middle of the same Wall at top there must be a square Hole for a Chimney, 3 inches broad, and 2 high. This being done, you must build the uppermost elliptical arch of your Furnace, whose vertical point must be 21 inches distant from the Grate; the *Axis* of the Ellipse 22 inches, and its transverse diameter 10. This Arch, therefore, will be formed by the rotation of such an Ellipse about its *Axis*, supposing this to be 16 inches from the Grate. When you distill in this Furnace, you take 2 Long-necks, 11 inches high, 9 wide, with cylindrical Necks 5 inches long, and $3\frac{1}{2}$ diameter, and place them horizontally, and parallel, so that their bottoms shall rest upon the Ledge in the opposite Wall, their mouths being parallel to the aperture they lie in. With Bricks, and Mortar, then, you close up intirely the whole aperture; and to the mouths of the Long-necks apply a cylindrical Tube, and to that a Receiver. With such a Furnace as this you may raise an incredible heat. It is safe, and easily managed; and makes the Fire exert all its strength upon the distilling Matter alone; and by means of the Ash-hole, it is easily regulated.

Other Furnaces.

The assaying Furnace is so plainly describ'd by the industrious, candid *Lazarus Erker*, that there is no room to add any thing upon this head; and a very accurate cut of it you may see in *George Agricola*.

And as for the Furnace with the *Vesica*, Alembic, Worm, and Refrigeratory that is too well known to need any description. I may now, therefore, dismiss this subject too, and thus put an end to the first and second part of these Institutions.

FIG: I.

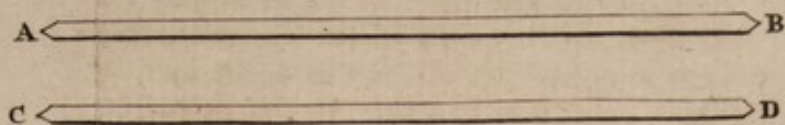


FIG: II.

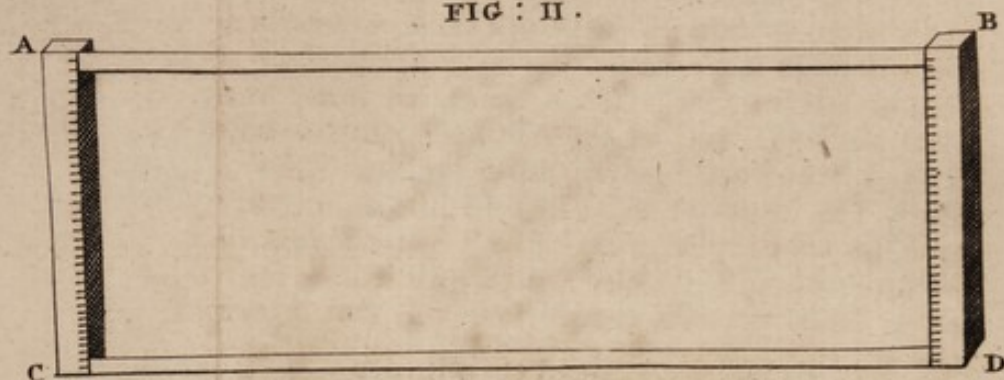


FIG: III.

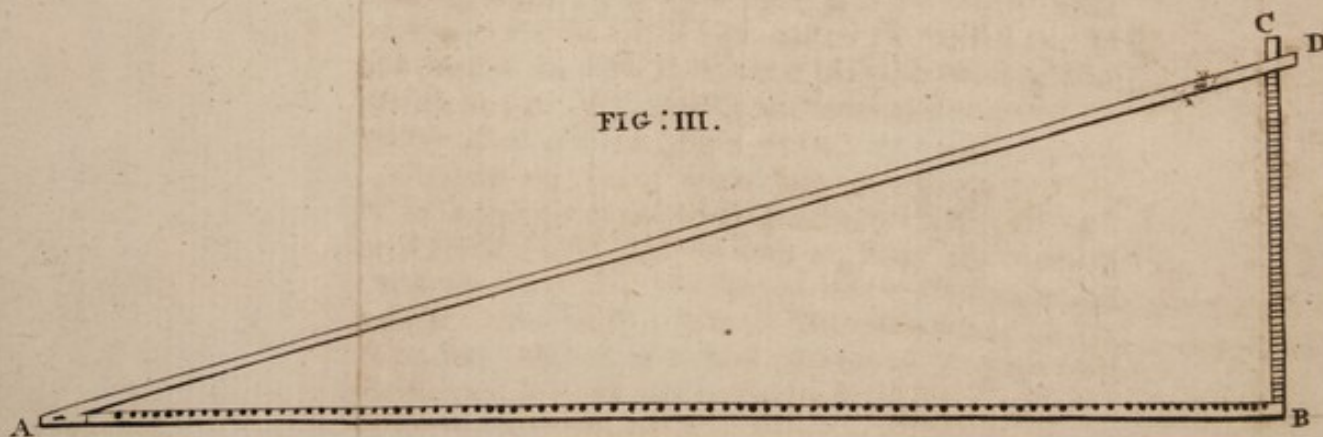


FIG. II.

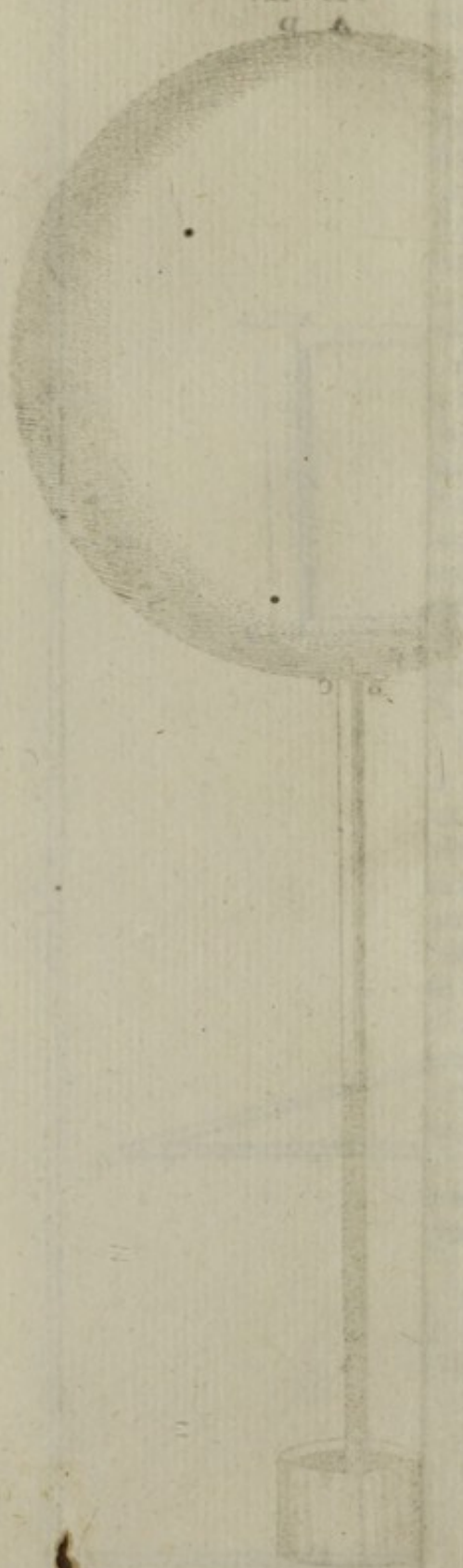


FIG. III.



FIG: I .

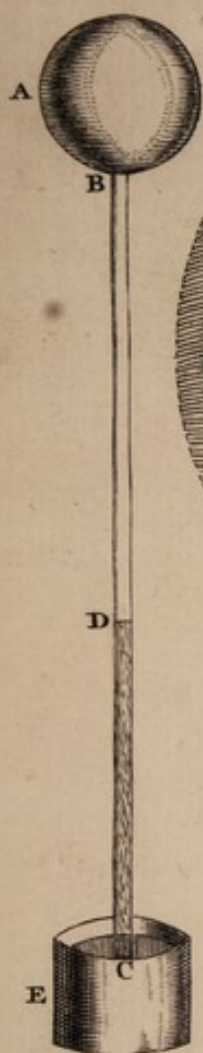


FIG: II .

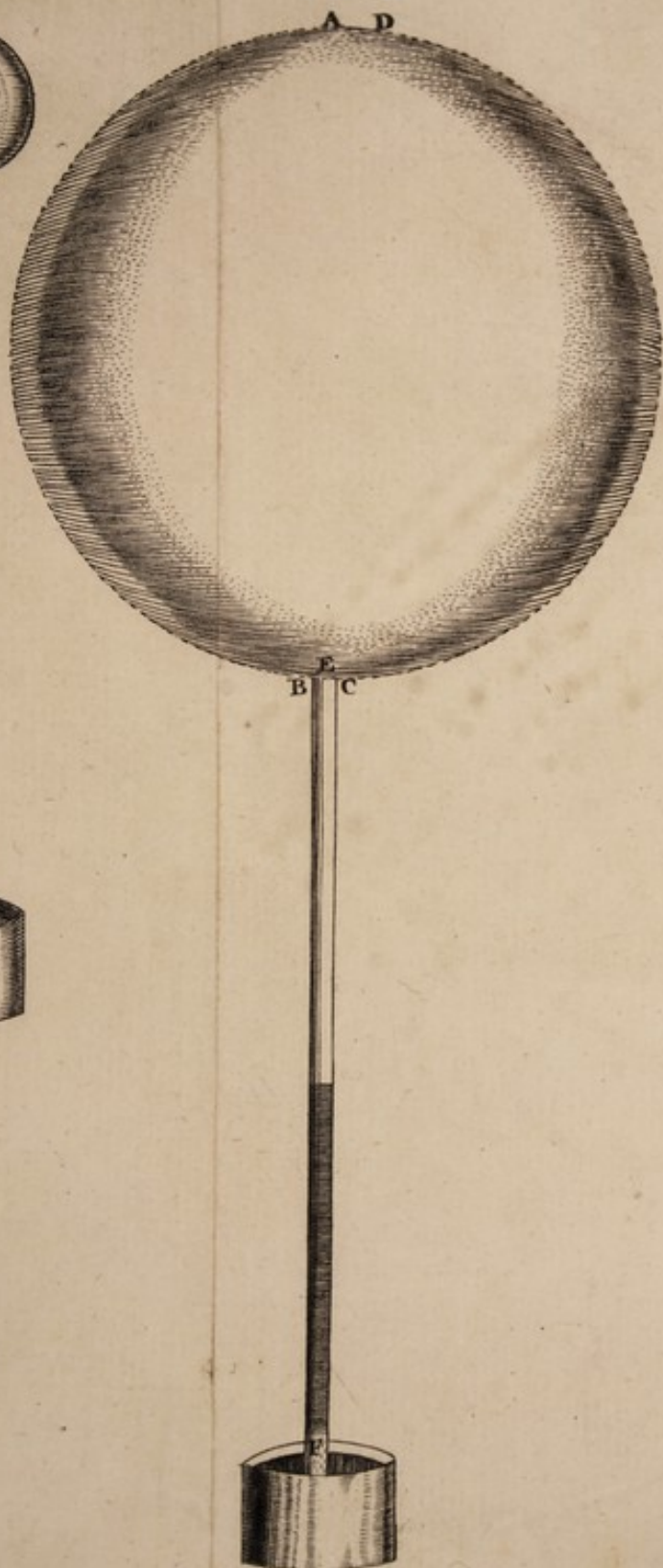


FIG: III .



The Explanation of the P L A T E S.

P L A T E I.

FIG. 1.

AB, CD. Two cylindrical iron Rods three feet long.

E. A Ring with a handle F, whose cavity measures exactly the thickness of both Rods when they are cold.

FIG. 2.

AC, BD. Two parallel Plates, divided into very small equal parts.

AB, CD. Two parallel Plates, which may be moved up and down by means of two Grooves, in AC and BD.

EF. The iron Rod to be measured when it is cold, and after it is heated.

FIG. 3.

AB. A brass Ruler divided into very small parts.

BC. Another, perpendicular to the former at B, graduated with very minute, and equal divisions.

AD. A third fixt upon an Axis at A, so that it may move upon the Ruler BC, and by this means may give you the number of parts upon BC, that the Rod made red hot, and set upon a certain point of AB, will elevate the Hypothenufe AD, higher than it did when it was cold, and plac'd upon the same point.

P L A T E II.

FIG. 1.

ABDC. The common Thermometer of *Drebbelius*.

A. Its hollow Sphere.

BD. The Neck full of Air to D, with which the Sphere is filled likewise.

DC. That part of the Neck that is filled with a colour'd Liquor.

E. A Vessel containing the same Liquor.

FIG. 2.

AB, DC, EF. A Thermometer of *Drebbelius*, more sensible than the former.

ABCD. An anterior view of the same.

FIG. 3.

ABCDEF. The same seen sideways; that the Segments of the Sphere of which the upper Cavity is formed, may come in view.

P L A T E III.

FIG. 1.

- A. A smaller Sphere, in which the contained Fire expands itself equably.
 B. A larger Sphere concentric to the former, and including it, into which the Fire diffuses itself equally out of the other.

FIG. 2.

- AFIG, BDIE. Two equal Spheres touching one another in the point I.
 CD. A right Line drawn from the Center C, of the first Sphere, which is a Tangent to the other at D.
 CE. A right Line drawn from the same Center C, touching the second Sphere at E.
 CFG. The Sector in which is contained that part of the Fire in the Sphere A, that may be equably communicated to the Sphere B, the proportion of which being found to the whole Sphere, shows what quantity of Fire thus equably expanding itself from the Center of one Globe can fall upon another of the same Magnitude in contact with it.

FIG. 3.

- A, B. Two Spheres equal to the former, and in contact.
 C. The Center of the Sphere A.
 D. The Center of the Sphere B.
 K. The point of contact of the Spheres.
 CKD. A right Line joining their Centers.
 EG. A Line parallel to CKD, touching both Spheres.
 FI. A Line parallel to EG, touching them both likewise.
 EFGI. The Cylinder through which all the Fire of the Sphere A being directed in parallel Lines, falls intirely upon the Sphere B; which therefore collects all the Fire that was before diffused through the whole superficies of the Sphere A: Whence the Fire will be four times denser in the Circle GDI, than it was in that Superficies.

P L A T E IV.

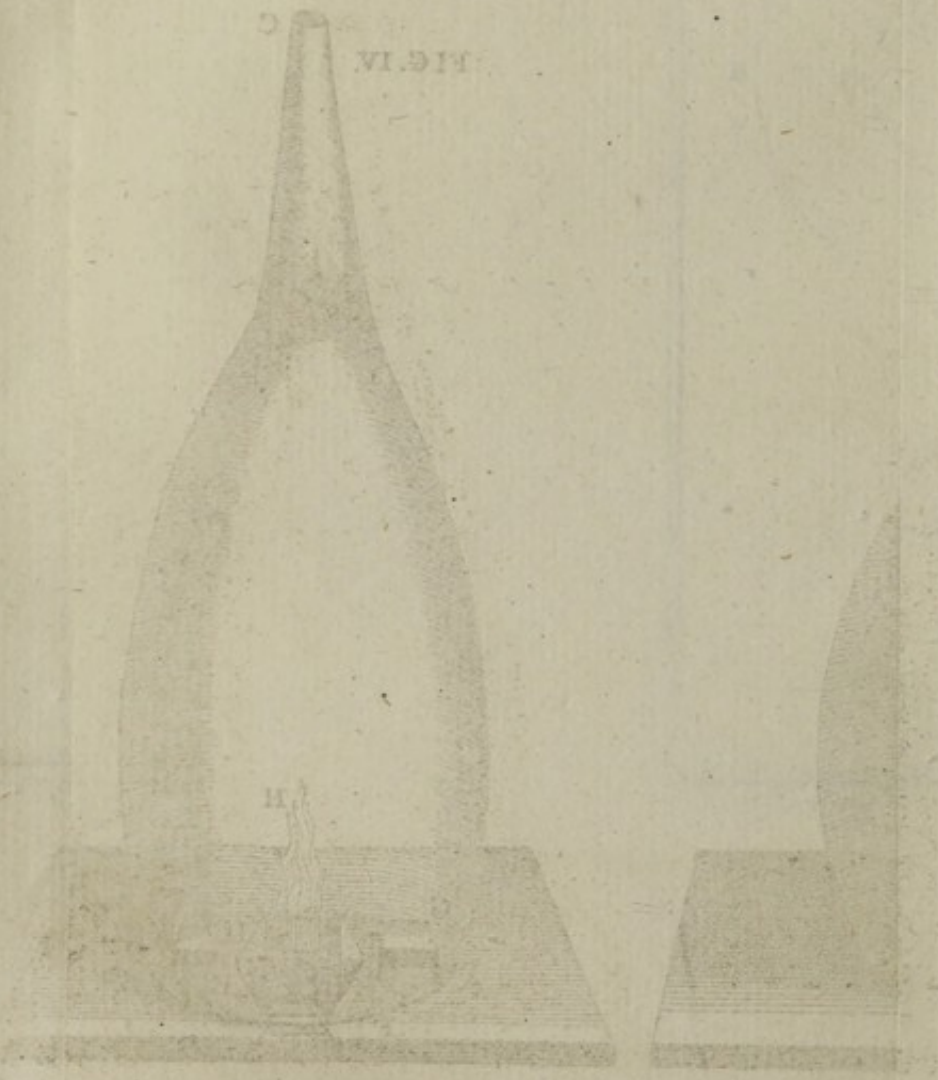
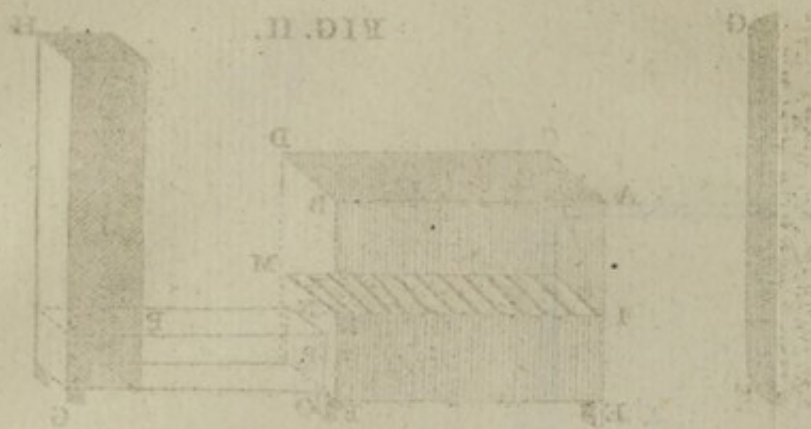


FIG. I.

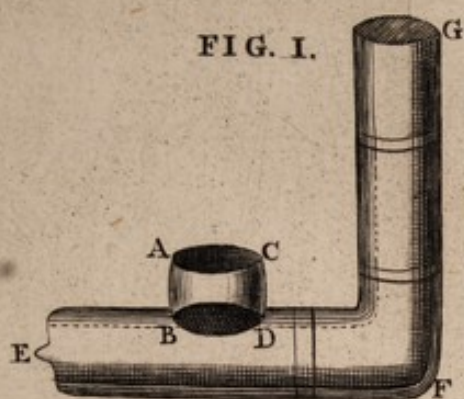


FIG. II.

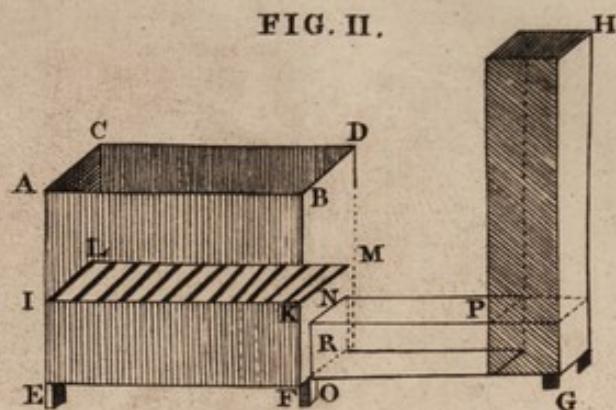


FIG. III.

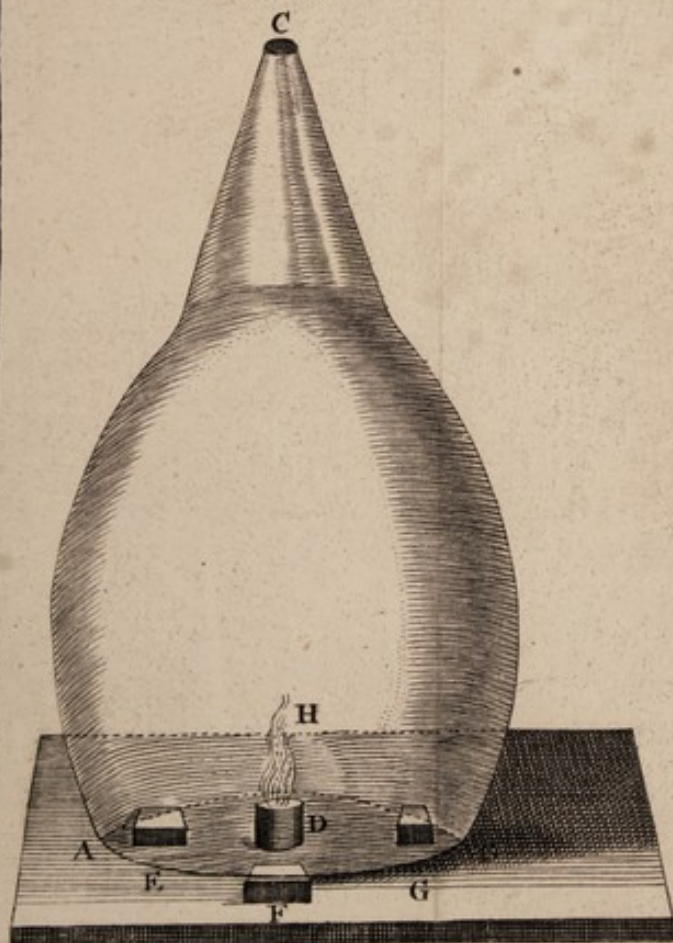


FIG. IV.

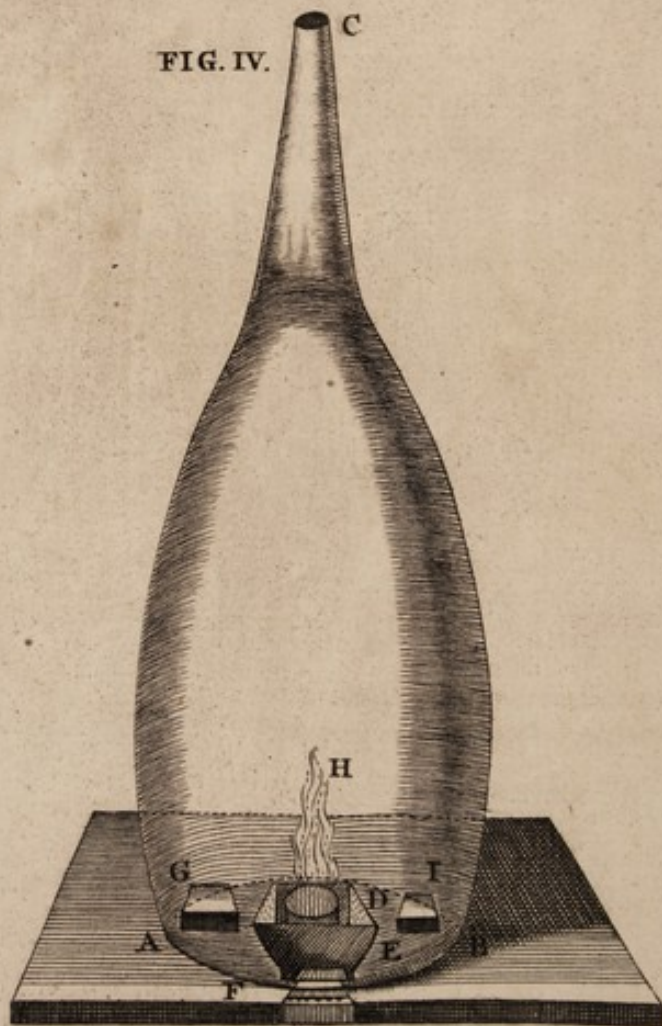


PLATE IV.

FIG. 1.

ABCD. A hollow Cylinder made of Iron Plates, and open at both ends, which is the Fire-place of the Machine.

BD. Its lower aperture where it communicates with the other Cylinder, by means of a Grate.

EFG. A hollow Cylinder made of the same Iron turn'd up at F, shut at E, and open at BD, where the Grate is, and at G, where the invisible Smoke passes out.

FIG. 2.

ABCDEF. A hollow Parallelipiped open at ABCD, in which the Fire-place is at ILKM.

ILKM. The Grate of the Fire-place, upon which is laid the combustible Matter.

EM. The place under the Grate into which the Flame and Smoke are depressed as soon as ever the Tube OGH grows very hot.

NO. The aperture, which is here square, but may likewise be made oval as in the Text. If it is made square, it must be a little narrower than KM, if elleptical, its Diameter must be of that length.

NOGH. A hollow Tube of the same Iron, either parallelipipedal or elliptico-cylindrical, as in the Text, open under the Grate at NO, and at the top H.

FIG. 3.

ABC. The biggest Glafs-Receiver I could get, open at C.

AB. The bottom of it cut out in a circular form, and therefore open there too.

D. A brass Cylinder in which the Liquor being set on fire gives the Flame H, confined under the Bell.

EFG. Three Bricks which the Bell is set upon, that the Air may have free admission to it underneath.

FIG. 4.

ABC. A glafs Vessel, as before.

E. A Pan with a live Coal.

D. A brass Dish, in which the Alcohol burns, the Dish standing upon the Coal.

F, G, I. Three Bricks on which the Glafs stands.

H. The Flame of the Alcohol set on Fire under the Bell.

PLATE V.

P L A T E V.

FIG. 1.

ABC. A Thermometer fixed to the board DEFG by the brass rings M, N, O.
 DEFGHIKL. A wooden Machine made to stand upon a table with the Thermometer.

PQ. A vessel in which the Bulb of the Thermometer may be placed, and then any liquors, you have a mind to make trial of, may be poured in successively and mixed together.

FIG. 2.

ABC. *Fahrenbeit's* first Thermometer, which by the dilatation of the tinged spirit indicates the increase of the heat of the Atmosphere.

AB. Its Bulb, which in the greatest observed natural cold contained 1933 parts of tinged spirit, of which the Pipe BC contained 96.

BC. A Pipe produced from AB and by a Scale fixed to it divided into 96 equal parts, that the spirit when it dilates, and ascends, may discover the augmentations of Heat.

FIG. 3.

ABC. *Fahrenbeit's* second Thermometer measuring the increments of Heat in the Atmosphere by the dilatation of Mercury.

AB. Its Bulb, which in the greatest observed natural Cold contained 11520 parts, of which the Pipe BC contained 96.

BC. A Pipe produced from AB, and divided by a Scale into 96 equal parts, by which the Mercury when it ascends determines the increase of Heat.

FIG. 4.

AB. *Fahrenbeit's* third Thermometer to measure the Heat of the Human Body.

AB. A clear glass Tube, perfectly closed hermetically, within which it is placed.

DC. The Thermometer within, either by its tinged spirit, or Mercury, indicating the increments, or decrements of Heat.

DE. Its Bulb.

EG. Its neck.

EF. The fluid in the neck, by its ascent pointing out the Heat, by its descent the Cold.

EFG. A paper divided into equal parts or degrees.

This Thermometer being held a good while under the arm, upon the breast under one's clothes, or in the mouth, will determine the Heat of the Body at that time.

FIG. I.

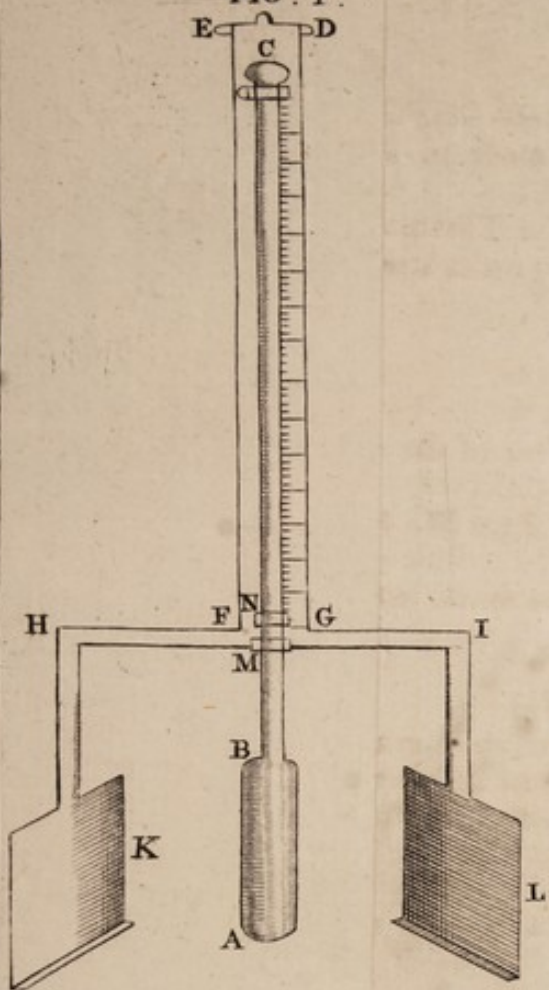


FIG. II.

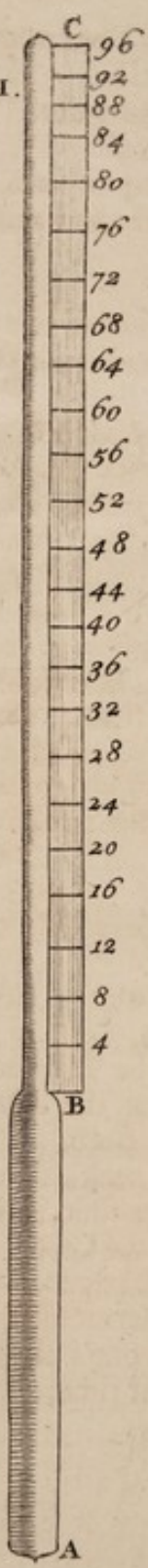


FIG. III.

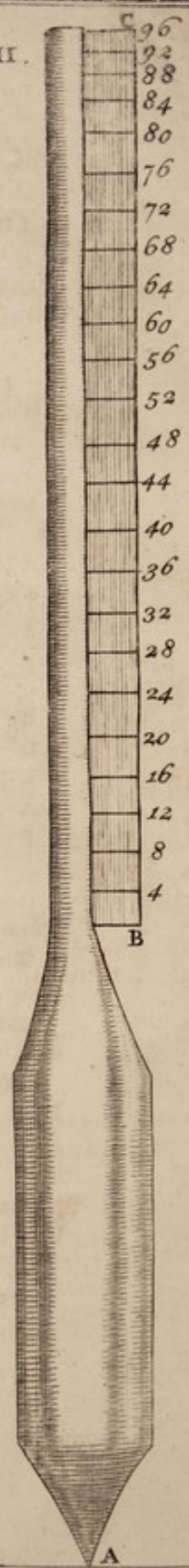


FIG. IV.



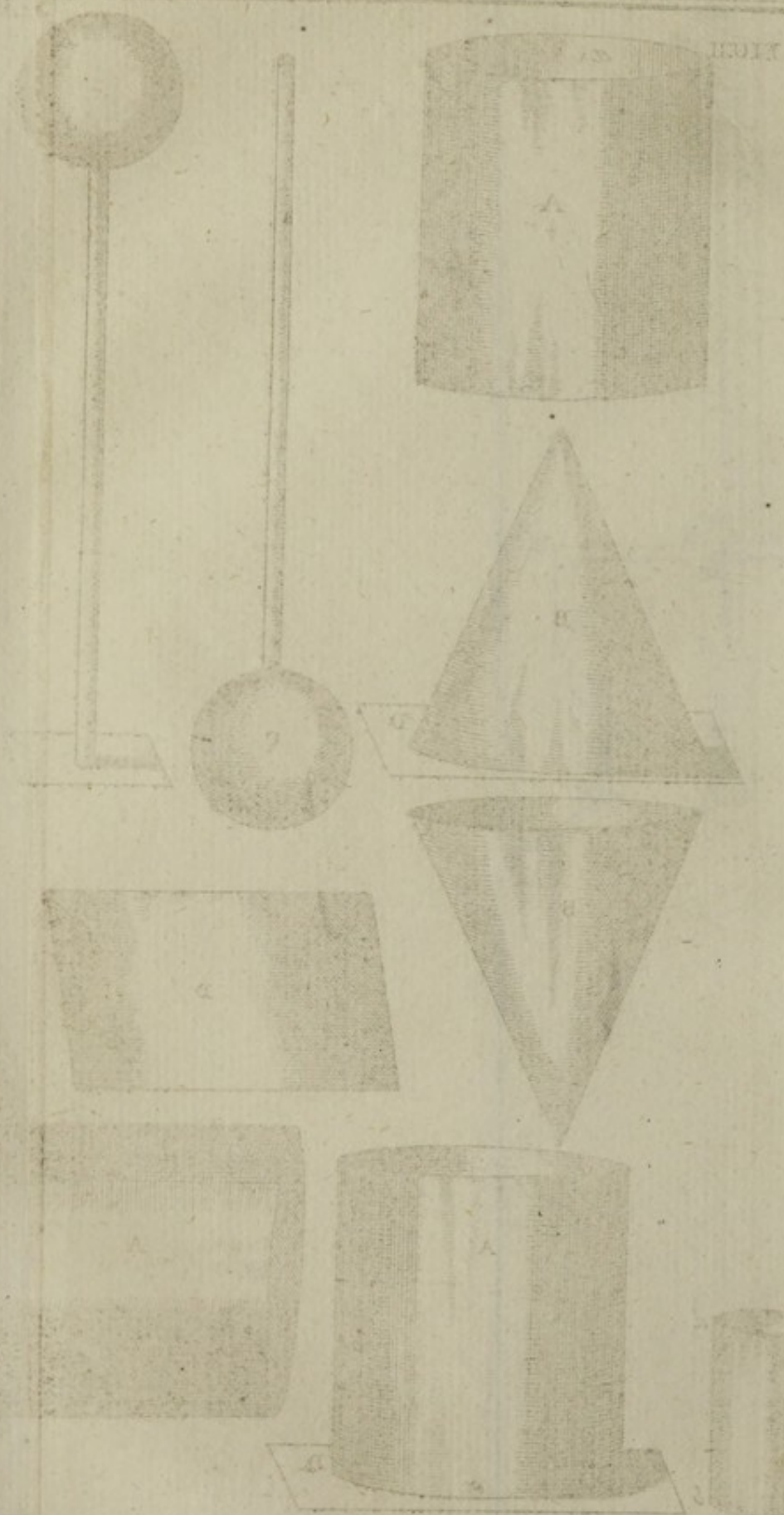
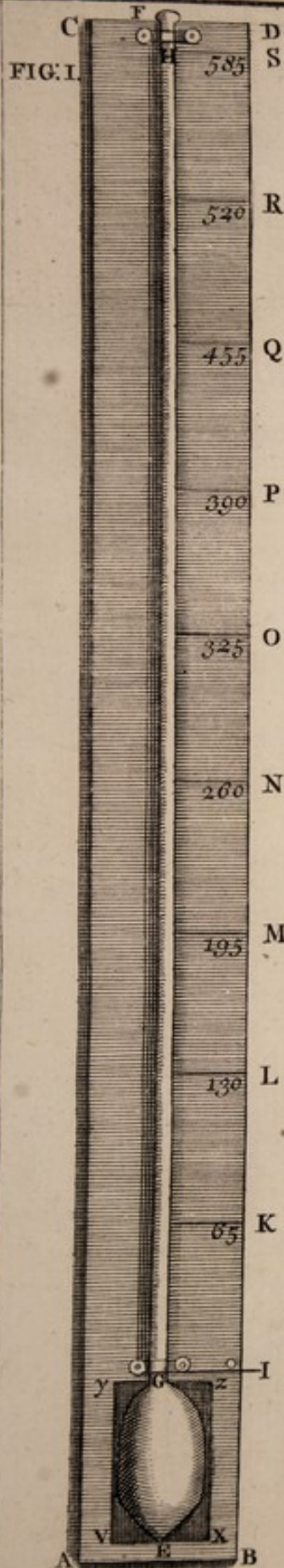
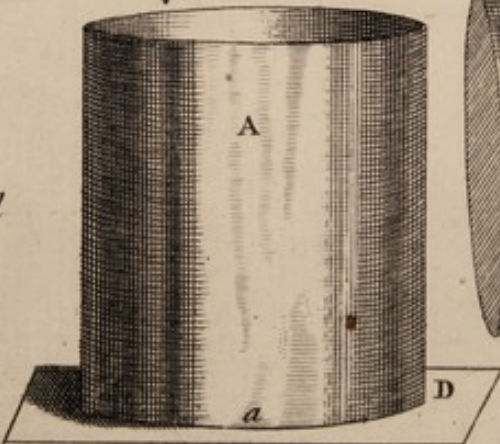
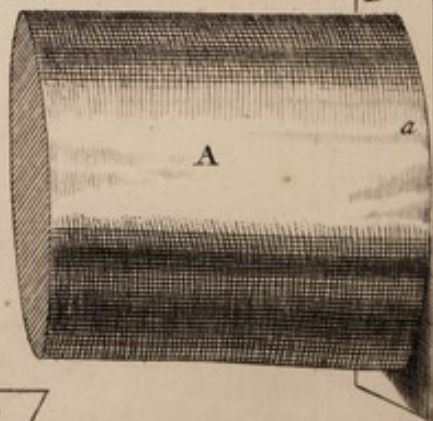
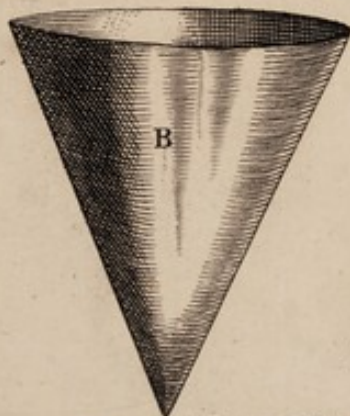
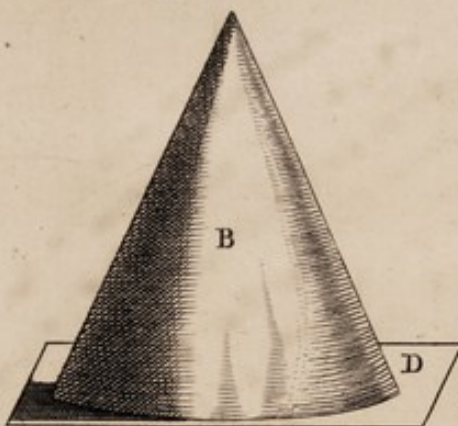
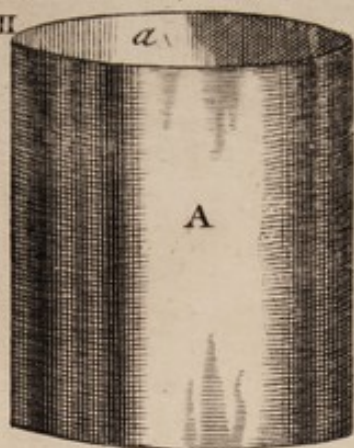


FIG. II



P L A T E VI.

- ABCD. A brass Plate hollowed at vxyz that the Bulb of the Thermometer may be let into it.
- EF. A Thermometer made with Mercury in such a manner, that in the greatest observed natural cold the Mercury may stand at I, and in the heat of boiling Mercury at F.
- GE. The Bulb of the Thermometer.
- GF. The pipe of the Thermometer divided by means of the brass Plate into 600 equal parts, which in this short Figure cannot be all represented distinct, and therefore here we have divided it into larger portions IK, KL, LM, &c. each containing 65 of such equal parts.
- G, H. Two brass Semi-circles by which the Thermometer is so fixed to the Plate, that you may take it off whenever you please.
- abcd. A brass vessel, into which the Thermometer may be put when taken off of the plate, that the heat of the Liquor to be examined, whilst it boils in this Vessel may be marked upon the neck GF, which then being applied to the Scale, will give you the degree desired.

FIG. 2.

- A. A hollow cylindrical Vessel open at a, quite full of water, but its mouth covered with the paper D, which is then inverted without any Water running out. The same Vessel covered in the same manner, and lying horizontally, without any Water running out.
- B, B. Conical Vessels, with which the Experiment succeeds in the same manner, as it does likewise in
- C. A small Bolthead.

PLATE VII.

P L A T E VII.

FIG. 1.

- ABbc. A strong glass Tube every where equally wide.
 AB. The longer Leg, some feet high.
 bc. The shorter, 12 inches high, and nicely divided into lines:
 A. The Mouth at which the Mercury is poured in.
 c. The extremity hermetically sealed.

FIG. 2.

- ABC. A very small Bolthead filled with Water and inverted.
 BC. The Bulb, at whose top C is contained the Air, which entering in the form of Bubbles ascended and burst asunder.
 AB. The Neck, whose orifice A is 5 lines diameter.
 A, d, e, f, g, h. Bubbles, in which form and size the Air admitted into the Neck is collected and ascends, not mixing with the Water, but associating into a large Body.

FIG. 3.

- ABC. A Glass like the former, full of Water, and inverted.
 BC. The Bulb still full of Water.
 BA. Its Neck, whose Mouth A is 8 lines in diameter.
 d, e. Large Air-bubbles, in which form and size the Air enters and ascends without mixing with the Water.

FIG. 4.

- ABC. The same sort of Vessel in a horizontal position, and full of Water.
 d, e. Large Air-bubbles, which continue thus a good while in the Water, without dividing.

FIG. 5.

- AB. A narrow glass Tube open at both ends.
 Ac. Water in which the part Ac of the Tube is immersed.
 cD. Water ascending in the Tube spontaneously.

FIG. I.

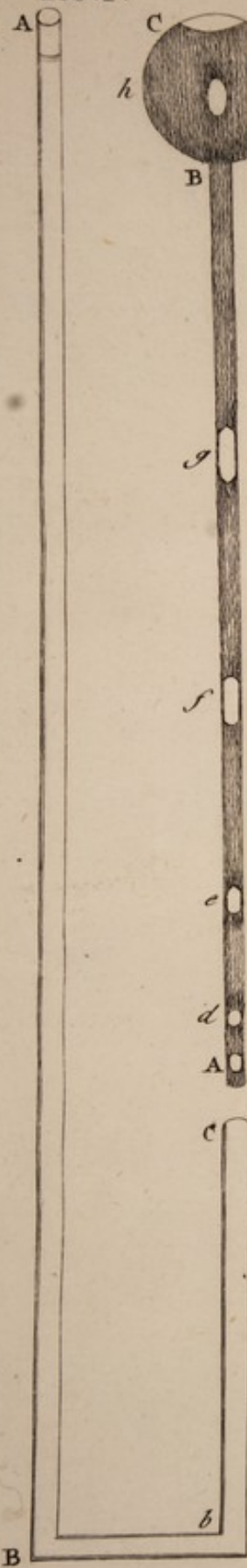


FIG. II.



FIG. III.



FIG. V.



FIG. IV.

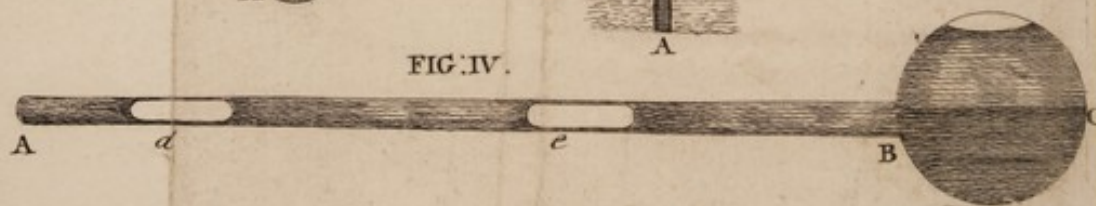


FIG. I.

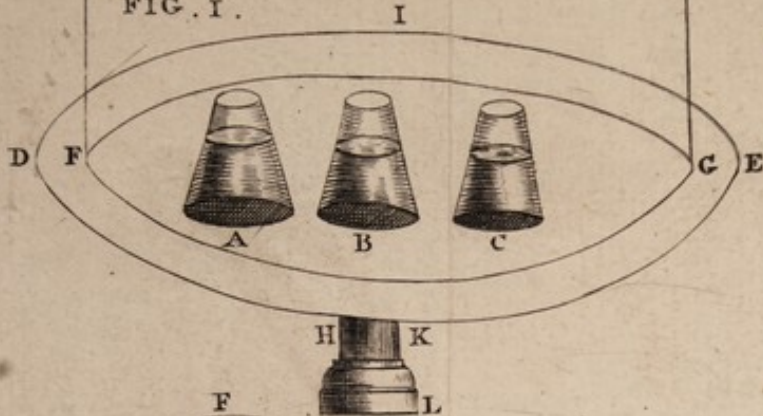


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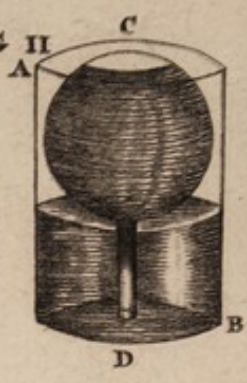


FIG. III.

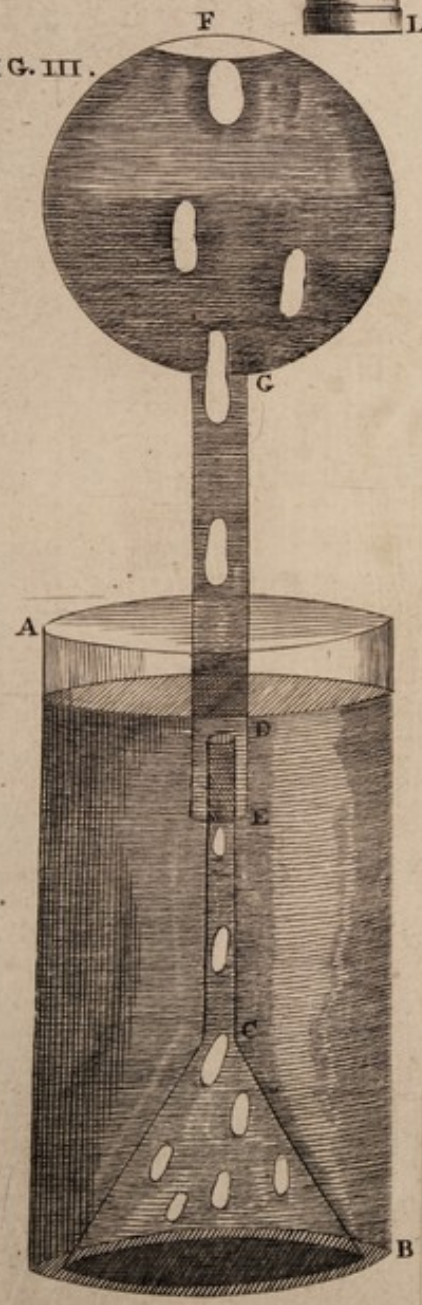


FIG. IV.

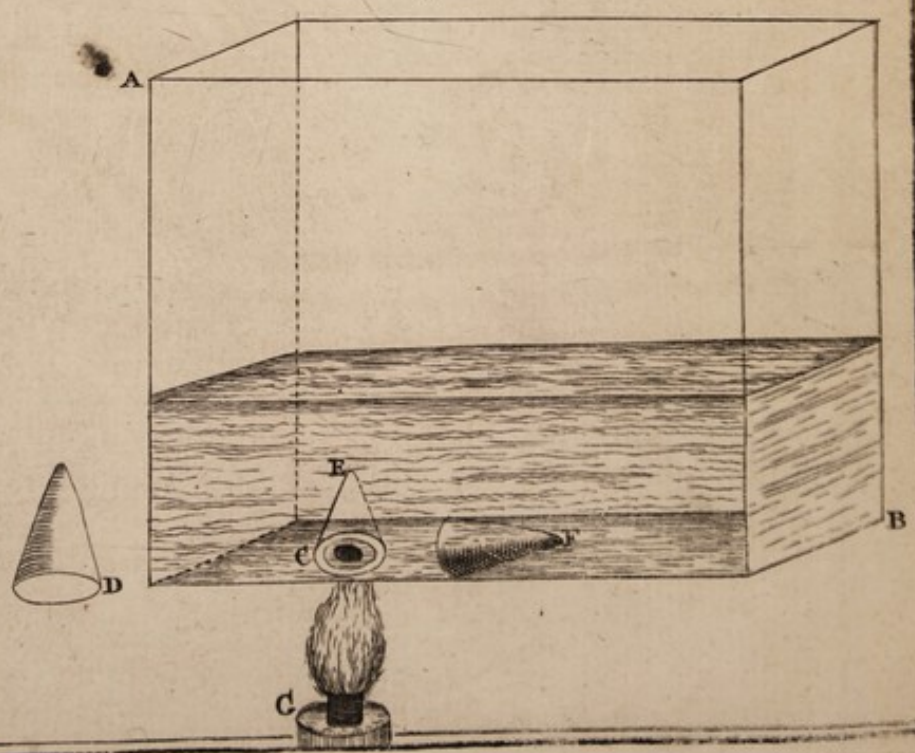




FIG: II.

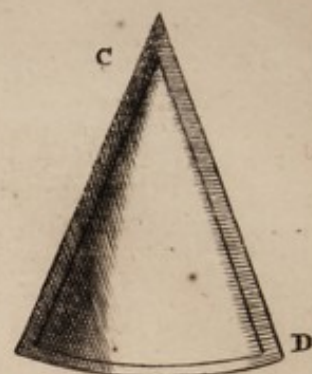
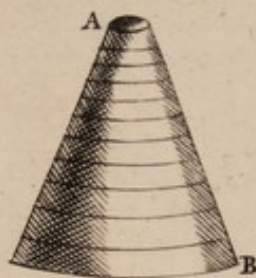


FIG: III. K H I L

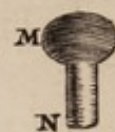
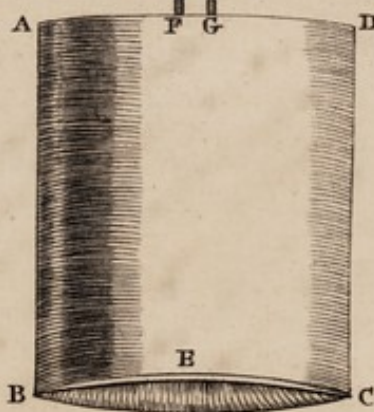
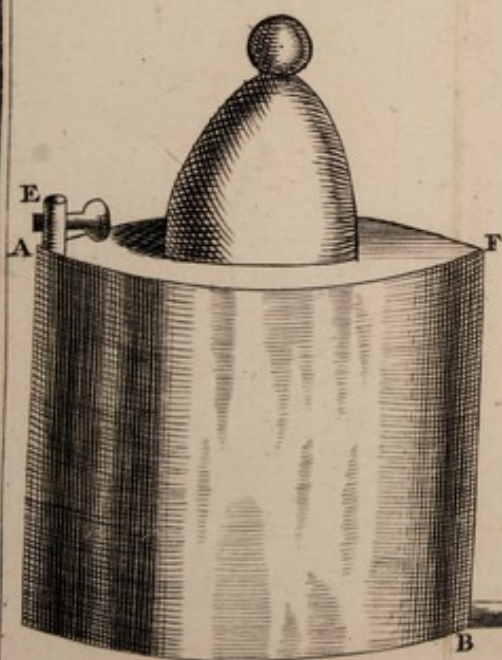


FIG: I.



A

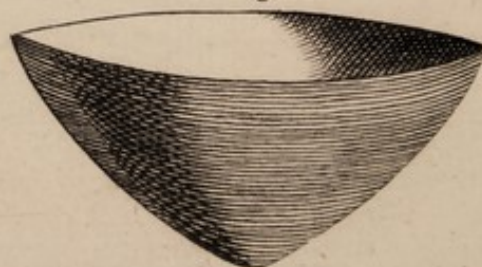


FIG: IV.

B



C



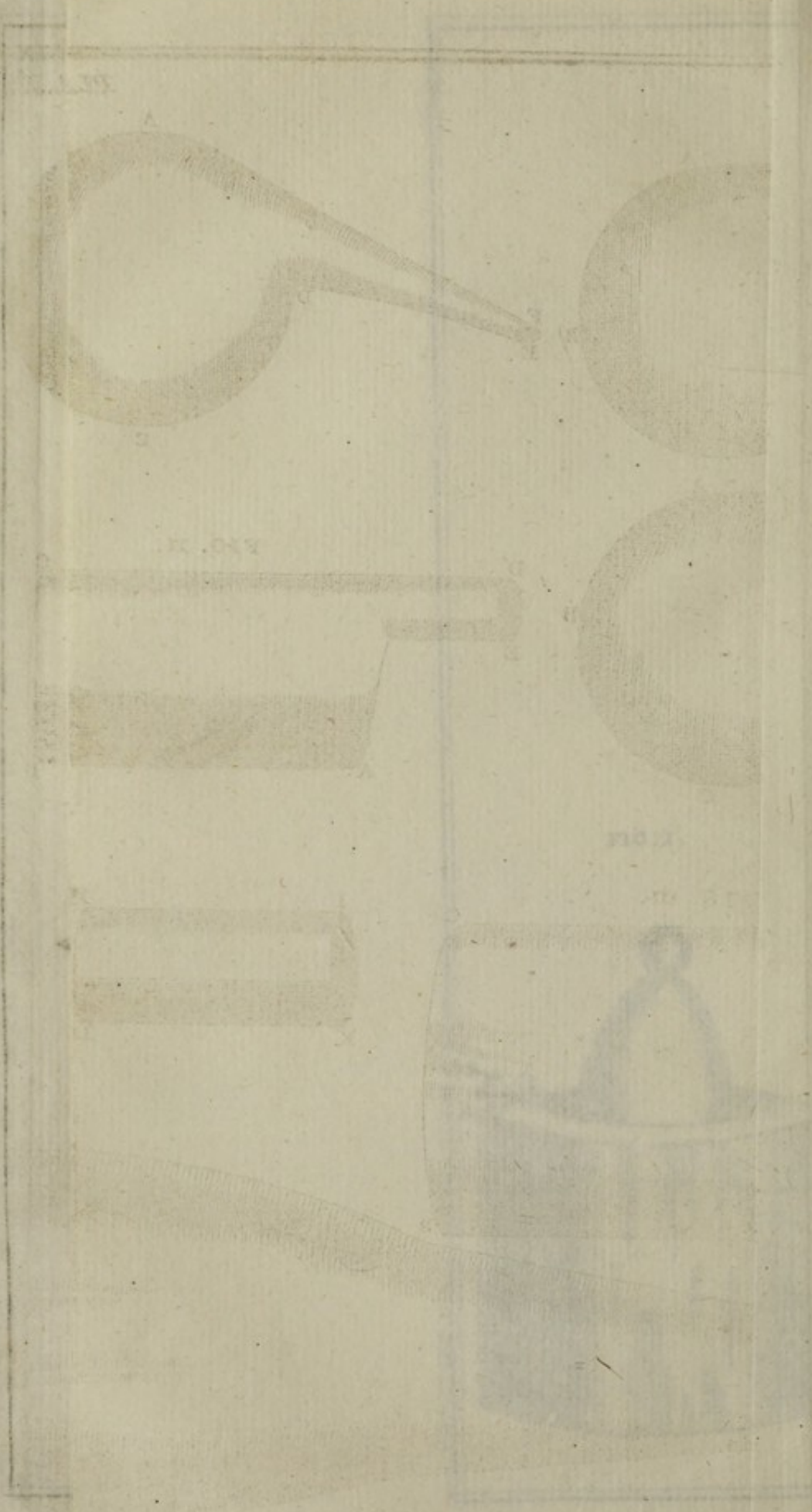


FIG. I.

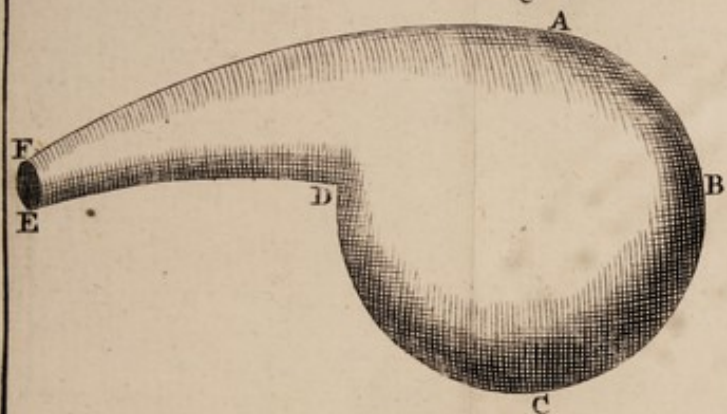
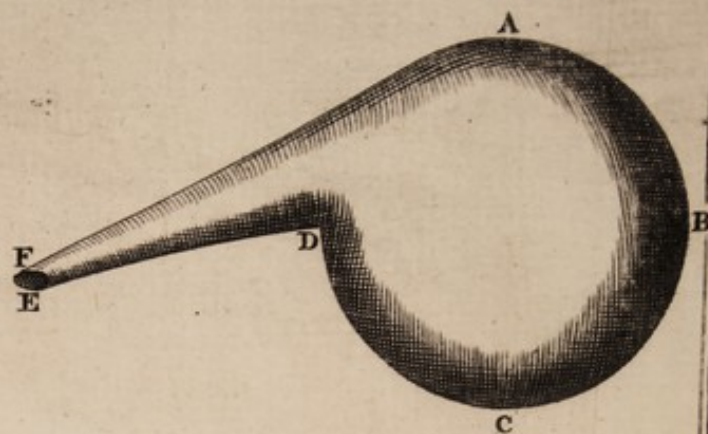
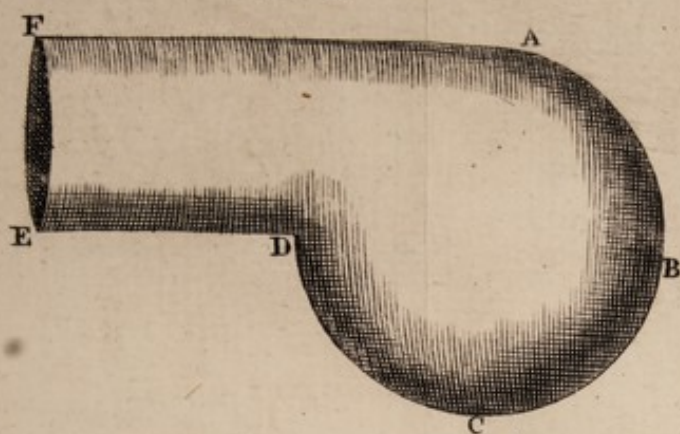


FIG. II.

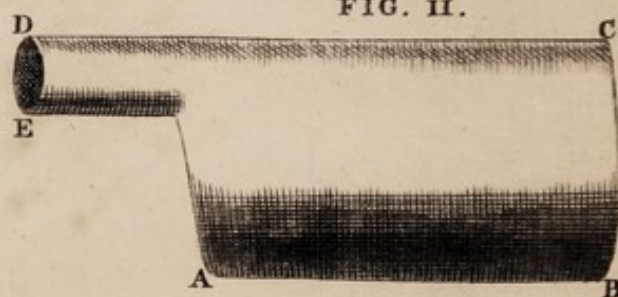


FIG. III.

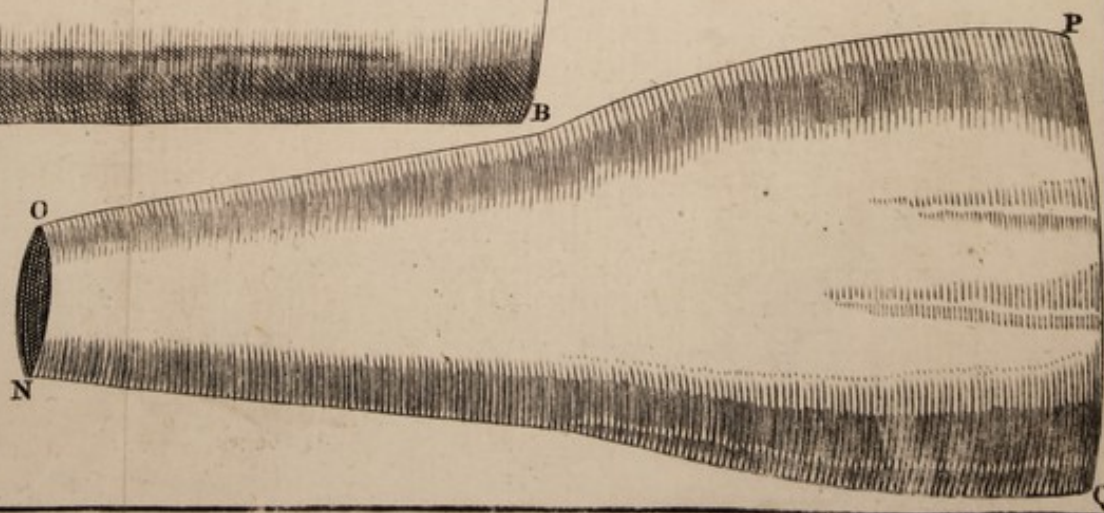
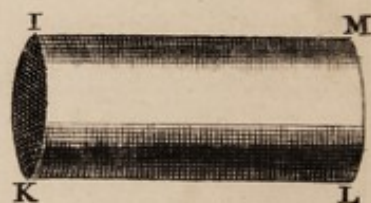
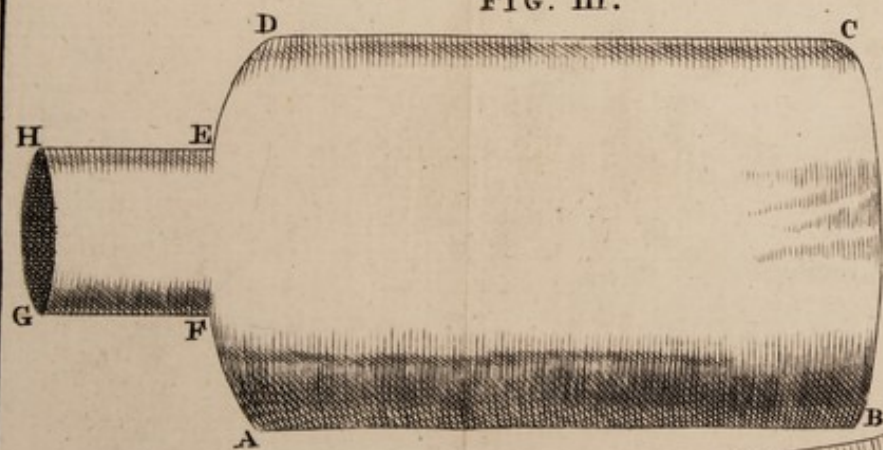


PLATE X.

FIG. 1.

ABCDEF. The true figure of a distilling Vessel, called a Cornute, or Retort.

ABCD. A hollow Sphere, the Belly of the Retort.

AF. A Tangent to the Sphere in the Vertex A.

DE. A right Line parallel to the Tangent AF, drawn from the point D, where the Diameter parallel to that Tangent cuts the Sphere.

Of these three forms, the last is the best.

FIG. 2.

ABCDE. A Vessel contrived for the distillation of the most fixed Bodies, as Phosphorus, &c.

FIG. 3.

ABCDEFGH. A Long-neck to be placed horizontally in the Furnace, so that the mouth may be a little way out.

IKLM. A hollow, cylindrical Tube, one of whose ends may be received into the mouth HG of the Long-neck, whilst the other is inserted into that of the Receiver ON.

ONPQ. A very large Receiver, which being placed horizontally receives the extremity LM of the cylindrical Tube.

X x x 2

PLATE IX.

P L A T E X I.

FIG. 1.

ABCD. A Tin Cylinder 6 inches wide, ending in
CDE. A Conical Tube 4 feet high, and an inch in diameter at the vertex E.

EF. A cylindrical Tube 4 feet long, and an inch wide.

FG. The same produced, that it may be inserted into the mouth of the Worm in the Refrigeratory.

HIK. Holdfasts to keep the ascending and descending Tubes tight together.

This is the Head used in the Distillation of Alcohol.

FIG. 2.

Glass Vessels so contrived as to fit into one another, by luting which together, you may increase the distance between the distilling Vessel and Receiver, to what length you please.

FIG. 3.

A Pelican.

FIG. 4.

A more compendious Pelican with two Boltheads.

P L A T E X I I.

FIG. 1.

The whole Apparatus as used in distilling.

ABCDEFGH. The earthen Long-neck placed horizontally in the Furnace.

IKML, A hollow cylindrical Tube inserted into the mouth of the Long-neck HG, and that of the Receiver ON.

ONPQ. The Receiver.

FIG. 2.

A chemical Vial, Bolthead, or Matrafs.

FIG. 3.

The biggest Receiver the workmen could blow, which fort the Chemists now-a-days make use of.

P L A T E X I I I.

FIG. I.

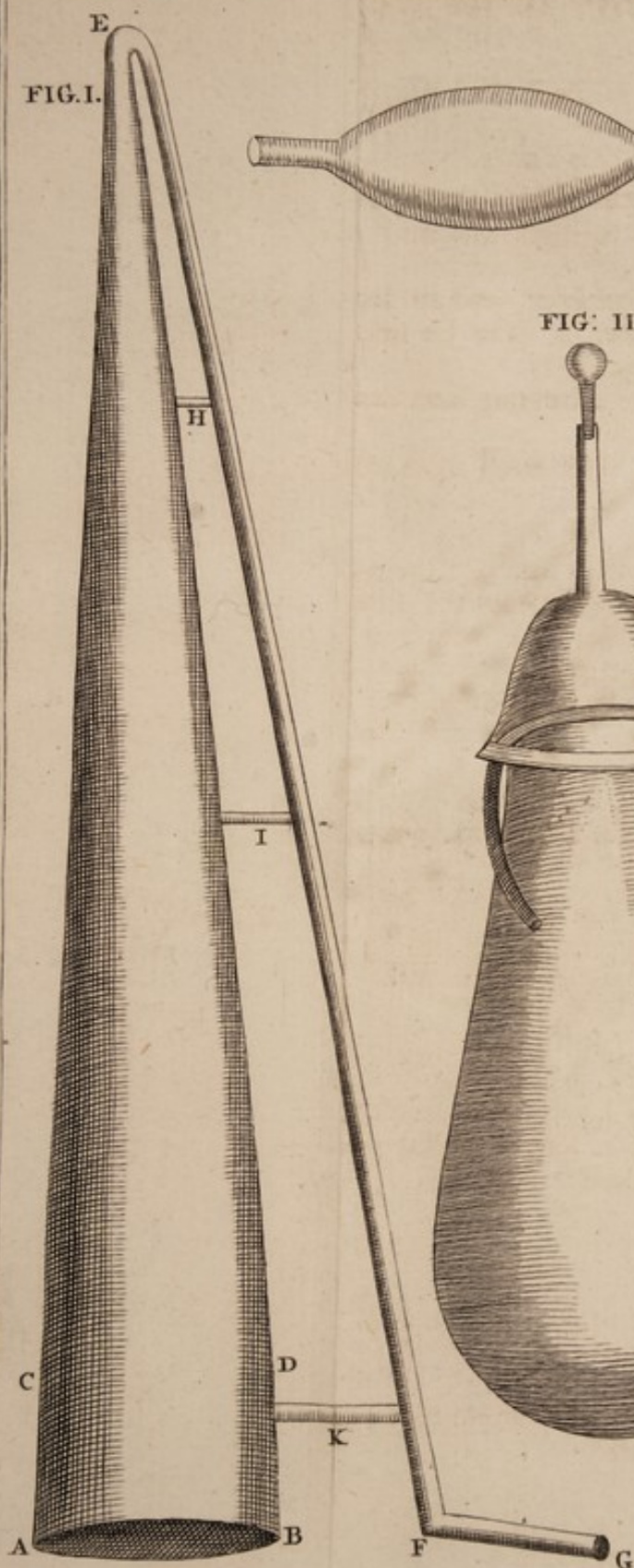


FIG. II.

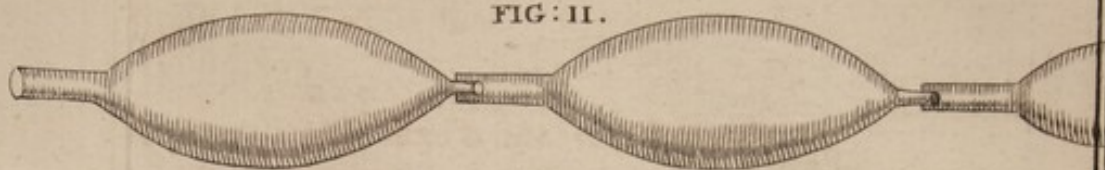


FIG. III.



FIG. IV.

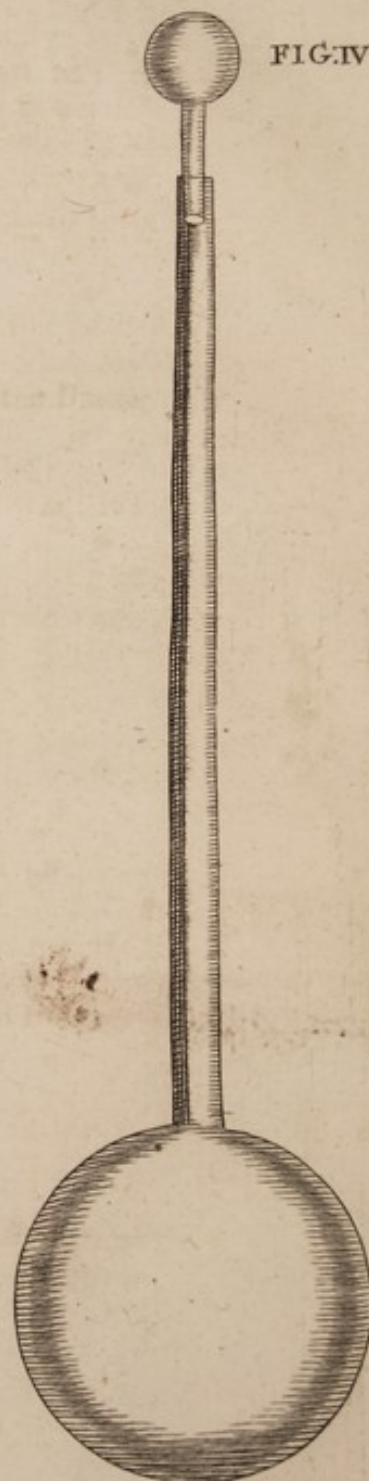


FIG. I.

FIG. II.

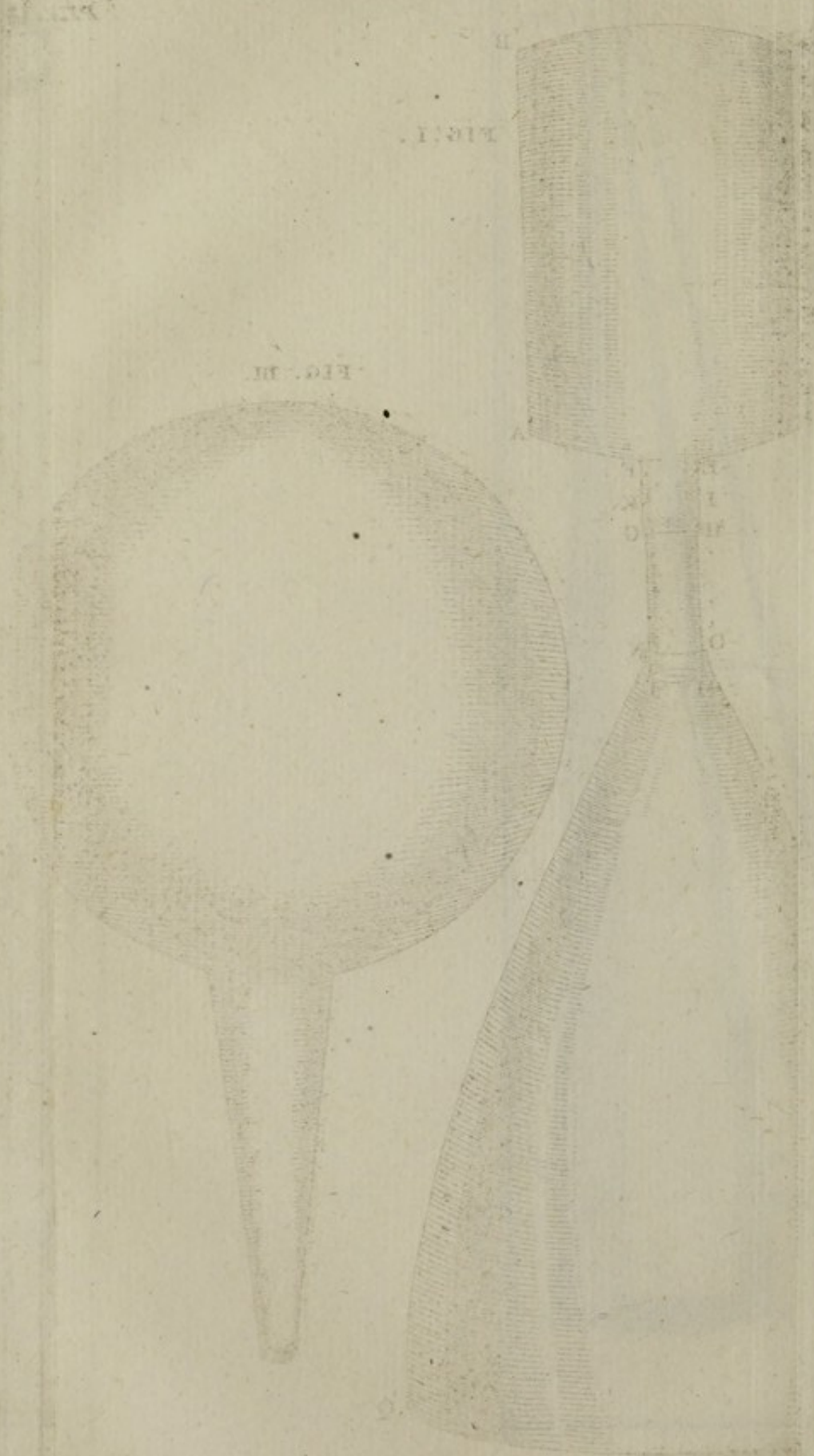


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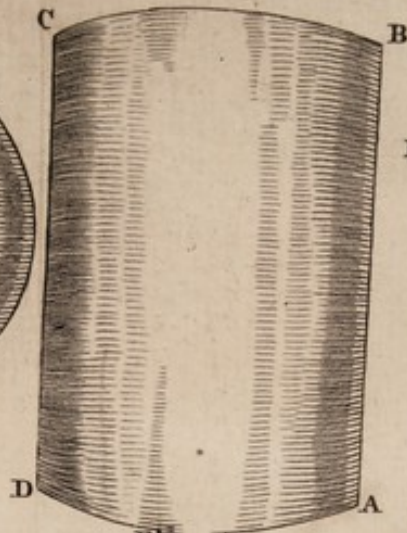
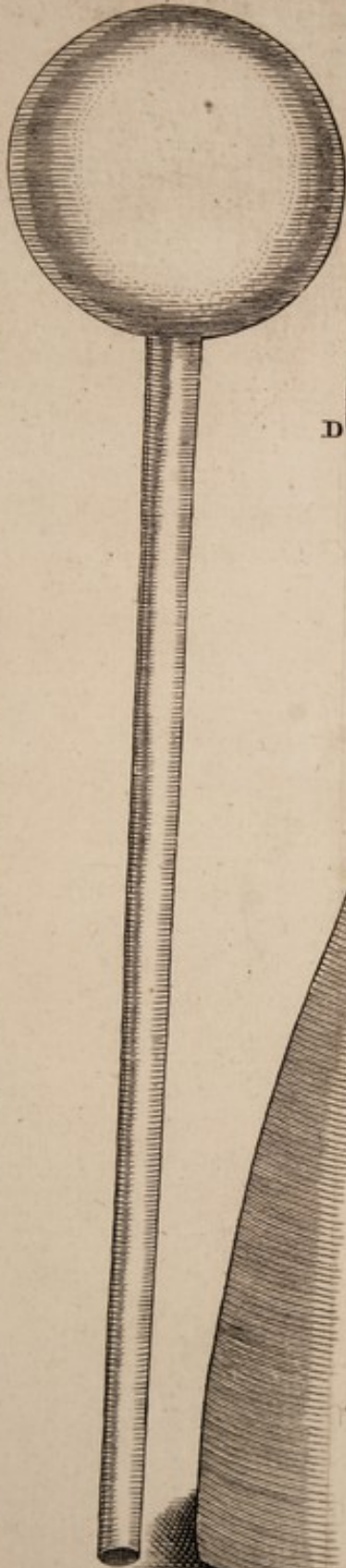


FIG. I.

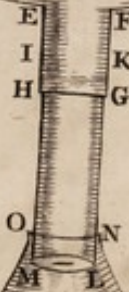
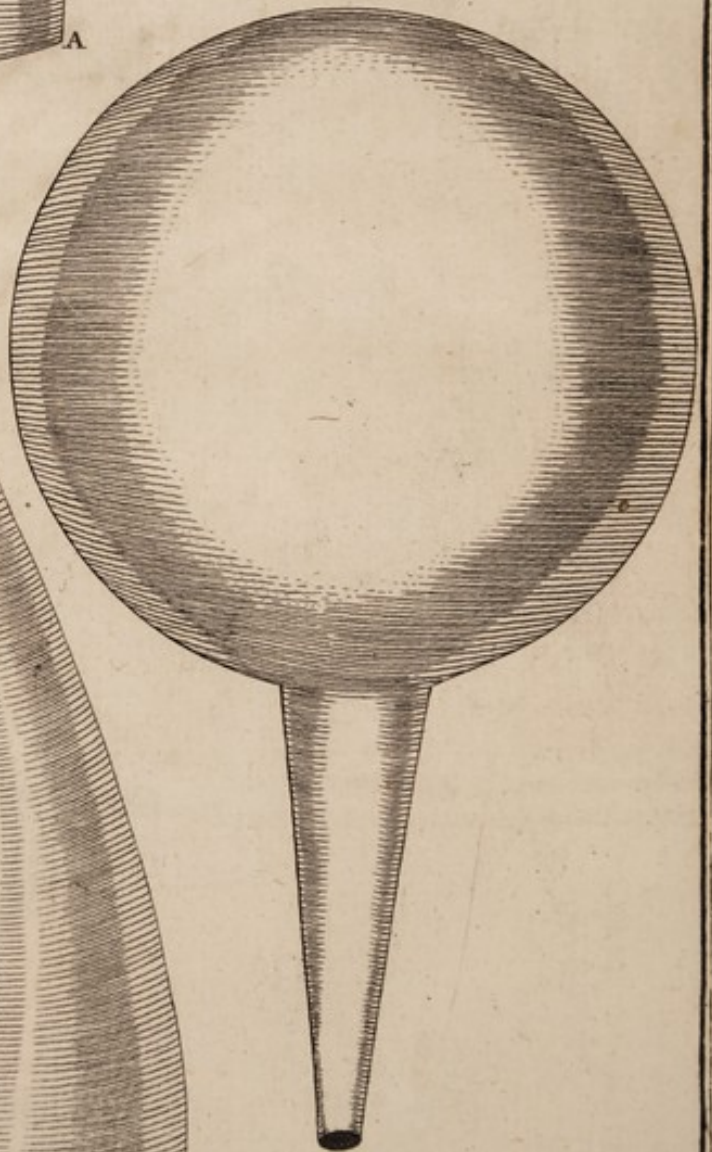
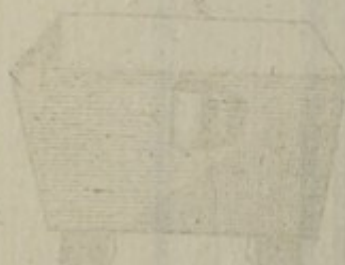
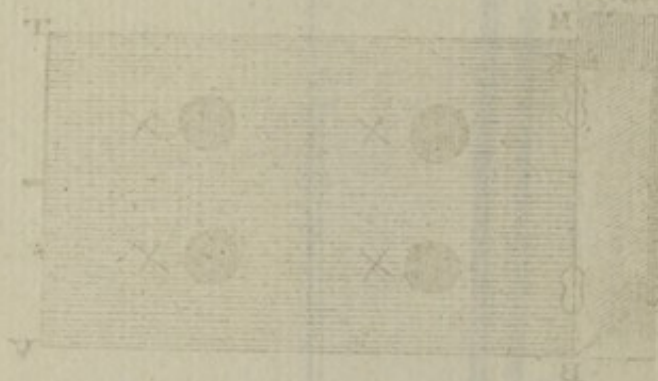


FIG. III.



P

Q



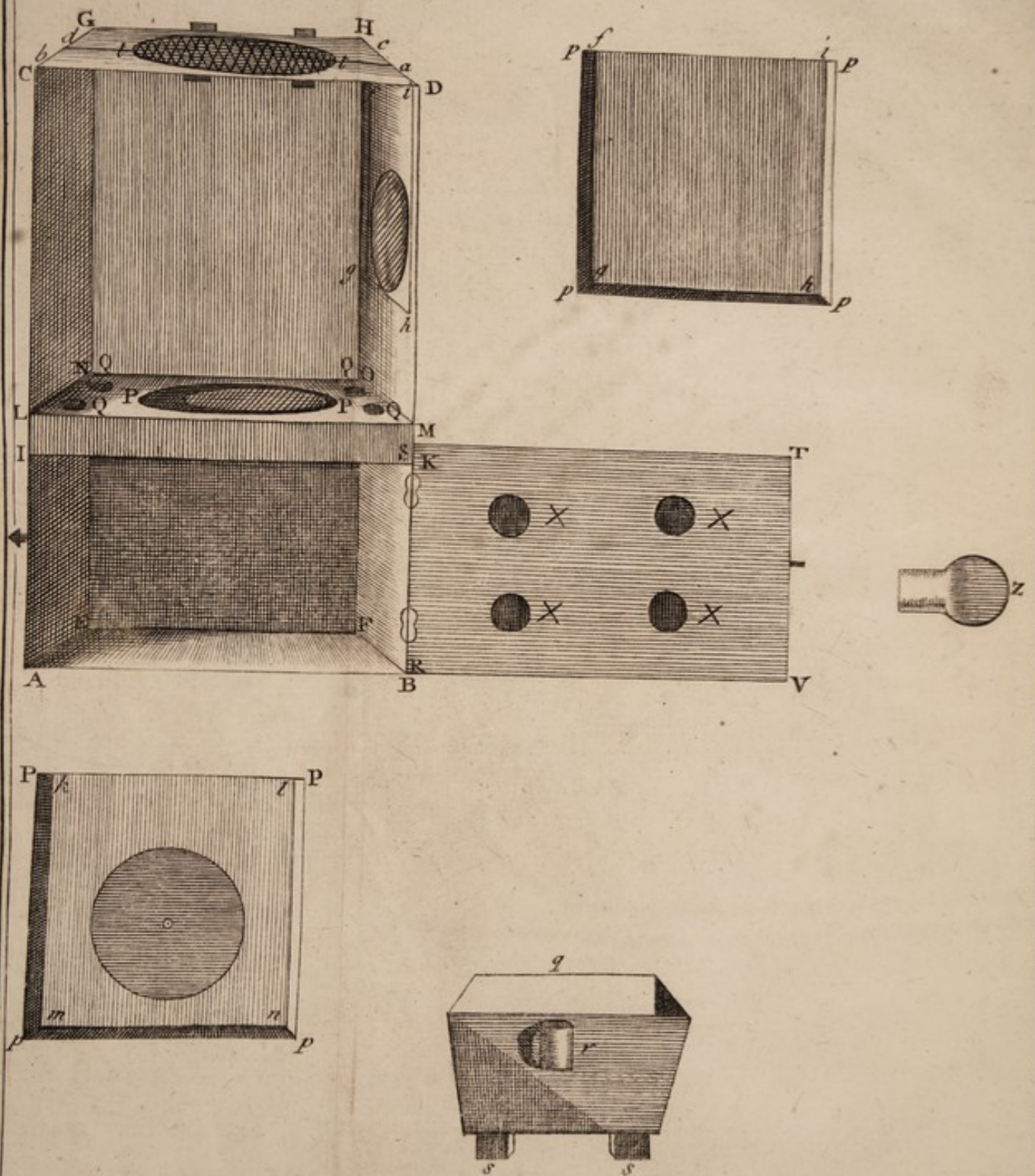


PLATE XIII.

The First Furnace.

- AB. One side of the square base 9 inches long.
 ABEF. The square base.
 ACBD. The height and breadth of the prismatical Furnace, which is 14 inches high.
 AI, BK. The height of the Fire-place 5 inches.
 IL KM. The thickness of the partition 1 inch.
 LC, MD. The height of the upper cavity of the Furnace 8 inches.
 PP. A circular hole 5 inches in diameter cut out in the middle of the Partition, in which is placed the bottom of the Cucurbit, Retort, or Bolthead, and whose upper edge is par'd away.
 QQQQ. Four smaller circular holes in the same, each an inch in diameter, made to transmit the heat from the Fire-place into the upper part of the Furnace.
 fghi. A square hole cut in the upper part of the side BDHF, the same letters representing the square board that fits into it, and is in the Plate placed on the side of it.
 fp, gp, kp, ip. The edge of this board cut away to half its thickness, which is to be put into the hole gH, hD, when you distill with a Cucurbit.
 klmn. Another square board exactly like the former, but with a circular hole in the middle O, of $2\frac{1}{2}$ inches diameter, to be used when you distill with a Retort.
 fg, hm. Each $5\frac{1}{2}$ inches.
 RSTU. The door by which the Fire-place is exactly closed up, which rises to the middle S of the Partition KM.
 XXXX. Four round holes in the door, to let the Air into the Fire-place.
 Z. Wooden Stoppers to fit into those holes to regulate the Fire.
 Cb Da, Gd Hc. Two folding Doors, which are so cut out in the middle, that when they are shut, they form a round Hole of 5 inches diameter tt.
 q. The Pan used in this Furnace.
 r. The Handle.
 s, s. The Feet.

P L A T E XIV.

Second Furnace.

AC, BB. Iron Feet 12 inches long.

CNOD. The bottom of the Furnace, being an iron Plate covered with a brass one 17 inches in diameter.

CGHD. A hollow iron Cylinder upon the Base CNOD, 19 inches high.

ELMF. The Grate consisting of an orbicular iron rim, and the bars in the middle y, which is supported by the bars E F, and is parallel to the base CNOD.

FL, MF. The breadth of the rim of the Grate $3\frac{1}{2}$ inches.

EC, FD. The distance of the Grate from the bottom 4 inches.

NOPQ. The door of the Ash-hole, 6 inches broad, and 4 high.

QR, PS. The distance of the door of the Fire-place from the upper part of the Grate 3 inches.

RSTV. The opening into the Fire-place, 6 inches broad, and $4\frac{1}{2}$ high.

ILKM. An Ellipse whose ordinates at the *Foci*, LM IK are 5 inches long, from which is formed the elliptico-conoidal, internal surface of the Furnace, by the rotation of the wooden pattern bc de, upon the axis cb.

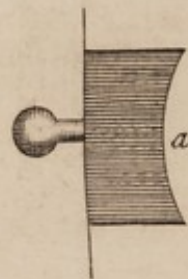
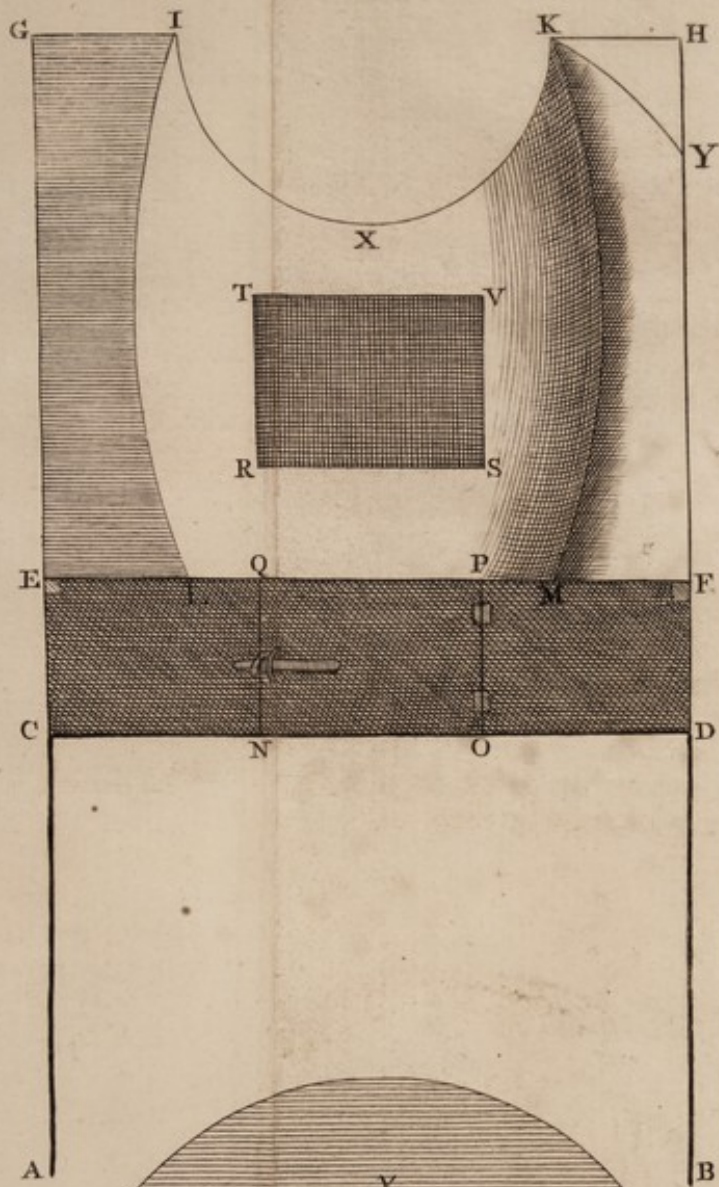
a. The Stopper of the Hole of the Fire-place seen side-ways.

Z. The same seen from above.

KHY. A Segment cut out for the Neck of the Retort to lie in.

IKX. A Pot 10 inches wide, and 5 deep.

P L A T E XV.



PLATE



FIG. 1

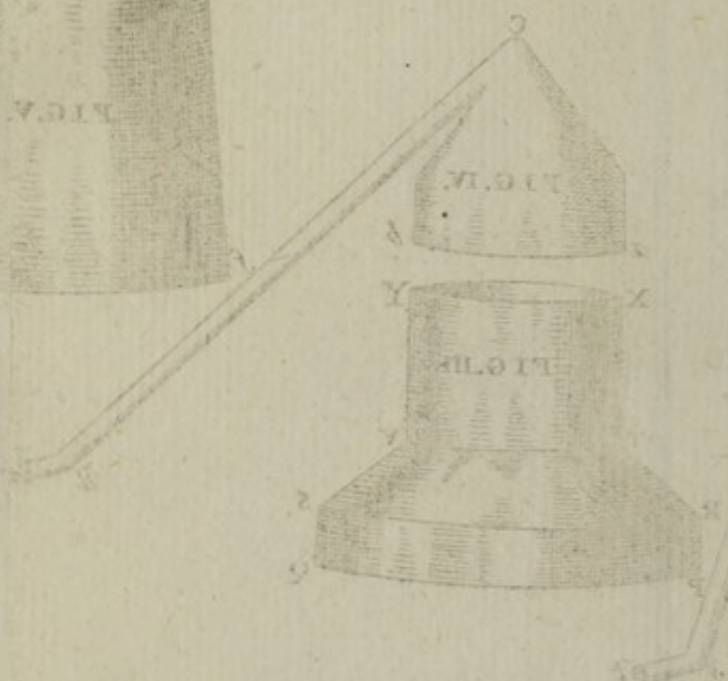


FIG. 2

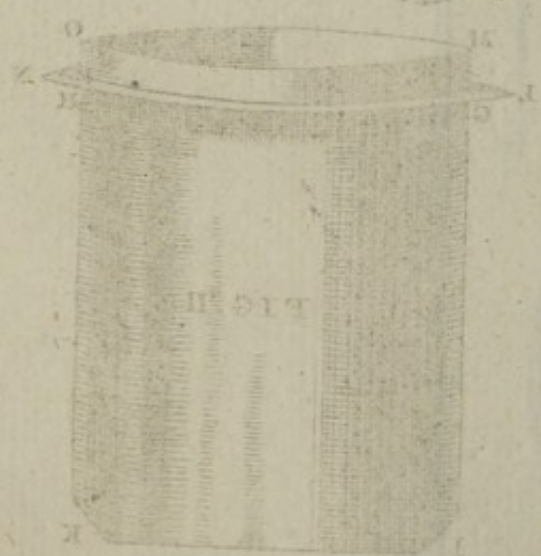
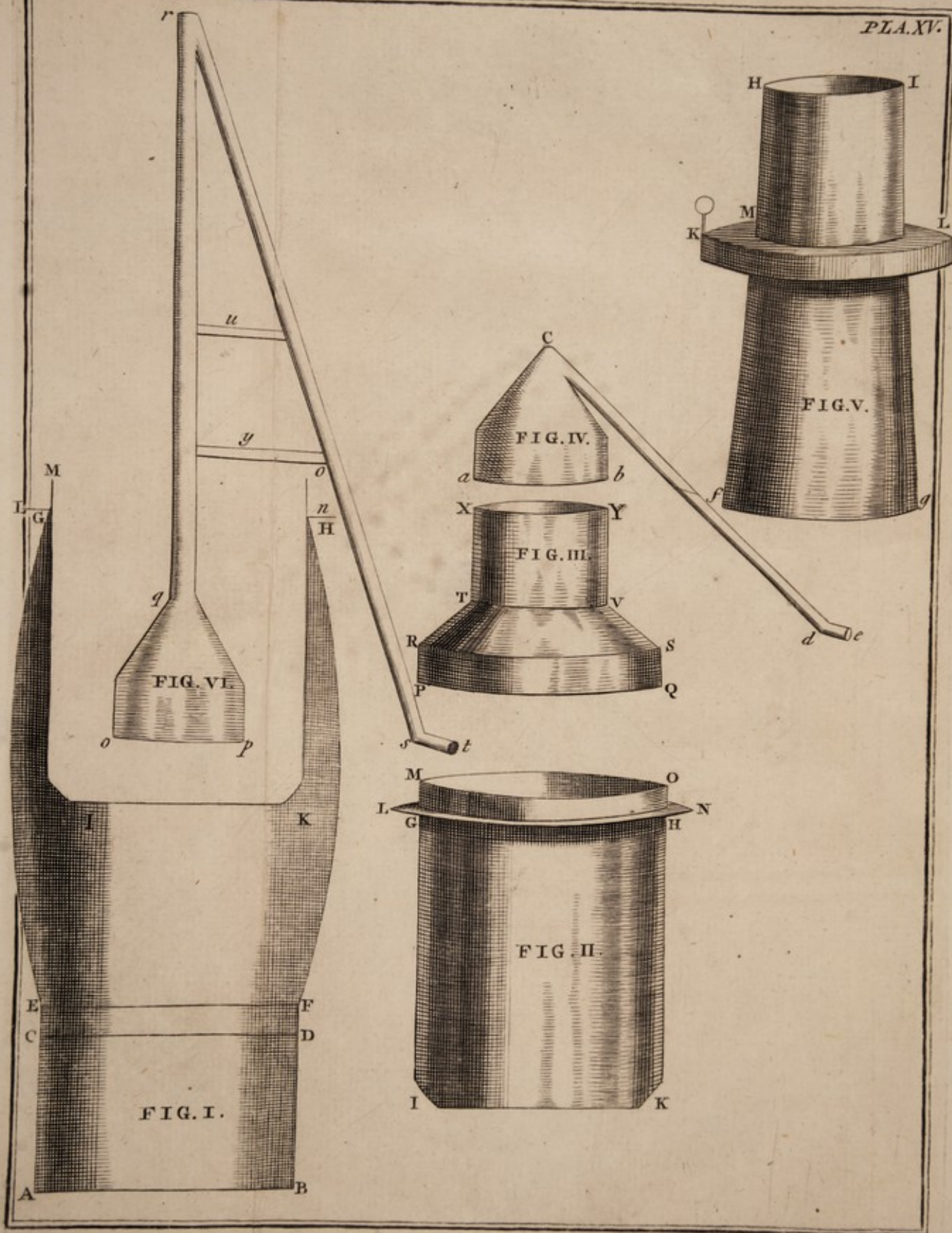


FIG. 3



P L A T E VIII.

FIG. 1.

A, B, C. Three glass Vessels with Water of different degrees of Heat.
DHEI. The brass Plate joined to the Tube KL of the Air-pump.
FGMN. The Bell that stands upon this Plate and covers the Vessels
A, B, C. from under which the Air is exhausted by means of the Tube KL.

FIG. 2.

AB. A cylindrical glass Vessel, with a plain bottom B.
CD. A glass Bottle, whose Belly C may be placed within the Cylinder AB,
that its mouth D may rest upon the bottom B.

FIG. 3.

AB. A cylindrical hollow Vessel open at A, with a plain bottom B, and
filled with Water.
BCD. A Funnel open at D, whose upper part ED is inserted into the neck
EG of the Bolthead EGF.
EGF. The Belly and Neck full of Water.

FIG. 4.

AB. A parallelipedal brass Vessel.
B. A plain bottom, which at C has a cavity impressed in it, in which there
is placed a drop of Water not boiled.
D. A conical glass Vessel, whose base is so large that it can surround the
Cavity C.
E. The Conoid plac'd over the drop of Water in the cavity.
F. The same lying upon its side whilst the Oil boils, that the Air may be
expelled, and the Oil may enter.
G. A lighted Candle, placed under the cavity in which the Water lies
under the Oil.

P L A T E IX.

FIG. 1.

AB. A brass Cylinder.

B. A hole in AB, into which the Tube BCD was soldered.

AE. A Cock fixed in AB, by which all the Air might be let out of the upper part AF, as the Water rose in the Cylinder, and which might be shut when that was perfectly full.

BCD. A brass, hollow, cylindrical Tube opening into the Cylinder at B, and open above at D, so that the Cylinder AB might be fill'd with Water, by pouring it in at D.

FIG. 2.

AB. A steel Cone divided into equal parts.

CD. A hollow wooden Cone, which, when dry in a certain degree, would just admit the Cone AB within its cavity.

FIG. 3.

ABCD. A cylindrical Vessel made, as they call it, of double Glafs.

BCE. The bottom of the Vessel rising a little inwards in the middle.

FGHI. The neck of the Vessel, with the cylindrical Mouth HI, an inch and a half in diameter.

KL. A Rim round the Mouth, for dropping out the Liquor, which would otherwise run down the sides of the Neck.

MN. A glafs Stopper whose cylindrical part N is exactly ground to the Neck of the Vessel HG. M. the Top of this, thick and flat.

QROP. A Vessel contrived for the more valuable Oils.

FIG. 4.

A, B, C. A Crucible, and Vessels made use of for fixed Bodies in the Fire.

PLATE XV.

Third Furnace.

FIG. 1.

- AB. The breadth of the Ash-hole 10 inches.
 AC. Its height 6 inches.
 EC. Its thickness 1 inch.
 EI. The distance of the bottom of the Vessel from the Grate 8 inches.
 IG. The height of the Vessel 12 inches.
 LG. The rim of the Vessel, which rests upon the top of the Furnace, and is 1 inch broad.
 GM. A perpendicular rim to receive into it the rim of the Vessels, Fig. 3. 4.
 EGHF. The interior elleptico-conoidal cavity of the Furnace, the distance of whose *Foci* is 20 inches, and a perpendicular to the axis at the *Focus* 5 inches.

FIG. 2.

A brass Vessel, either to distill with, or to serve for the bath of the Furnace, Fig. 1. The letters the same as before.

FIG. 3.

A brass Cover, whose Rim PQRS fits exactly into the Rim MOGH of Fig. 2.
 R, S. Two Handles.
 RT. SV. The middle of the Cover rising obliquely to be produced into
 TX, VY. A cylindrical Neck to receive the Alembic.

FIG. 4.

A tin Alembic, whose Rim a b fits exactly into the Rim x y, and head ends in the *Rostrum* cde, the extremity of which may be inserted into the mouth of the Worm in the Refrigeratory.
 If, therefore, the Vessel GK is perfectly closed with the Cover py, and that with the alembic, and is fitted into the Furnace, then in this Vessel you may distill any thing with Water and a Worm, as likewise Balsams, Turpentine, &c.

FIG. 5.

The Vessel for distilling in *Balneo Mariæ*.

fg ML. The Vessel in which the Bodies are put that are to be distilled in *Balneo Mariæ*, which is made so as to go into the Vessel GK, Fig. 1. its Rim KL being fitted exactly to the receiving Margin MO. In the surface of the Rim KL there is a Hole, by which you may pour Water into the Vessel GK. If therefore the Vessel f I is fitted to the Rim MO, then the Water boiling in GK, will distill in *Balneo* through the Vessel f I, the Alembic abc, Fig. 4. being fixed into the Rim HI.

FIG. 6.

A tin Alembic described Pl. XI. whose Margin op being exactly fitted into the Rim HI, Fig. 5. serves for the distillation of Alcohol, the common Spirit of Wine being in the Vessel f I.

P L A T E XVI.

Fourth Furnace, which is the melting Furnace.

- abcd. A hollow stone Base arched at cd, and 3 feet high.
 cdef. The Ash-hole, plain at bottom, and 5 inches high.
 efih. The Grate.
 ab, cd, ef, hi. 12 inches each.
 hk, il. The Fire-place 6 inches high to kl.
 kmnl. A paraboloid Cone, whose Axis is 8 inches, and inferiour ordinate 6 inches.
 mnpo. A cylindrical Chimney 3 inches wide, and 2 feet high.
 au, y4, bx, z3. The thickness of the Stone-work of the Furnace 5 inches.

P L A T E XVII.

Fifth Furnace.

FIG. 1.

- AB. The breadth of the Furnace 20 inches.
 AH, IB. Each 8 inches long.
 HI. The breadth of the Ash-hole 4 inches.
 HK, IL. The height of it 11 inches.
 KM, LN. The distance of the Door of the Fire-place from the Ash-hole 3 inches.
 MN, OP. The breadth of the Door 7 inches.
 MO, NP. The height 9 inches.
 BG, DF. The length of the Furnace 38 inches.
 QRS. The Aperture in the middle of the side to place the Long-necks in.
 QR. The length of the Limb of this Aperture 20 inches.
 US. The height of the middle of it 12 inches.
 ST. The thickness of the upper Wall of the Furnace 6 inches.

FIG. 2.

- AB. A little brass Furnace for our first process, in which there is fitted a brass Plate, just at the top of the door of the Fire-place B.
 CDEF. A tin Alembic fitted to the upper Rim of this Furnace.

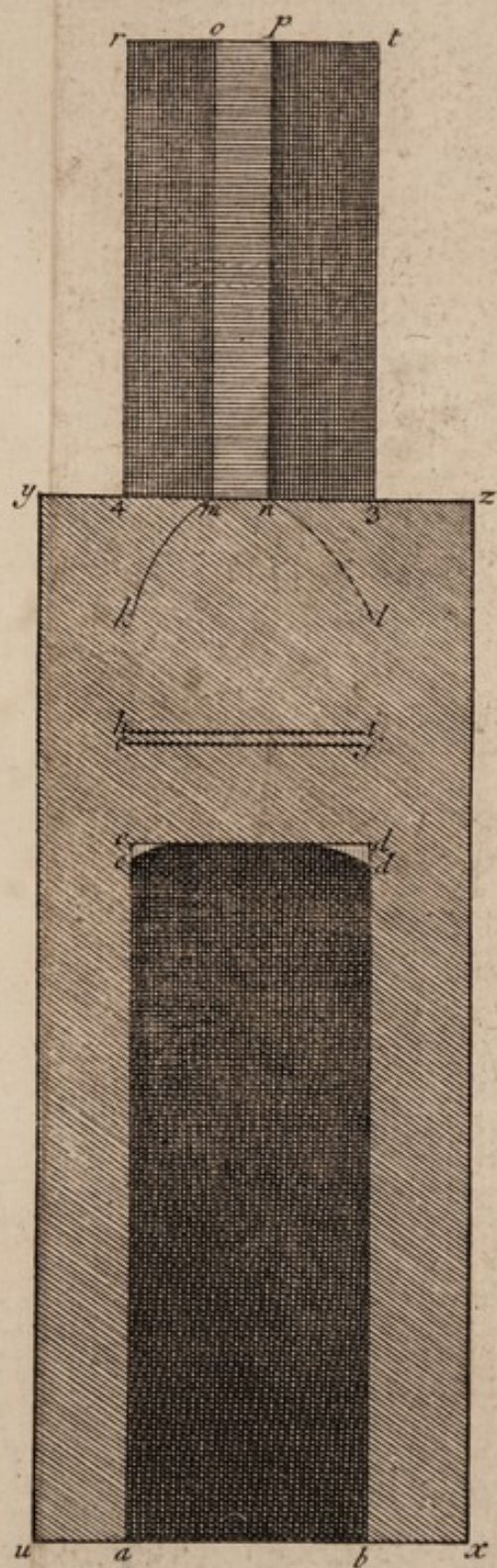


PLATE I

FIG. I

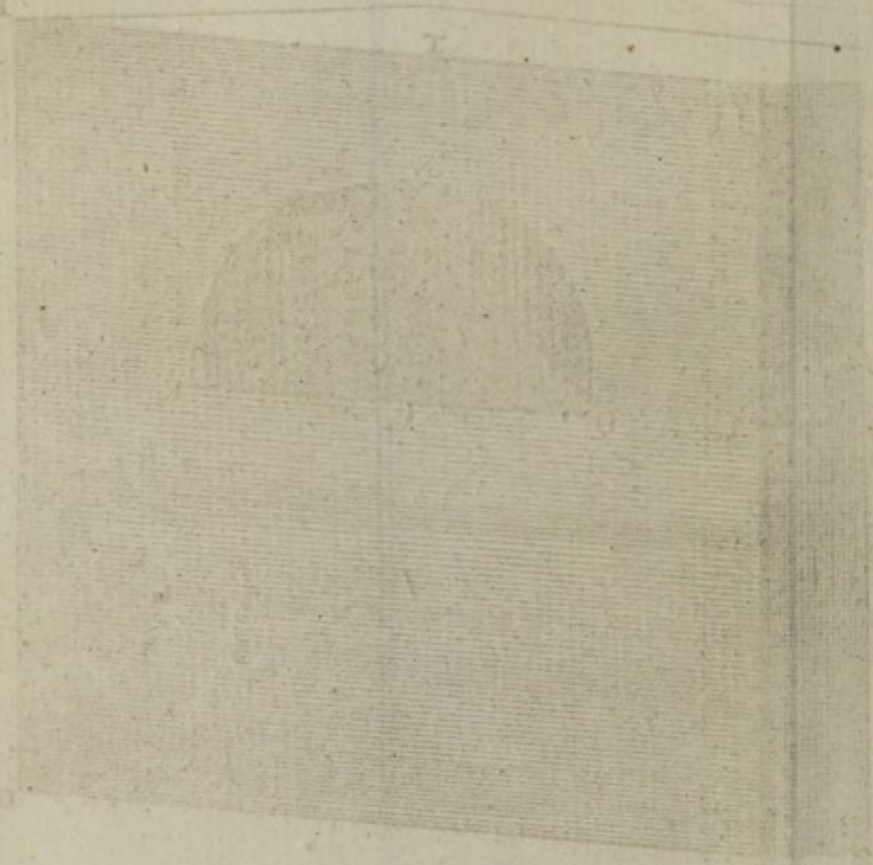


FIG. II



FIG. I.

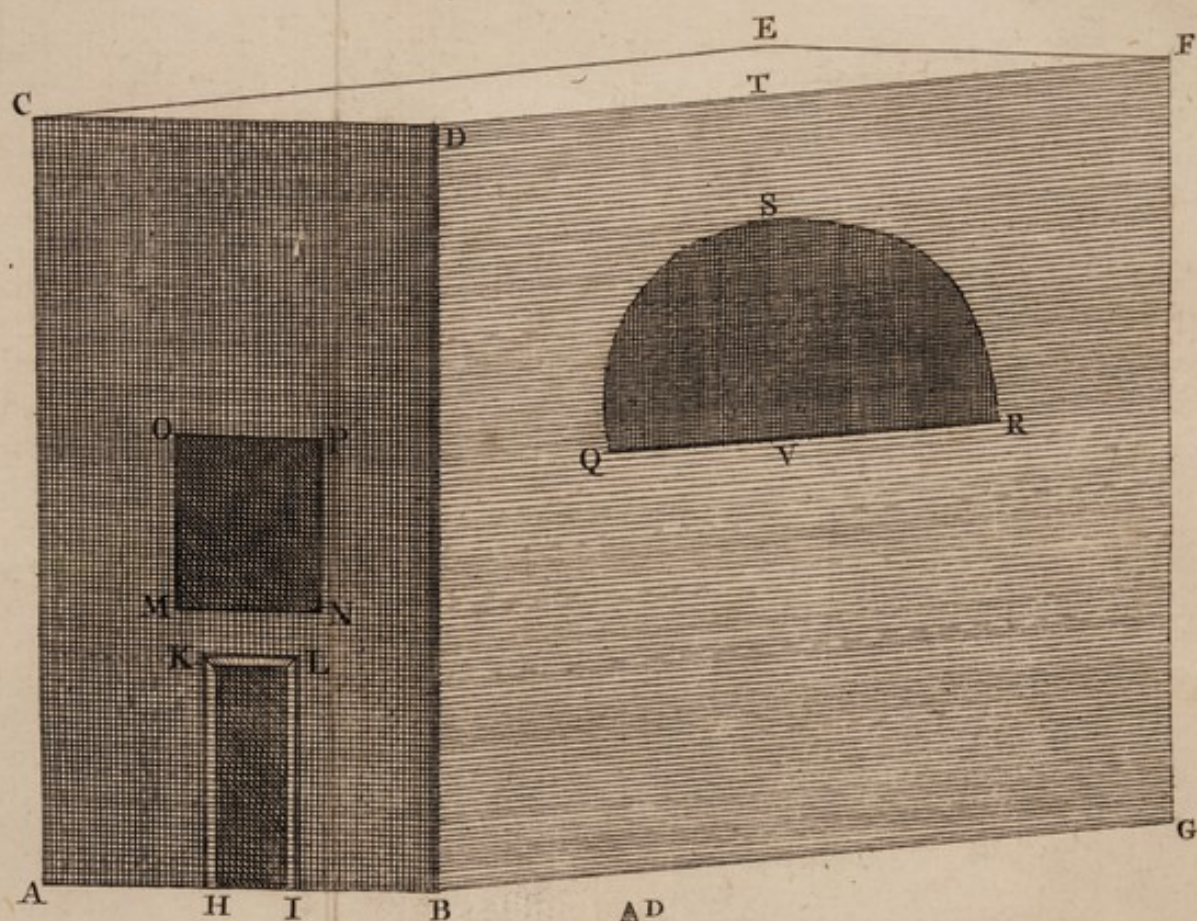
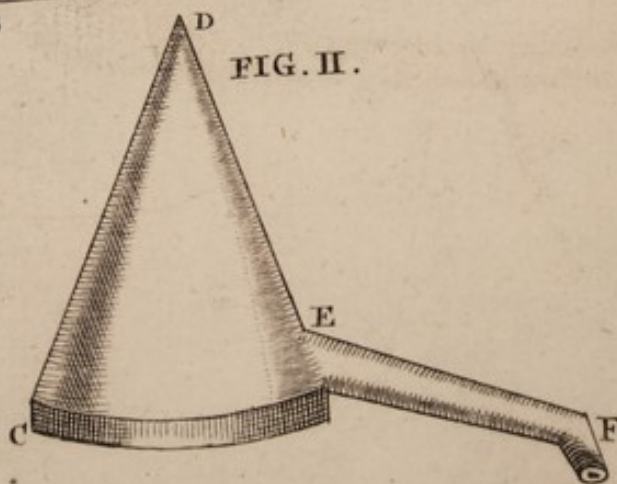
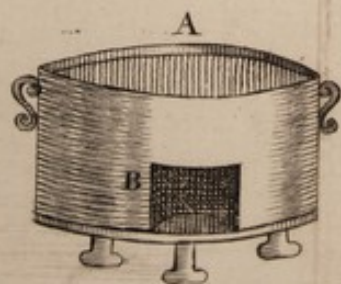


FIG. II.



I N D E X

T O T H E

F I R S T V O L U M E.

N. B. *The Numbers denote the Pages.*

A

Acids seem to differ chiefly in the quantity of Water they contain 453. Experiments upon them with Alkali's 452. Considered as *Menstruums* 462. Native *ibid.* Vinous 434. Acetose 464. Fermenting *ibid.* By burning Vegetables 465. By distillation *ibid.* Fossil native very rare 466. Fixed frequent *ibid.* In Sulphur, Alum, Vitriol of Iron *ibid.* In Calcanthum 467. Which are all the same *ibid.* Specific Gravity *ibid.* Fossil of Nitre 468. Of Sea-salt *ibid.* *Aquæ Regiæ* 469. Corollaries concerning them *ibid.* Agreement 470. Difference 471.

Agitation perpetual in the universe from Heat and Cold 92.

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tery Vapours 272. Attracted into the empty Interstices of Liquids 299. Contains a good deal of Gold 249. divided into different *Strata*, each of which contain different kinds of exhalations. 287. Hot and moist for a great while produces a plague 281. Generated from Oil of Tartar and Oil of Vitriol 310. From Spirit of Nitre and Iron 312. From Spirit of Nitre and Oil of Caraways 313. Adheres to Solids 294. To Fluids *ibid.* To itself 295. Elastic separated from Bodies by Fire 314. The universal Chaos of all Bodies 268. Produced from Vinegar and Crabs-Eyes 308. Condensed by Cold 267. Mixes Bodies together 315. The effects of its gravity *ibid.* A hidden vertue 292. Very corrosive in *America* 298. Don't act in Water as Air 307. Expressed out of Water by Frost, and collected makes Ice light, and rare 360. Not very penetrating itself 307. What it does in Fossils 248. Does not enter into Water already saturated 300. Never at rest 101. Never hardned

Y y

by

I N D E X.

by Cold 249. Impregnated with Mercury will raise a salivation 288. When it contains least Water may appear most humid 272. Naturally contained in our Fluids, but so dissolved as not to act like Air 308. Contains Water on the highest Mountains 277. Most of all Bodies contracted by Cold 266. Always in a pretty rapid Motion 257. Mixes itself with almost all Fluids and other Bodies 247. Separated from Water by boiling 301. Agitated with a vast force excites heat 112. Compresses Bodies so much more as they are nearer to the center of the Earth 254. The occasion that scarcely any body is ever at rest 316. Whence it often becomes poisonous 287. Always capable of rarefaction 262. Mixes with more difficulty with Liquors than any other known Fluid 295. Warm, its surprizing effects 163. How cool it must be for a Person to live in 116. Gives Fire often a surprizing power 236. Its effect, as fluid and heavy together 255. Its Elasticity augmented by Heat 265. Its Properties, as elastic 294. Law of its Elasticity 260. Its Gravity 252. A small portion equal to the whole 264. Fineness of its parts 250. Lubricity of them 251. Attraction of them *ibid.* Contains native Spirits of Vegetables 282. Their fermented Spirits 283. Their Spirits produced by Fire *ibid.* Their Oils *ibid.* Their Salts 284. Their Earth *ibid.* Intire parts of Vegetables *ibid.* Spirits of Animals 285. Their Excrements *ibid.* Nearly all their parts *ibid.* Their Eggs *ibid.* Fossils 286. Salts *ibid.* Sulphurs *ibid.* Metals *ibid.* Weight of its elastic part 292. Separated from Water by Frost 322. Out of a hot animal Liquor 303. Its quantity in Water greater than the Water itself 306.

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From Animals by

Y y y 2 Com-

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Elements of Chemistry :

BEING THE

ANNUAL LECTURES

OF

Herman Boerhaave, M.D.

Formerly PROFESSOR of

CHEMISTRY and BOTANY,

And at present,

PROFESSOR of PHYSICK

IN THE

UNIVERSITY of LEYDEN.

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HERMAN BOERHAAVE, M.D.

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PROFESSOR OF PHYSIC

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S E R I E S

O F

CHEMICAL OPERATIONS,

Dispos'd according to the Rules of ART.

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162. Vitriol of Iron.

163. *Ludovici's* Vitriol of Iron with Tartar.

164. A white, grey, and red *Calx*, of Vitriol of Iron.

165. A Liquor of Iron *per Deliquium*.

166. A golden Tincture of Vitriol of Iron.

167. Iron dissolv'd in *Rhenish* Wine.

168. Iron dissolv'd in Vinegar.

169. The sublimation of it with *Sal Ammoniac*.

170. A preparation of Iron with Sulphur.

171. A *Calx* of Lead with the Vapour of Vinegar.

172. Vinegar of Lead.

173. Salt of Lead with Vinegar.

174. Salt of Lead with Spirit of Nitre.

175. Salt of Lead manag'd with Alkali's.

176. A *Calx* of Vitriol of Lead.

177. A Balsam of Lead with express'd vegetable Oils.

178. A Balsam of Lead with a distill'd vegetable Oil.

179. Glafs of Lead.

180. The solution of Mercury in Spirit of Nitre, or *Aqua Fortis*.

181. Vitriol of Silver.

182. The Lunar Caustic, or *Lapis Infernalis*.

183. The silver Hydragogue of *Boyle*, or *Angelus Sala*.

184. Burning Silver.

185. The recovery of Silver from its solution in Spirit of Nitre.

186. The *Luna Cornea*.

187. Tin dissolved in *Aqua Regia*.

188. The solution of Copper in distill'd Vinegar.

189. Its solution in *Sal Ammoniac*.

190. Its solution in *Aqua Fortis*.

191. Its solution in *Aqua Regia*.

192. Its solution in a volatile Alkali.

193. The Purification of Mercury.

194. The solution of Mercury in *Aqua Fortis*.

195. Vitriol of Mercury.

196. *Mercurius præcipitatus albus*.

197. *Mercurius præcipitatus ruber*.

198. *Mercurius Sublimatus*.

199. Turbith of Mercury.

200. Caustic Oil of Mercury.

201. *Æthiops* of Mercury.

202. Factitious Cinnabar.

203. An *Amalgama* of Mercury with Lead and other Metals.

204. The Ablution of Metals with Mercury.

205. The Solution of Gold.

IV. Upon saline Semi-metals.

206. The resolution of Vitriol into a Spirit, Oil, and Colcothar.

207. *Ens Veneris*.

V. Upon sulphureous Semi-metals.

208. The solution of Antimony in *Aqua Regia*.

209. True Sulphur of Antimony.

210. Glafs of Antimony.

211. *Regulus* of Antimony with Salts.

212. *Regulus* of Antimony with Iron and Nitre.

213. the alchemistical *Regulus* of Antimony.

214. Golden Sulphur of Antimony.

215. *Crocus* of Antimony.

216. A milder Emetic of Antimony.

217. *Stibium Diaphoreticum Nitratum*.

218. Common diaphoretic Antimony, call'd sweet Antimony.

219. *Nitrum Stibiatum*.

220. Fix'd Sulphur of Antimony.

221. The distillation of Antimony into an icy Butter, and Cinnabar.

222. The

A Series of Chemical Operations, &c.

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| <p>222. The distillation of the Butter of Antimony into a liquid Oil.</p> <p>223. A <i>Mercurius Vitæ</i> of Antimony, and its <i>Regulus</i>.</p> <p>224. <i>Spiritus Vitrioli Philosophicus</i>.</p> <p>225. <i>Helmont's</i> Flowers of Antimony.</p> <p>226. <i>Helmont's</i> fix'd diaphoretic Antimony.</p> <p>227. The <i>Diacetateffon Purgans</i> of <i>Helmont</i>, from the fix'd Flowers of Antimony.</p> | <p>Chemical Solution.</p> <p>Coagulation.</p> <p>Precipitation.</p> <p>Effervescence.</p> <p>A short recapitulation concerning Alkali's and Acids.</p> <p>The production, destruction, and alteration of Smells, and Tastes.</p> <p>The production, destruction, and alteration of Colours.</p> |
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I N T R O

INTRODUCTION.

IN examining into the writings of the Chemists nothing has given more disgust to men of sense, than the multitude of Experiments they met with, describ'd without any manner of order, under the title of Processes. For the number of these is so great, and the nature of them so different, that a man's life would scarce be sufficient for going through 'em, were it possible for his patience to hold out to the end. But what is still a greater difficulty in our way, in the prosecution of these studies, is our really not knowing the design with which the Artists themselves have taken all this pains: for if as a Philosopher you consult them upon this head, you'll scarce meet with any thing to your satisfaction. And afterwards, when Chemistry came to be taught in the Universities, the practical part of the Art seems to have been intirely confin'd to the exhibiting some Operations in an irregular manner, just as every particular Professor thought proper. When I first therefore set about teaching the chemical Art, which is now more than thirty years ago, I carefully consider'd with myself, whether it was not possible to give my Pupils Examples of all the chemical Operations in such a manner, that, according to *Hippocrates's* Rule, nothing should be left out, that was of Consequence to be known, nor any thing be added, that was not necessary.

In order to this, then, in the first place we must take Care, that we don't do the same things over again; for what can be more trifling than to give repeated instances of what may be sufficiently understood by one? Thus for example, when I have once shewn you, by what art you may procure a fragrant water from Baum, there will be no need to tire your patience with the same thing again in sweet Marjoram, Rosemary, and Rue: Nor when we have taught you how to draw an aromatic Spirit from Citron-Peel with Spirit of Wine, will it be necessary to repeat the same with other Bodies of the like nature.

But here however it will be absolutely necessary to give an ocular proof of every particular Operation that has any thing peculiar in it, and which is proper to be known in the Art, and does not evidently appear by some other Experiment: for every Person that has a mind to get acquainted with the chemical Art, ought to be acquainted at least with the Methods, by the help of which, are prepared those things that are here of service; nor can he ever be a perfect Artist without 'em. Thus for instance, if we want to know the nature of vegetable Salts, of what consequence is it that we have seen the manner of procuring their Salt from them by burning them, unless we know likewise from experiment, how from some of 'em it may be procur'd too by distillation, and putrefaction.

In the third place, I thought, we shou'd most probably attain our end by following here the method used by the Mathematicians; that is to say, always to exhibit that Operation first, the knowledge of which is necessary to the right understanding, or proper performing that which follows, and then to link them together in such a manner, that every one may stand next to that on which it most directly and immediately depends: for by this means we shall with the least labour and expence, and in the shortest time come to the knowledge of the principal uses

of the whole Art, whose excellence in particular is this, that it opens to the human mind the powers of Nature, and furnishes us with proper helps for securing, and restoring of health.

In the last place, in composing this practical part of Chemistry, I thought I ought not to regard the service of Physic only, tho' I prefer that to all other Arts; for nothing has prov'd more fatal both to the chemical, and medicinal Art, than an idle Opinion, that all kinds of chemical Productions were proper to be made use of as Medicines. Certainly, Chemistry is not only assistant to Physic, but its usefulness extends likewise to every branch of natural Philosophy. See Vol. I. p. 50. & seq. Let the Physician therefore rejoice in the labours of the Chemist, but by no means claim them wholly to himself.

Since the Operations, now, of the chemical Art are taken up in the examination of Vegetables, Animals, and Fossils, hence we shall distribute them according to these three kinds of Bodies. And here we shall be obliged to begin first with the vegetable Kingdom, as the Productions of this are always and every where at hand, and as most Animals even subsist upon Vegetables, and are really made up of them, after they are, by their proper concoctive powers, assimilated to the animal Nature; for if there are some of them that intirely live upon other Animals, yet if you will look back to what these fed upon, and so on, you will at last come to some, which were supported by Vegetables, and thus laid the *Basis* of all the following. But besides, Vegetables, on account of the simplicity of their constituent parts, and their readier separation, are chemically resolved with more ease, and understood with less difficulty. Fossils, indeed, it must be confess'd, are still more simple, but then the management of them requires a profounder Skill, Instruments much more occult, and Operations not so obvious. The nature of the thing, therefore, leads us to begin with the Vegetable Kingdom.

And here we shall suppose you are acquainted with all those things which were explained to you in the *Theory of the Art*, Vol. I. from p. 36 to 40, and which, according to our present design, will be here all confirm'd by Experiments.

A chemical Operation, now, is the changing a Body by Instruments proper to this Art, and in such a manner as this Art determines. And the first Operation that is performed in a course of chemical Demonstrations ought to have these four Conditions: In the first place, it should be very easy; not requiring a great deal of labour, nor much force to be exerted upon the substance to be worked upon: Secondly, it ought to be very simple, not being compounded of different Operations, nor wanting a great variety of Instruments to its performance: In the third place, the alterations induced upon Bodies by this first Operation ought not to change them too much from their proper nature: And fourthly, we shou'd take care, that the Effect of this Operation shou'd, as much as possible, be a mere separation of the parts, just such as existed in the Body before the resolution, and not a production of new ones by means of this very Operation; for as by our Art Bodies are separated either into their natural constituent parts, or into others, actually produced by their being exposed to the Fire, it is plain, that in the first Operation, the former only shou'd be extracted, which being afterwards properly compounded together, we are certain, would again produce exactly the very same Body.

If these four circumstances, now, are carefully attended to in this first Operation, there will four very considerable advantages arise from it likewise: For in the first place, the Operator will hence evidently and certainly learn, of what kind the parts were, that actually existed in the Body before the resolution, and are now separated from it; and by this means will be able to form a judgment of the nature of the compound thus examin'd, and of the parts that concurr'd towards its composition; whereas if we have not a proper regard to these conditions, we shall fall into very great mistakes, if we imagine that the parts procured from Bodies by a chemical *Analysis*, did in reality exist in the same manner in the Bodies themselves before the separation. But in the second place, the Chemist will hence have an opportunity of examining with certainty the *residuum* that is left after the first Operation is compleated; for if by this, nothing but the native parts are gently separated, the remainder will suffer very little alteration. In the third place, the remaining part will be hence properly suited for farther examination, and so may be gradually exposed to the efficacy of various other chemical Operations; whereas, if the object was very considerably altered from its proper nature, any future trials upon it wou'd be of very little service, nay, wou'd rather puzzle the affair than illustrate it. And in the last place, we shall hence have a very accurate knowledge both of the action made use of in the Operation, and of the instruments by which this action was excited, without any danger at all of confusion: Of what consequence now these advantages are in the Chemical Art, the thing speaks itself. For my own part, I should have been heartily glad to have met with any Author, who had prosecuted his Experiments upon these Principles.

But in the Body itself that is exposed to this first Operation, there are some particular circumstances requisite likewise. And of these this is the first, that the matter that is separated from it by this Operation should be the most simple that cou'd be produc'd by any; so that from all Bodies it might be nearly of the same nature, such as we look upon Water to be. Secondly, this Body should be of such a nature as properly to yield these parts, thus extracted from it, without being itself first compounded from them. And thirdly, it should be one that is easily separable into those parts which we propose to procure from it: For it is possible, that a Body that is simple, and may be manag'd with ease, may not be resolvable into the parts of which it is made up, without a vast deal of Difficulty; as is sufficiently evident in Gold, Silver, and Mercury. And the advantage of attending to these circumstances in examining this first Body, will be particularly this, that by this means, the separation will be brought about in the most natural order, and the remainder will be properly disposed to give out distinctly any other parts that may be afterwards procur'd from it by a farther chemical Examination.

But again, the Instrument made use of in this first Operation must have its particular properties likewise. For this in the first place, ought to be exceeding simple, that so the operating cause, excited by means of this instrument, may be easily understood and applied, and at the same time, by reason of its simplicity, it may not taint the Body to be chang'd, by an admixture of its parts, which are often of a different nature. Secondly, the action of the instrument thus made use of, should be of such a nature, as to enter into the following Operations likewise; so that hence this instrument may be a kind of uni-

versal one, concurring in all other Operations, and lending its assistance to other instruments. In the third place, it is necessary, that this instrument should change the form of the Body as little as possible, no more than is just absolutely necessary for performing this first Operation; for without this caution, we shall do nothing distinctly: And lastly, this instrument must not by its action much alter, and confound with one another the different parts that may enter into the composition of the Body under examination: For if these parts should either be considerably altered, or confusedly mix'd and compounded together into a different substance, the Operation of such an instrument wou'd do more harm than good in our Philosophical Inquiries.

When an instrument then qualified in the manner described, applies its proper action to a Body circumstantiated as above, then the Operator will know accurately the power of this first action; and in any following Operation, so far as the efficacy of this is concern'd in it, he will be able to determine what will happen there likewise: All these effects, therefore, will be evident, and distinct, ought first to be known, and will give light into others. And hence, in particular, which will be of excellent service, we shall be able to discover very clearly, what parts do in reality naturally concur towards the composition of the Body under examination.

From all these things laid together, then, at length it follows, that the action of a soft Fire, such a one as is spontaneously every where present, applied to the liquid and most volatile parts of Vegetables, as it makes very little alteration in them, and separates them very gently, will perform this first Operation.

But every Vegetable, now, is compounded of parts both solid and fluid.

The solid parts of Vegetables, are either Vessels, or larger firm parts, formed by the coalescence and concretion of these together.

The absorbent vessels of Plants, by their open orifices, suck in the more liquid fluids that are applied to them. These apertures are dispersed through the whole surface of every part of the Plant, but more particularly in the root inserted into the Earth. In a moist warm Air, and in a damp warm Earth, they are dilated; and on the contrary, are contracted by cold, and drought. Hence, those that are covered in the Ground, are larger than those that are exposed to the Air: And hence too they take in more juices in Summer, than they do either in Autumn or Winter. But there are some Orifices likewise that draw in the Air, in the manner of a Windpipe, and convey it into the more intimate parts of the Plant, as appears very evident in the stalk of the Dandelion.

Again, in Plants there are Vessels fitted to carry on a circulation, containing the Juices imbibed by the absorbent Orifices, and propelling them from these Apertures through every part of the Plant. And this propulsion seems principally owing to Heat and Cold, the first dilating, the other contracting, and thus, by their contrary actions alternately succeeding one another, disposing the elastic Fibres to a continual agitation of the included Fluids. Are there any Valves here likewise? This has not yet appear'd to the Senses. And indeed, the successful growth of some Plants, when the stem has been inverted, seems to evince the contrary; for had there been Valves, they must have prevented it.

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A third kind of Vessels in Plants are those, which change the Juices they receive, in such a manner, that they become of a quite different nature from what they were before: For these, when they are admitted into the beginnings of the Pipes, are by no means the same, as when they have circulated through the Plant, but gradually put on the nature of every particular one, in proportion as they have been longer exposed to the action of a greater number of its Vessels, as appears by every kind of Experiment. And there seems to be a *series* of Vessels arising in a proper manner from one another, in every one of which, there is continually prepared a new sort of Juice in various parts of the Plant.

But farther, in the fourth place, amongst those Vessels there are observ'd some too, which arising laterally from those larger ones, receive into them a particular Juice, which these again perfect more and more, according to its peculiar nature; as we see evidently in the Aloetic Ducts of the Aloe, which contain a Liquor perfectly distinct from every other contained and generated in the rest of the Vessels of the same Plant. In the Celandine too, there are Vessels which in the same manner separate, and prepare a golden Juice; as we see a milky one in its proper Vessels in the Spurge.

But in the fifth place, we must here take notice likewise of those particular repositories in Plants, which receive the Juices prepared by the last-mentioned Vessels, and detain them for a considerable time, by which means they seem to undergo some farther alteration, and be carried to greater perfection. Thus we see a pinguious matter collected, detained, and perfected, in particular cells, and passing often through a great many very distinct forms; as is sufficiently evident in Native Oils, Balsams, and Resins.

And sixthly and lastly, there are excreting Vessels too, which naturally exhale the finer Juices out of the Body of the Plant, or by bursting from the too great quantity of the contained fluid, discharge themselves on the external surface. This needs no proof at all, for every one knows, that Fluids are separated from Plants in an invisible form; and that Gums and Resins break their Vessels, and run out of them.

In every particular kind, now, of these Vessels, the Juices are found to be perfectly different, distinguishing themselves by their proper nature from all the rest: And this difference does not only consist in their Fineness, Thickness, Fluidity, Tenacity, Acrimony, and Softness, but in their Colour, Smell, Taste, Medicinal, Nutritive, and Poisonous Qualities likewise. And in different parts too of the same Plant, there is the same variety observ'd, even to the very minutest: Thus in the little repositories in the *Petala* of the flower of the Aloe, we find a honeyish Liquor, whilst the Juices in the other parts are bitter. And in the same manner in the Root, Flower, Fruit, Seed, Leaves, Bark, and Wood of Vegetables, there are found various sorts of Juices. But even these native Juices of Plants are themselves compounded of perfectly different kinds of Elements, mixed together in a certain proportion; and hence, as this varies, their appearances again are very different. From this various mixture, therefore, arise Aqueous, Spirituous, Saline, Saponaceous, Gummy, Oily, Balsamic, Resinous, and Gummy-Resinous Fluids, and those that ooze out in form of tears, or distill, upon an incision made in the Bark, or upon wounding the tender Twigs, in form of a limpid, acidish Liquid; as we see
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evidently in the Vine, Birch, Walnut-tree, and many others. These things, Gentlemen, it was necessary to premise to you, before we set about our first Operation, that you may see how we may come at something distinct and certain in this affair, if we proceed cautiously in the method proposed, and how much confusion must follow an Operation that is not so properly regulated. From what has been said now, give me leave to draw the following Corollaries.

In the first place, then, there is a vast deal of difference in the Juices of Plants, with regard to the Chemical Art, as in these there are some parts so volatile, that they either spontaneously exhale, or suffer themselves to be separated with a very little trouble, so that if they are exposed but to a very soft Fire, they will be disengaged from all the rest, almost in their natural state, and original purity; whilst on the contrary, others are with difficulty extracted from their concrete, require a greater degree of Fire, and consequently, when they are separated, will be more blended and confounded with one another.

In the second place, as there is such a variety of Juices contain'd in different parts of the same Plant, hence there will be a vast deal of difference in our Chemical Operations, according as one, or other of these come under Examination. Does not the pulp extracted from the pods of the Cassia yield something vastly different from what the bark does? As the medullary part of the Sugar-cane affords something exceeding sweet, whilst what is drawn from the other parts, is inclining to the acid. We should not hastily say, therefore, that we have by the Chemical Art procured such and such substances from any Plant, without first carefully taking notice what particular parts we made use of in the Operation: If we do, we shall labour in vain.

But in the third place, as in the particular parts of most Vegetables, there is observed such a great difference of Colours, as we see in Apples, Pears, Cherries, Strawberries, Mulberries, and other Fruits, as well as in the Leaves, and the beautiful variety of the Flowers; hence this too, according to the various manners of extracting the Juice, will be found to be different. Thus, the Spurge, for instance, and the Poppy, if they are slightly wounded, discharge an exceeding white Milk; whereas, if the whole Plants are pounded together, the Liquor that comes from them is of a brownish green. The Root of the Bete, on the other hand, when it is pounded, gives a Liquor that is very red, tho' the colour of it is not so, if you make a slight incision in it. This diversity, therefore, ought to be attended to.

In the fourth place, we take notice of the Scents of Plants; and here how great is the variety? In the Jessamy, all the other parts are inodorous, the Flower only so sweetly scented. In the Citron, the Peel of the Fruit, the Juice, the Leaf, Flower, and Wood, have all a different smell. And here there seems to arise a particular scent in the various Juices of the same Plant, as they are more remote from the pores of its bibulous surface. This consideration now of the smells of Plants, ought to be so much more taken notice of, as they serve to distinguish them so accurately from one another, and are separated from them, by the first in particular, of our Chemical Operations.

In the fifth place, we observe farther, the vast variety there is in the Tastes likewise of different Plants; which is so remarkably great, that among so many thousand of different kinds, you will scarce ever find two in which it is perfectly the same, every one having a Taste peculiar to itself. Nor is this only
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the case in different Plants; but even in different parts of the same Plant, we find, upon examination, that it holds good likewise. And this, in the same sense, is true too of their Smell and Colour.

But in the seventh place, the Juices of the very same Plant appear so different from themselves at different times, that one wou'd scarce take 'em to be the same, whether you regard the Colour, Smell, or Taste, not to mention their particular vertues, which differ so much in crude Vegetables, and those come to maturity, that there can be no comparison between them. For if we examine the very same Vegetables in the Spring, Summer, Autumn, and Winter, we evidently find so great a diversity in them, that they don't seem at all to be the same. Thus some Plants, when they are in flower, are exceeding fragrant, which at other times are quite inodorous. Hither too may be referr'd that difference that arises from the various Soils in which the Vegetables are planted; for we see those that grow in mountainous places are of another nature from those that grow in grounds that are marshy.

In the eighth place we observe, that almost all Plants at the time they spring, increase and flourish, abound with watery, thin, saline Juices, and at that time contain a good deal of Salt; whereas when they have undergone the heat of the summer, their Water is exhaled, and they are replete with Spirits, and Salt, but more particularly with a pinguious Oil. What is drawn from the very same Plants, therefore, and by the same Operation, will be found at various times to be perfectly different.

But I add, eighthly and lastly, the chemical Art, therefore, let it be cultivated with ever so much caution, can scarcely preserve the peculiar Properties of Herbs without any alteration; for it always mixes together all the parts that are first and easiest separated from them, changes them in some measure from their original, and easily mutable nature, and gives them not only new forms, but new qualities. Far be it from us therefore to imagine, that the Chemists can always by their Operations separate for us those excellent vertues with which Nature has endued many particular Plants, since they very often, nay indeed for the most part, mightily alter them, and often change them into something that is quite contrary. This the Chief of the Chemical Tribe *Van Helmont* openly acknowledges, p. 141, § 45. p. 458, 459, where he expressly says, *Happy is the Man who knows how to remove distempers quickly and safely by crude Simples, which is the most ancient method of cure, and is commended in the sacred Writings. For the Ens specificum is altered by Fire; and hence Extraëts and Magisteries frequently lose the efficacious qualities of the Bodies they are prepar'd from: Thus therefore the Chemical Art often secretly robs them of their excellence.* And this certainly is a golden observation, that deserves to be attended to in the most careful manner. In the mean time however it is absolutely certain, that the Chemist by his exquisite labour sometimes produces new Bodies which were not in being before, and indeed with such vertues as Nature was not in the possession of; by which means Art is then able to perform what, in the nature of things, was not possible before, as with a great deal of reason the same ingenious Author takes notice in the same place.

These things then, Gentlemen, the nature of our subject oblig'd me to explain to you, before I could pretend to set about our Operations upon Vegetables. If the length of these observations has been tedious, you'll be pleas'd at least with

with my care and caution. For one physical action being properly performed without any mistake, will give light into a thousand others that follow from it; whereas one wrong step here will give rise to innumerable errors, and the more harm we shall always do, the farther we proceed. In prosecuting this affair, now, in the first place I shall expose to your Examination the Bodies I am going to operate upon, before I do any thing with them, that thus you may see perfectly what they naturally are before Art has made any alteration in them. And to this purpose I shall leave them here in Plates, with proper Inscriptions. In the second place, I shall accurately describe, even to the minutest circumstance, the Operation itself, with which I shall treat the Body thus examin'd, and then shall go through it before you, that thus you may be acquainted with the causes, which perform the work proposed. In the third place I shall lay before you the effects produced in the Body by the Operation thus described. And then fourthly I shall expose to your view the *residuum* that is left after the Operation is finish'd, that by accurately examining this, and carefully comparing it with the Body before the Operation, you may be able to discover all the sensible Alterations that have happen'd in it. In the fifth place I shall punctually describe the Instruments I have occasion to make use of in every particular Operation. In the sixth I shall draw some Physical Corollaries, evidently flowing from the Operation we have been engaged in. And then, seventhly and lastly, shall add the medicinal vertues of Bodies thus chemically prepar'd. And here I shall be particularly careful to advance nothing but what is confirm'd by Experiments, and shall cautiously avoid extolling them to an extravagant degree, and ascribing more vertue to any thing than what it really possesses. Hence I shall take notice of the insignificancy of some, and the pernicious nature of others that too often meet with a commendation which they do not deserve. And in this point particularly it's scarce possible, but I should be of some service to you, as the careful observation of betwixt 30 and 40 years, that I have been closely engaged in Chemistry and Physic, must have render'd me tolerably acquainted with these things; nor have I the least Temptation to deceive you.

In the first place now I shall begin with a fresh, crude Vegetable, that is not yet chang'd from its natural disposition; and from this I shall first draw that part that wou'd have exhal'd with the Summer's heat, which is most volatile, and sufficiently simple. And here I will make as many Experiments as I can successively upon the very same Plant, that by this means you may accurately learn, what different Operations, digested according to Art, and applied in a regular manner, are able to effect upon it. Thus, after I have exhibit't to your view all the chemical methods by which a fragrant Water may be drawn from green Rosemary, I'll proceed to show all those by which the Salts, Oils, and other principles may be procur'd from the very same Plant, as far as is any ways possible, as this is the way to get an accurate and distinct knowledge of the Actions of the Chemical Art: Whereas, if, on the contrary, the Water is prepared from one Herb, the Salt from another, the Oil from a third, a fermented Spirit from a fourth, and a volatile Salt by putrefaction from a fifth, we shall then neither have a clear notion of the *Analysis* of any Plant by these Operations, nor see distinctly the true action of these Operations upon Plants, but shall only get a confus'd Idea of all together.

These things then being set in a proper light, we now proceed to the Operations themselves, with some Hopes of Success.

CHEMICAL OPERATIONS,

PART I.

Upon VEGETABLES.

PROCESS I.

A distill'd Water, exhaling in form of Vapour from green Rosemary, with a Summer's Heat.

APPARATUS.

1. **T**AKE a Plant gather'd in its prime, and in the morning, whilst the dew is yet upon it, that is not bruised, and by this means has its Juices blended together, but that still contains them all in their distinct Vessels, just as nature had disposed them, and that has not the least foreign matter mix'd with it, except the dew that adheres to it.

2. Upon a circular, broad, clean plate fitted within the cylindrical Furnace. Pl. XVII. Fig. II. let this be laid fresh gather'd to the height of two or three inches, gently, without pressing it down: Then let the Furnace be cover'd with a large conical pewter Head, and to the nose let there be applied a glass Receiver.

3. With a clear live Coal, not at all smoaky, dispos'd in the fire-place, let there be excited an equable heat, not exceeding 85 Degrees in *Fahrenheit's* Thermometer, which must be kept up as long as any liquor distills into the Receiver. You may then take out the herb and put in some more fresh, and treat this in like manner, and so proceed till you have procured a sufficient quantity of this Water.

4. Let the Liquor thus prepared be set by for some days in a cold place, and in a clean glass Bottle closely stop'd, and then it will be clear, and will have the Smell and Taste of the Plant.

The NATURE and USE of this WATER.

IN this Liquor then is contained, 1. the Dew, which is made up of its proper parts, Vol. I. p. 273, which are not clear'd from the Plant, without a great deal of difficulty, and which adhere to it when it is dried. In this Dew likewise, thus disposed on the Surface of Plants, are contained those liquid parts of them, which being concocted by the Heat of the day, and exhaling in the night, are entangled in it, and together with it form one Liquor, which is often considerably tenacious: This we see particularly in Wax, Manna, and Honey.

2. In this Liquor is contained a fine Fluid, that exhales from the Vessels of the Plant under examination. And this consists chiefly of pure simple Water, as appears evidently by letting it stand for some time in an open Vessel, for then the Smell and Taste are lost, and an insipid Water is left behind. The other part is that subtil, volatile Matter, which gives every Plant its peculiar Smell and Taste; for this the senses plainly perceive in this Water, but after the Operation is over, there is scarce any thing of it remaining in the *Residuum* of the Rosemary.

3. In this, farther, seem to be contained Seeds or other little Corpuscles, from which in time there generally appears in it a very fine kind of Weed, or Mucilage, of a whitish colour, which is suspended in the middle of the Liquor, and grows gradually broader and broader. These Waters I have kept in Vessels very closely stoppt, and let them stand very quiet, and after a year I have observed this began to be formed, and then every year grew gradually larger and larger, till at last the whole Water was grown turbid, opake, and slimy with this Mucilage. This Liquor therefore contains elementary Water, and the *Spiritus Rector* of the Plant, which, though it is in an exceeding small quantity, yet is wonderfully efficacious, and gives to every Plant its distinguishing Smell and Taste. Hence this Water, when it exhales, is the Vehicle of this Spirit, which possesses in a very small compass the singular vertue of the Plant, is vastly subtil and volatile, and hence easily separable, and when it flies off, leaves the remainder vapid and effete. For this reason therefore the medicinal vertue of these Waters depends chiefly upon the *Spiritus Rector*. And this, in a great number of them, being of a very mobile active nature, affects the Nerves, puts the Spirits in motion, and quickens them when they are languid. But besides this common principle of action, there is something else in it, which is proper and peculiar to particular Plants, and is often wonderfully efficacious. This, according to his odd way of writing, *Paracelsus* called the *Ens Appropriatum*. Thus the fragrant exhalation of Lavender, and Baum, both agree in this, that they stimulate and quicken the Nerves when they are torpid, but the smell of Lavender has besides a peculiar efficacy, different from that of the other. And indeed from this singular vertue there are often very surprizing effects produced in the human Body, which can only be come at the knowledge of, by an historical account of them, when they have been first discovered by Experiments. And this proper vertue frequently acts directly contrary to the former common one: Thus the Spirit of the *Indian* tuberous Hyacinth is vastly sweet, but produces wonderful convulsions in hypocondriacal men, and hysterical Women: Rue diffuses a very odorous Scent likewise, but this removes the disorders occasion'd by the former. But we must take notice likewise that careful observation has discovered, that to this fine Vapour of Plants are often owing those surprizing effects, which vegetable substances bring about in the human Body, either by evacuation, or some other less sensible manner; for when this alone is separated either from Medicines or Poisons, they frequently become inefficacious without any loss of their weight. Let the Chemist therefore proceed slowly and cautiously in extolling the vertues of these Waters, nor pretend to do it, till his Doctrine is sufficiently confirm'd by Experiments. It appears, however, from observation, that these are frequently of service, when the Spirits are low and faint, and on account of their fragrance, are very grateful to smell to; for nothing strikes and revives the brain

and senses more directly than such a Water of Baum when it is pregnant with its Spirit, or that singularly scented Water drawn from Rue. If these Waters, now, are very carefully secured in close Vessels, and are kept in a cool place, they will retain their virtues for a considerable time, even for the space of a year; but if this very volatile Spirit can find but the least aperture imaginable, it secretly disengages itself, and leaves the Water effete. But from this Operation we learn farther, what part that is, which spontaneously exhales from Plants, and so is lost, when they are dried by the Heat of the Summer, viz. this Water and the Spirit we have been describing. Hence we discover, likewise, what Liquid that is which first rises in distillation; what it is that gives to Plants their proper and distinguishing scent, viz. this *Spiritus Rectior* alone; and what those *Effluvia* are, which exhale from growing Vegetables, particularly in the Summer time, and in the open Air; for it is very probable, that these exhalations which happen continually, especially in the day time, agree in their proper nature with the Liquor that is artificially drawn from the same Plants by means of this first Operation: Tho' it must be confess'd, indeed, that in this they differ, that the natural exhalation is carried on by means of new particles perpetually supplied by the soil that nourishes and supports the Plant; whereas in our artificial one, only those parts are separated and collected, which were actually in the Plant when it was pull'd out of the ground, nor can afterwards be supplied by any fresh recruits. And hence the ingenious Dr. Hales, observes, in his *Vegetable Statics*, that to this head belongs that Juice, which upon an incision made in the branches of Plants in the Summer season, distills into Vessels disposed in a proper manner to receive it. p. 50. From these Observations, then, we understand, that Plants may diffuse surprising virtues through the neighbouring Air, nay, and by the assistance of Winds to very considerable distances. Nor should we too hastily reject the accounts of the stupendous effects of these *Effluvia* which we meet with in the Natural History of Vegetables, as intirely fabulous; as that the shade of the Walnut-tree causes heaviness, and makes the Body costive; that the exhalations from Poppies at a small distance, occasion drowsiness; that the vapour from the Yew has prov'd fatal to a person sleeping under it; and that the smell of Bean-blossoms being receiv'd into the Nose for a considerable time, has affected the Brain. Certainly, the powerful action of the Sun is capable of exciting Atmospheres of Spirits about Plants that are wonderfully efficacious; and the Wind is able to diffuse them through large spaces. The shades of thick Woods, by means of the Vapours collected there, have often been the occasion of diseases, nay, and even death itself, to the persons that lived in them; as has appeared by fatal instances in *America*, a country famous for its numbers of poisonous Trees. Nor is it at all surprizing, that this Spirit of Vegetables should produce such various effects; for in every particular one, it is perfectly singular, and absolutely inimitable by any Art, but generally grateful, and beneficial to our Spirits. As in some Plants now, these Spirits discover themselves evidently to our Senses, whilst in others our Organs of Smell and Taste are scarcely affected by them; hence the Chemists, for this first Operation, have set apart those Vegetables, that by their Smell, in particular, are remarkably agreeable. Of the officinal *European* ones, I have here given you a short list, with some few from the *Indies*.

Southernwood.
 Agrimony.
 Garlick.
 Dill.
 Angelica.
 Anise.
 Masterwort.
 Oranges.
 Calamint.
 Sweet Cane.
 Cardamoms.
 Caraway.
 Cat-Mint.
 Garden-Cloves.
 Cassia-Wood.
 Selery.
 Onions.
 Chervil.
 Camomile.
 Cinnamon.
 Citrons.
 Scurvy-grass.
 Coriander.
 Saffron.
 Cummin.
 Dittany.
 Fennel.
 Galangals.
 Clary.
 Hyssop.
 Jessamyne.

Bay.
 Lovage.
 White Lilies.
 Lilies of the Valley.
 Limons.
 Mace.
 Marjoram.
 Marum.
 Feverfew.
 Melilot.
 Baum.
 Mint.
 Spignel.
 Creffes.
 Wallnuts.
 Nutmegs.
 Basil.
 Origany.
 Poly-mountain.
 Leeks.
 Roses.
 Sage.
 Savory.
 Wild Thyme.
 Saxifrage.
 Hartwort.
 Tansy.
 The Tuberoſe.
 Valerian.
 Violets.

T R E E S.

The Fir.
 Orange Tree.
 Benjamin Tree.
 Box.
 Cedar.
 Citron Tree.
 Pockwood Tree.
 Wallnut Tree.
 Juniper.
 Bay Tree.
 Mastich Tree.

The Limon Tree.
 Myrtle.
 Peach Tree.
 Pine.
 Rose.
 Savine.
 Elder.
 Sassafras Tree.
 Storax Tree.
 Tree of Life.
 Lime.

Of these Vegetables now, some contain the volatile aromatic part that comes out in this Operation in one part, some in another. Thus their peculiar virtue

tue is found sometimes in their Root, witness the camphorated balsam in the Root of the Cinnamon; in their Wood as in Rosewood; in their Bark as in Cinnamon; in their Catkins as in the Walnut; in their Flowers, Leaves and Seeds very frequently; in the Water that distills from them, as in the Walnut-tree; and in their Balsams, Gums, Tears, and Resins, as in the balsamic ones. All these things, then, Gentlemen, we learn from this first simple Process, to which more might still be added, but I am afraid I am grown tedious already.

P R O C E S S II.

An Infusion, and Decoction, from the remainder of the first Process.

THIS second Operation ought to be set about and performed, exactly with the same cautions as we gave concerning the former, and then it will have the same advantages. Since, therefore, it appeared in the preceding Process, what was the effect of a dry Heat of 85 degrees; hence we see, in what manner Fire and Air act upon Plants in this degree. We shall now, then, examine what effects Fire and Water have upon them from the 85th degree, to the 212th, or that in which Water boils; for Water heated 85 degrees only, will dissipate the Water of the first Process; and hence this is known already.

A P P A R A T U S.

I. TAKE the Rosemary that remains after the first Operation. This has lost its greenness, and is turned brown; its Body which was before full, and succulent, is contracted, become shrivel'd, and lighter; it has very little left of its natural Smell; it has acquir'd a Taste somewhat different from that, proper to Rosemary; and it now may be easily rubb'd to pieces betwixt one's Fingers, tho' before it was tenacious, and viscid. This you have all been eye witnesses to, as I left each sort in a plate for your examination. Or instead of this, you may take the same Herb moderately dried in an open shady place, or indeed, just gathered, for this will make no considerable difference, as the Water of the first Process will be always separated and lost in the boiling.

2. Upon this, in a clean Vessel, pour pure Rain-water heated from the 85th degree, to the very next to that of ebullition, viz. the 211th; and take care that the Herb is perfectly covered with the Water. Let them stand in this degree of Heat for the space of half an hour, or more, in a close Vessel, and then let the Liquor be poured off. This is of a brown colour, without much smell, but has the taste of Rosemary, deprived of the Water of the first Process. This is called an infusion of Rosemary, and contains its virtues not a great deal altered. If the Water of the first Process is added to this, the Mixture will possess the proper medicinal virtue of the Plant; and perhaps this is the best method of prescribing them, except you prefer their express'd Juices.

3. Or you may boil the Herb in Water for the space of a few minutes; and then the Liquor poured off, is call'd a Decoction, or Apozem. If this is performed

formed in an open Vessel, you lose all the Water of the first Process, and a good deal besides, as will appear in Process 15, 23—30. But if this is perform'd in a tall chemical Vessel, with an Alembic over it, and a proper Receiver, then, if to this Decoction you add the Water that exhales, it will contain what is principally medicinal in the Plant. And if it is done in *Papin's* Digester, it will possess the whole virtues, without the loss of the Spirits or Water of the first Process. The proper quality, however, of the Plant, as it distinguishes itself by its Smell and Taste, will here be found to be somewhat altered, and it will differ a little too in its effects. Preserving the Smell, Taste, and Colour intirely, is certainly in this case exceeding difficult.

4. Upon what remains after the first Decoction, I put more boiling Water, keep it constantly boiling, and then pour off the Liquor, carefully taking off all the scum that rises during the boiling, which I put into a clean Vessel, and keep by itself: This is oily, and being gently dried will burn. And thus I proceed to put on fresh Water, and collect all the scum, and pour off the Decoction, till the last Water, after it has boiled for a considerable time, is as pure, and has no more Colour, Taste or Smell, than when it was put on; and during all this time, I take all possible care that no heterogeneous matter, as Soot, Smoke, or the like, should come amongst it. This, however, is a tedious Operation, nor will be compleated in less than twenty times boiling; and yet, which is pretty surprizing, the Leaves of the Rosemary will still remain intire, will be full of Water, and will be of their former shape and size, but their green Colour will be changed to a brown one, and they will sink to the bottom of the Water, tho' they swam in it before.

5. The denser a Plant is, and the more tenacious on account of its greater quantity of Resin, the more of this oily Scum will rise to the top, and the less of its oily resinous virtue will be communicated to the Water, as this is not capable of dissolving it. And for this reason, when a Decoction is to be made with substances of this kind, they require a previous maceration for a considerable time, or the addition of a fix'd alkaline Salt, and longer boiling; as is sufficiently known in the Decoction of Pock-wood.

6. If such Vegetables, however, that abound with Resin, are boil'd whilst they are fresh, green, and full of juice, then their native saponaceous part keeping their resinous part still liquid, makes it dissolve in Water much more easily, than when the Vegetable is dried, and this is form'd into one mass. This appears evident in the Decoction of the shavings of green Guaiacum in *America*, from which they soon obtain a very penetrating Liquor with which they cure the Pox; whereas, when the Wood is old, it resists the Water more powerfully, and proves less efficacious.

Since, therefore, by boiling them, all those parts are separated from Plants that will rise in form of Vapour, with 212 degrees of Heat; hence those Plants are unfit for this Operation, whose virtues are so volatile as to be carried off by this action of the Fire; and on the contrary, those whose efficacy is contained in parts that are more fix'd, and that will bear this degree of Heat without exhaling, are properly disposed for such Decoction. Acid, Astringent, Viscous, Aromatic, Demulcent, Emollient, Cooling, Nourishing, Saponaceous, and Viscid Substances, not too resinous, are referred hither, as

Wormwood.

Wormwood.
 The Thorn-tree.
 Wood Sorrel.
 Sorrel.
 Brooklime.
 The Berberry-tree.
 Shepherd's Purse.
 Succory.
 Quinces.
 Dwarf-Elder.
 Endive.
 Fern.
 Fumitory.
 Gentian.
 Crane's Bill.
 Grass.
 Hellebore.
 St. John's-wort.
 Myrtle.

Water Lilies.
 Poppies.
 Plantain.
 Knot-Grass.
 Purslain
 Sloes.
 Cinque-foil.
 Rhubarb.
 Currants.
 Roses.
 Water Germander.
 Comfrey.
 Tamarinds.
 Dandelion.
 Tormentils.
 Paul's Betony.
 Periwinkle.
 Nettles.

As also the Juice of any Summer Fruit just press'd and not fermented.

In the mean time however, I wou'd not have you imagine, that I believe, myself, or design to insinuate, that the peculiar vertue of Plants, which almost always resides in their *Spiritus Rector*, must necessarily distinguish itself, by some remarkably disagreeable, or pleasant smell, or by a warm, pungent taste; for it is very possible, that a Spirit may be vastly active, and yet scarcely affect our organs of sensation, as we see evidently in the root of the black Hellebore, the *Cicuta Aquatica* of *Gesner*, the deadly Nightshade, and many others. These things therefore ought to be very carefully considered, before we venture to lay down any general Rule.

The Nature, Vertues, & Use of these Infusions and Decoctions.

1. **T**HESE Preparations are capable of passing through the Lacteals in the small Guts, and through the mesenteric Veins, and hence of being mixed with the Blood of the *Vena Cava*, and *Vena Porta*, and so being blended by the vital actions with the Fluids of the human Body, and being transmitted through all the kinds of the larger Vessels, to the *Viscera*, and all the other parts; for they are saponaceous, penetrating, and miscible with any of its humours.

2. There, therefore, they can act with that proper and singular efficacy that remains in the Infusion, or Decoction, which is then wonderfully increased by the action of the vital motions, and produces very speedy effects.

3. But in the mean time they want that Vertue, which was contained in the Water of the first Process, with this limitation, however, that more of it is preserved in the Infusion, less in the Decoction. This loss however in the last is made amends for, by the Juices of the Plant's being rendered more efficacious by

by the action of the Fire during the boiling; for by this means they are more thoroughly resolved, and more intimately united with the Water. Hence if the Decoction is made in a Still covered with a Head, and the exhaling Water is afterwards mixed with the Decoction, then this Mixture will be very pregnant with the proper virtue of the Plant, as will appear, Process 15; for in this we shall find almost all its efficacy.

4. But here we ought very carefully to consider, that the medicinal action of an infusion, or decoction depends as well upon the efficacy of the hot Water, and its quantity, as upon the virtues of the Plant contained in it: This the Physicians are well apprized of. Wou'd not a Person be in the wrong, who in the abuse of Tea, shou'd impute all the bad effects to the Leaves only, without having any regard to the scalding Water which is such a very great part of it? And when others ascribe to Tea a power of rendering the Spirits agile and lively, why shou'd the diluting quality of the hot Water be left out?

5. Hence we understand the matter, and effect, of these Infusions, and Apozems, and the law, method, and instruments, by which they shou'd be prepar'd for medicinal uses; as well as the power that the hottest Water has upon the solid Parts of Plants. Who now, that had not seen it, cou'd have believ'd, that boiling the tender Leaves of Rosemary for the space of two Days, shou'd not have destroyed them? Nay, but which is still more surprizing, boil the small, fine, Flower, as long as ever you please, and then carefully take it out, and view it either with your naked Eyes, or a Microscope, and you'll find, that its form is not in the least altered. These things I have tried with a great deal of patience; and what was the effect? Why I found the Hairs, *Apices*, little Protuberances, and Lineaments to continue perfectly the same, without any alteration at all. Hence the Physicians may understand, why the minutest Vessels of the human Body are not dissolved by its proper humours, though they have so great a degree of heat in them; and hence they may learn, that the mechanical attrition arising from the action of the Pulse upon 'em, is much more likely to have this effect, than the efficacy, either of warmth or moisture. And for these reasons, likewise, they must readily confess, that the ultimate Elements of our Bodies are not so much saline, saponaceous, or oily, as they are merely terrestrial, connected and held together by a proper *Gluten*: for all that I have asserted of the power of boiling Water upon Vegetables, I have found to be true in boil'd animal Substances likewise, and I have publicly demonstrated it.

6. If the Leaves, after this Operation, are dried, they appear contracted, and small; but if they are again infused in hot Water, they very accurately recover their former size and figure.

7. The proper virtues of some Plants, however, are by thus boiling very much altered: *Arum*, if it is treated in this manner, grows mild: *Asarabacca*, if it is infused, will vomit, as its expressed Juice will when it is crude; but if it is boil'd for a considerable time, it loses its emetic quality and becomes a Diuretic, and Aperient.

PROCESS III.

A Sapa, Defrutum, Extract, Rob, and Jelly from the Product of the second Process.

HAVING examined in a proper manner the Infusion and Decoction of the second Process, in the next place we must proceed to inquire, what will be left behind, when the Water that was made use of in those Operations is again drawn off: for then we shall gradually discover what part of the Plant it was that gave them their virtues, and by this means the Chemist will learn, what part of it may be dissolved in boiling Water and separated from it.

APPARATUS.

1. **P**UT the Infusions and Decoctions of the second Process into a clean Vessel, cover them, and let them stand for some hours in a cool, still place, that the Sand, and other heavy Bodies, that don't belong to the Plant, may fall to the bottom. Or, instead of this, they may be run through a Bag, till they become limpid; but then the gummy and subresinous parts, though they are properly part of the Plant, will, by reason of their tenacity, be separated likewise; and hence though these strained Liquors may be better for medicinal purposes, yet for a chemical Examination they will not be so proper. The Apothecaries, when they want them very fine, make use of the following method. They take some Whites of Eggs, and by beating them together for a considerable time, mix them intimately with their decoction, and then boil them together, by which means, the Whites unite and harden in the decoction, and at the same time inviscates the grosser parts of the Liquid, which, upon being afterwards strained, loses great part of its foulness, and becomes sufficiently pure. Thus then we have three methods of clarifying Decoctions: By letting them stand quiet; by straining them; or boiling them with Whites of Eggs; of which, for a Chemical Inquiry, the first is most proper.

2. The Liquors being thus depurated, let them be put into a clean cylindrical Vessel, or one that grows wider towards the top, and set upon a clear Fire, and brought to the very next degree to boiling, and thus be exhaled to the consistence of a thicker Honey. And here you must be careful that they don't boil much, lest any parts shou'd be dissipated that ought to be preserved; and that towards the end they don't burn, for fear of destroying their Virtues.

And as from these Infusions and Decoctions, so from the fresh express'd Juices of Herbs, and summer Fruits, in particular, or even succulent Roots, as Liquorice, for Instance, may be prepar'd the same Extracts likewise. And in this case, you take those that are very fresh, and in their prime, clean them, pound them, express their Juice, dilute it with Water, depurate it by letting it stand quiet, and straining it, and then in the manner just described evaporate it to the consistence it appeared of when it was first press'd. This fresh press'd Juice, or that which by Dilution, Colation, and Exhalation, is reduced to its natural thickness, we may call Must. Must, when it is boil'd to one half, which then still retains its natural Taste, and is better fitted for keeping, is called a *Sapa*.

If by boiling it is reduced to one third, it acquires the name of a *Defrutum*, from *Defervendo*: This too still possesses its native qualities, and will keep longer. But when, after it is nicely clarified, it is gently boil'd, till a drop of it let fall upon a cold plate, grows of a pretty solid Consistence, like Ice, as it were, and is very clear, then by a term borrowed from *Gelu* (Frost) it is call'd, a *Gelatina*, or Jelly. When it represents a thinner Honey, it has the name of a Syrup; when a thicker, of a *Rob*, or *Robob*. And all these preparations are promiscuously called Extracts; which sometimes therefore are more liquid, sometimes less, and sometimes of a hard Consistence.

The NATURE, VERTUES, and USE of all these.

1. **A**LL these Preparations may be dissolved in hot Water, and then resemble the Decoctions of the second Process, but by boiling have lost something more of their Vertues.

2. They may be kept good for a considerable time, even for Years.

3. They retain a good deal of the Taste of the Plant, though they have lost the volatile part in the Preparation.

4. The efficacious parts of the Plant, that are now set free from the Confinement they were under from the more solid parts, and remain after the Operation, they preserve for a great length of time uncorrupted.

5. Hence it appears, what Plants have lost, when they come to be old, and rotten; for from these, Water will extract nothing at all. Nay, and dead Plants, that are alternately penetrated by the Moisture of the Air, Dew, and Rain, and then resolved, agitated, and dried by the Heat of the Sun, have their Juices all gradually washed out, and become dry and effete. The Worms too will so consume the Moisture of Plants, that when they are thoroughly worm-eaten, there remains nothing but the more solid parts, which are indissoluble, earthy, and inactive.

6. These Preparations are exceeding serviceable in long Navigations. Sailors are liable to diseases from their salt, dried, smok'd Provision; and Fruits prove their cure. If they have with them therefore Jellies of Barberries, Cherries, Quinces, Juniper-berries, Lemmons, Sevil and China-Oranges, Currants, Elder-berries, or Grapes, upon diluting these with Water, they have at once a noble Medicine in these cases. And these again they can recruit in a few hours time, when in their Voyage they touch upon any fruitful Island. This certainly is found to be of excellent service both to the *English* and *Dutch*.

7. In the mean time, however, it is proper to take notice, that those Juices that have a great deal of Salt in them, when they are inspissated in this manner, cannot without difficulty be kept from melting in the Air. Salt is averse to being kept dry, and is a magnet to Water. For this reason, who can make a Jelly from that beautiful Juice of Lemmons, that will retain its consistence? Certainly, by means of the Water of the Air, it will run into a Fluid. Let the thick Juice of these therefore be kept in Glasses nicely stop'd. Those Plants likewise are improper for these uses, whose medicinal Vertue consists in some volatile part of them.

P R O C E S S.

PROCESS IV.

The burning the Plant that remains after the second Process, now become insipid and inodorous, though still retaining its natural Figure, into Ashes of the same shape, that have no taste of Salt.

HAVING thus then discovered what happens to Vegetables from the action of a warm Air, and boiling Water, and what by this means is procured from them, let us now inquire, what effect an open Fire will have upon the parts that are left behind.

APPARATUS.

1. LET what remains of the Plant after the second Process, now qualify'd, as explained, *Pro. II. Of the Nature, &c. No. 5, 6*, be put into a clean iron Vessel, for instance, an Iron Ladle. This then I now place upon a clear open Fire, where there's no Smoke to disturb the Operation, which requires proper care, for something of a saline nature may otherwise easily get amongst it. In this strong Fire then I keep it, till through various changes the whole at last grows perfectly red hot. And here you observe, first, a smoke arising of different sorts, continually growing thicker, and blacker, and at length becoming a kind of pitchy Vapour. In the second place, during all this time, it sends forth a strong smell of something burning, which increases proportionably as the Smoke grows greater. In the third place, when the Vapour is exceeding black, and the Smell most fetid, there then at once bursts out a bright Flame, the Smoke disappears, and the Smell grows considerably less. In the fourth place, the Herb acquires a very black colour before the Flame appears, nor will it take Fire before, tho' when it is once perfectly black, it begins to burn immediately. In the fifth place, when the Flame is over, then the Leaves have lost their blackness, and are become white; and wherever in any part there is still remaining something of blackness, there the leaf sparkles only with heat, but does not flame, and this continues so long as there is the very least portion of black left. But when the preceding Flame and this Scintillation have consumed all the blackness, there then remains nothing but white Ashes, which cannot by any action of the Fire be made to produce Sparks any longer. And in the sixth, and last place, which is the most remarkable of all, you see that though the Herb has born such a violent action both of the Fire and Flame, yet the form of the Rosemary is to such a degree preserved in these white Ashes, that if you examine one of the Leaves, as it lies, with a Microscope, it discovers not only the original shape of the Rosemary, but even the Down, Hairs, Protuberances, Lineaments, and *Lacunæ*, as evidently as if the Herb was still intire; and yet if you do but blow upon them, or touch them ever so lightly, they presently drop into Dust, having lost all their cohesive Power.

2. The Ashes, carefully prepared in this manner, I find to be insipid, and inodorous. These I put into the purest Rain-water in a clean glass Vessel, and boil them, and then depurate the Decoction by letting it stand quiet, and afterwards filtering it: By this means the Liquor becomes limpid, inodorous, and perfectly tasteless, except that it has somewhat of a smack of boil'd Lime.

If you evaporate this Liquor in a clean Vessel, it leaves no fix'd Salt at the bottom, but a small matter of a kind of burnt Lime; and the Ashes that remain after this Liquor is decanted, are white, perfectly insipid, fix'd in the Fire, and merely terrestrial, without Water, Spirit, Oil, or Salt; and if they are work'd with Water into a Paste, reduc'd to a proper shape, and dried, they furnish us with the best Cupels that are able to bear any degree of Fire. All now that we have here observ'd, holds true of every Vegetable whatever, treated in the manner propos'd, so that this Demonstration is universal.

The USE of this PROCESS.

1. **H**ENCE we learn, that Water, with the assistance of so much Fire as it takes in when it boils, is capable of extracting from Vegetables every thing that is saline, and that, both the volatile part and the fix'd.

2. But we see that their Oil cannot be separated from them, by any Ebullition, or any quantity of Water: For the Oil, which still remain'd in these Leaves, discovered itself; First, by a thick, scented, bitter, black Smoke, which was afterwards converted into Flame; Secondly, by the black Colour which the Plant acquired when it began to burn, which black Colour render'd it a Coal, the Oil being torrifed, made black, rarified, and more distributed over the Earth of the Plant by the action of the Fire, and thus disposing the Plant to flame, or be ignited with a great deal of ease; Thirdly, by an open Flame, produc'd and sustained by this black pinguious Matter, which intirely consumed all this black Oil; and fourthly and lastly, by that sparkling Fire that remain'd in this Coal after the Flame was over, and there exerted itself so long as any of this pinguious black Matter was left, but that could not be excited again by any Art whatever when that was quite consum'd.

3. Hence this last Oil cannot be separated from a Plant, except by Fire, and that a flaming one too, in the open Air: For if with the *Residuum* of the second Process I fill this Ladle, and cover it over with an iron plate, and then expose it ever so long to the strongest Fire, the Herb will remain black, brittle, of a bitter Taste, will never grow white, but will become and remain a Coal; and yet as soon as ever you remove the Cover, it will burst out into a flame, and will then be converted into white Ashes.

4. We hence learn farther, that it is this Oil that connects the terrestrial Elements into coherent *Stamina*, which are dissolved when this is separated from them; for tho' the boiling Water had extracted so much Salt, and Oil, in the second Process, yet what remained cohered together equally as before; but when once this last Oil was totally consum'd, there was not then the least cohesion, but the terrestrial parts spontaneously dropp'd asunder. The Oil, therefore, that is procured from Plants by boiling them in Water, is not that *Gluten* to which they owe their cohesion, this depending alone upon that which is separated from them last of all. Is this last kind of glutinous Oil, therefore, the very same in all kinds of Vegetables, whilst that which is dissolved in the Decoction is peculiar to every particular *Species*? If so, then the pinguious part of Vegetables is threefold. First, the oily Scum; secondly, the pinguious part of the Decoction; and thirdly, this conglutinating one, separable only by an open Fire.

5. The other part of Vegetables, which remains after a Decoction has been made from them, is true mere Virgin Earth, subtil, without any Cohesion, immutable in the Fire, the same in every Plant, and in every quality perfectly like the Ashes of burnt Animals, without any difference at all: This it is that gives a firm *Basis*, both to Plants and Animals; and this procured either from one or t'other, the Assayers find equally proper to make their Tests of.

6. If you mix Water with these loose Ashes, they acquire again some degree of Tenacity, as appears in the Tests just mentioned: But if you work them with a proper quantity of Oil they cohere more strongly. Oil, therefore, and Earth, compose the solid *Stamina* of Vegetables.

7. All the medicinal, nutritive, and poisonous qualities of Vegetables, reside absolutely in that part, which, by Decoction with Water, may be extracted from them; and the conglutinating Oil that then remains with the terrestrial Elements, has nothing at all singular in it, nor the Earth when it is quite alone.

8. The longer, therefore, Plants are a drying, and the drier they are, so much the more they proportionably lose of their Vertues: Nay, this is true to such a Degree, that if any Plant whatever is for a long time exposed to the open Air, there remains nothing at last but mere inactive Earth.

9. Hence it comes to pass, that Plants are able to bear the actions of a moist Air, Dew, Rain, and the Sun, without being destroyed, if they can but be supplied with fresh nourishment from the Earth: And hence it happens, that boiling Water, let it boil ever so strongly, is not capable of dissolving the most tender Flower, as it cannot separate this last conglutinating Oil from the Earth. It is the Earth, therefore, alone, that gives them all a firm *Basis*.

10. In the ultimate solid *Stamina* of a Plant, therefore, there does not reside any Salt; and consequently in those you will seek for it in vain. And all this holds good likewise in the ultimate Solids of Animals.

11. The free admission of the Air, renders Fire capable of separating this ultimate Oil from the Earth; nor is the Fire alone, without the assistance of Air, capable of effecting this, no not even in those parts that are the most tender.

PROCESS V.

The Preparations of the third Process being burnt, yield Ashes that are salt.

HAVING seen what effect an open Fire has upon the remainder of the Plant after the second Process, we must now examine, what will be the consequence of applying the same to the Infusions, Decoctions, and Extracts prepar'd by the third; that by thus again, comparing the effects of the last Process with this, we may understand the proper power of Fire upon Plants. Please therefore to give your Attention.

APPARATUS.

1. LET the Extracts prepar'd by the third Process, be gently dried in a clean iron Ladle, with a very clear Fire; and they will then be black, shining and tenacious. When they are reduced to this condition, if they are urg'd by a stronger Fire, they smoke, and continue to do so more and more,
till

till at last, when the Ladle begins to grow red hot, they diffuse a stink of somewhat burning, emit a very black, bitter, thick, Vapour, and then burst out into a Flame, upon the ceasing of which, the Matter that remains, continues to sparkle wherever there appears any blackness, which being consumed, it moulders into Ashes of a pale yellowish Colour, tho' before it was exceeding black.

2. If you keep these Ashes a good while in the Fire in the Ladle, they grow somewhat white, remain fix'd, and have no smell, but are salt, having an acrid, lixivious, sub-urinous Taste, and if they are put upon the Tongue in these circumstances, they leave upon it something of Earth. If they are dissolv'd in pure Water, and then filter'd, inspissated, and dried, they yield a yellowish white Salt that is acrid, igneous, and lixivious, and of a sub-urinous Taste. And here we observe a difference, both in the degree of Acrimony, and the quantity of Salt, arising partly from the various natures of the Plants treated in this manner, and partly from the different degrees of Fire made use of in the Operation.

U S E.

1. **B**oiling Water, therefore, dissolves the Oil and Salt of Plants, and that Earth which is most intimately united with them.

2. But this Oil being compounded with the Salt of the Plant into the form of a Soap, may, in the Plants, be perfectly mix'd with Water; and hence we have an idea of their native saponaceous Juice.

3. The Water being separated from this natural Soap, the Oil of it, which is inflammable, grows black when it comes to be exposed to a stronger Fire, rarifies, is distributed over the surface of the Salt, is kindled into a true Flame, consumes, and then there remains the Salt, depriv'd of this Oil: Here, therefore, there arises a true vegetable Coal from Water, Salt, and Oil.

4. This Oil it is, that gives the Extract its Colour, and produces the dense, black, fetid Vapour, as well as the black Colour the Extract acquires at the Fire, and the smell of the Plant, if any happens then to remain; and this is the only inflammable part.

5. If the Water of the first Process, the Infusion of the second, and the Salt prepar'd by this fifth, are mix'd together, they make a Compound, whose medicinal Vertues are very considerably efficacious.

6. When you make use of Plants for this Operation, that are very acrid, and possess an igneous, volatile quality, discovering itself by making the Eyes water, the very same things happen as we have describ'd; but then there scarcely remains any Salt in their Ashes, this, in them, being of a volatile Nature. This we see evidently in Onions, Scurvy-grass, Horse-radish, Mustard, and many others.

P R O C E S S

PROCESS VI.

The fresh Plant, or the Residuum of the first Process being burnt, produces salt Ashes.

APPARATUS.

1. **L**ET it be put into a clean iron Ladle, and set upon a clear Fire, without any Smoke, which must be gradually raised by very gentle degrees. In the first place, then, there will arise a Smoke, which will diffuse a smell of Rosemary, will be watery, without colour, or sub-pellucid, and will continue till the Plant begins to be almost black. In the second place, when it is become black, there issues out a thicker, blacker, and more fetid Smoke, and then the whole becomes black like a Coal; and presently after it breaks out into Flame, burns, ceases to smoke, and when the Flame is over, shines and sparkles, and there remain at last the white *Exuviae* of the Herb in their proper shape, as in the fourth Process, nor as yet to be distinguished from them by any mark whatever. Hence, therefore, the Oil of the Plant always grows black, when it is exposed to the action of the Fire, whether it is carried up out of the Fire and agitated in the Air, and produces a pitchy Smoke; or is spread over the Earth, or Salt, or both together, and discovers itself by its sparkling; or whether this black oily Smoke is lighted by the Fire, or being very rapidly roll'd about constitutes the Flame, from which, when it extricates itself, it produces a black Soot, and thus evinces, that a lucid Flame is an Oil rendered black, and whirl'd about in the Fire. And as soon as ever the Matter that thus grows black in the Fire is absolutely consum'd, then neither Flame nor Sparks can be procur'd from it any longer by any contrivance whatsoever; but then every part of the Plant, without exception, becomes white.

2. The Ashes prepared in this manner, if they are made from the fine parts of Vegetables, retain their figure to the greatest Exactness, tho' they have born this violent action of the Fire: But when a very thick part of them is burnt, then the whole grows perfectly black, and becomes a Coal, of which that part only which is next to the Air is first consum'd by the Fire into white brittle Ashes, and then the black *Stratum* under these burns away in the same manner, and so on successively, by which means it happens, that the Figure, whilst it is burning, is destroy'd, the action of the internal combustible parts, protruding from the Center the external ones that are now turn'd into Ashes; which does not happen, if the substance that is exposed to the Fire is but thin. If these Ashes are applied to the Tongue, they impress upon it an acrid, igneous, lixivious, urinous Taste. If they are diluted in pure Water, and then filter'd, and the Liquor is evaporated, it leaves a Salt, as in the fifth Process, but in much less quantity, and there remains in the filtering Bag a large quantity of pure Earth, such as was procured by the fourth.

USE.

1. **W**ATER, with the assistance of Fire, dissolves only the Juices of Plants, leaving their proper solid parts unaffected.

2. Fire itself is scarce able to effect any thing more, and when it acts alone really extracts less from them, inasmuch as it still leaves a Salt.
3. Water separates a great deal of their combustible matter, which being left behind disposes them to burn more powerfully.
4. The saline parts of some Plants are not rendered volatile by Fire, but only the Oil that adheres to them.
5. The Oil and Salt that are naturally mixed in Plants, are dissoluble in Water, and remain united together, but are separated by Fire.
6. In the humours, therefore, both of Animals and Vegetables there is a native *Sapo*, whilst they are in a sound state; but if the Oil or Salt that compose it exist there by themselves, they both become diseas'd. Thus, as the great *Hippocrates* observes, Bodies, when they are mixed together, often conduce to health, though they prove noxious when they are asunder.
7. The essential difference betwixt Plants consists in their Juices alone; the Earth and conglutinating Oil being common to all.

P R O C E S S VII.

The Native Salt of Plants procured from their Juice fresh press'd: An Instance in Sorrel.

THE preceding Operations have taught us, what are the Effects of Air, Water, and Fire upon both the Solids and Fluids of Plants, and what parts those are which are procured from them, and into which they are resolved by means of these Instruments; and have given us besides one *Species* of fixt Salt produced from them. But now we must more accurately examine, in what form the Salt of Plants does actually exist in their native Juices, of what Principles it is there compounded, and what particular Qualities it then discovers, that by this means we may properly distinguish betwixt those Vegetable Salts that are naturally generated in the vegetable Kingdom, and those which are produced by a chemical Fire; for this, it is of considerable consequence for us to be acquainted with. The method however of procuring these Salts I cannot possibly go through before you here, as the Process will take up the space of some months before it is finished: The beginning therefore and end I'll exhibit to you, and the rest I'll supply by Description; and hence you will be able to discover what a prodigious difference there is betwixt these native Salts, and those produced by Fire. And this I desire you will particularly take notice of, as nothing has given occasion to grosser Errors than a Notion, that is got among the Chemists, that Salts exist exactly in the same manner in the Plants themselves, as they find them when they have procured 'em from them by the Torture of the Fire. If we would proceed with caution here, certainly, we cannot conclude, that such a particular Salt was actually in the Plant, because, by the assistance of Fire we have produced it from it. No, according to the Rules of Art, we can only reason thus: With a determin'd degree of Heat, I procured from such a Plant, such a Salt, and consequently there was naturally in such a Plant some Matter, which being treated in that manner, yielded that Salt; and no farther. Upon examination, now, we shall

shall find, that the combustible, pinguious part, accurately united with the pure saline one, will give the native Salt.

A P P A R A T U S.

1. **I** TAKE a large quantity of broad leav'd Garden Sorrel, pull'd out of the ground betimes in the morning, now it is in its prime, and just ready to flower. This I wash in a running Stream from all the Mould and Sand that hangs about it, and then cut it, pound it, and put it into a hempen Bag, and press out as much Juice as is possible; which will be very acid, green, and as thick as Must.

2. This Juice I dilute with six times as much very clean Rain-water, that it may more easily pass through the filtering Bag.

3. This diluted Juice I pour into a conical Linnen Bag, and when it is run through, pour it back again, and repeat this till it becomes a limpid, pure, thin Liquor; which will then be gratefully acid.

4. The Liquor thus depurated, I put into broad glass Vessels, and by boiling it very gently in a place that is not dusty, and with a Fire that is not smoky, I inspissate it till the remainder acquires nearly the consistence of new Cream: This will be exceeding acid.

5. This inspissated Liquid I pour into a very clean Urinal, so that it may rise a little into the Neck, and then very gently pour some pure Oil of Olives upon it, to the thickness of a line, which being done, I set it by in a Cellar on a Pavement, where it must stand quiet for the space of eight months. By this means, then, under the Oil which prevents any Fermentation, Putrefaction, or Production of Mucilage, there is generated a Salt resembling a kind of Tartar, which, when the Liquor that swims at top is decanted, comes as near as possible to the native Salt of the Plant.

6. This Salt, if it is slightly washed with cold Water, as expeditiously as possible, from the mucilaginous impurities that adhere to it, and is then gently dried, gives you the native Salt of the Plant, which I have never discovered to be alcalious in any Plant whatever, when it was thus contained in the Juice, disengaged itself thence, and became concreted into saline Masses. If you compare this, now, with the Salt produced in the fifth and sixth Process by an open Fire, you will find a prodigious difference in the Colour, Taste, Figure, and all its effects, both physical and medicinal. This is purely separated from the native Juice of the Plant; that is the proper production of the Fire, not existing in the same manner in the fluids of the Plant, but being, as *Van Helmont* very justly expresses himself, a New Creature.

7. The Instance I have here given is in Sorrel, but you may perform the same Operation upon any other succulent Plant whatever, though you will always have a Salt of a different nature, according to the various Plants you make use of. If the Juices have a manifest pure acid taste, or an austere acid one, then the Salt thus procured will be like the Tartar generated in an acid, or rough Wine. But if you treat in this manner Plants that are exceeding succulent, but neither acid nor oily, as a great number of the medicinal ones are, then the Salt produced will be of another nature, proper and peculiar to them, and approaching perhaps nearer to Nitre. Brooklime, Succory, Dwarf-Elder, En-

dive, Fumatory, Grafs, Water-Creffes, Water-Lilies, Plantain, Knot-grafs, Self-heal and Dandelion yield fuch a kind of Salt. And hence the Juices of thefe Plants, on account of the large quantity that they contain of this fubnitrous Salt, are endued with excellent medicinal vertues, make their way thro' Veffels that have been long obftruded, refolve the pitchy Tenacity of the black bile, and prove powerfully efficacious in ftubborn chronical Difcafes. But again, if for this purpofe, you make ufe of Plants whofe Juices are vifcid, and glutinous, as we fee in Purflain, the Seeds of Fleawort, and the greater Comfrey, you never will procure a Salt from them till their tenacity is deftroyed by a previous Fermentation. And in the fame manner, all thofe Juices, in which there is a large quantity of Oil, are unfit for this Operation; for though they actually contain a faline matter in them, yet this is fo invifcated in the Oil, that the particles have not power to unite together into chryftalline Glebes, as Oil always prevents the formation of Chryftals in any Salt whatever. And befides an abundance of Oil always occafions a deficiency of Salt, both in Animals, and Vegetables; and the contrary; for which reafon you can fcarce procure any of this Salt, from Plants that are full of rich aromatic Oils, or Balfams.

U S E.

HENCE then we learn the nature of the Salt, thus prepared, which is the true native Salt of the Plant. This is diffoluble in Water; is compofed of an oily, and faline principle; is often acid; never alcalious, for where there is any fuch Salt, that flies off in the boiling and infpiffation; moderately fix'd; eafily mutable; mifcible with the human Fluids; and capable of penetrating into thofe Veffels of the Body that are confiderably fmall, and hence of exerting its proper Power there. If it is dried, it is partly combuftible, as the infpiffated Subftances in the fifth Procefs, and then it is converted into fuch a Salt as was obtained by the fifth and fixth.

P R O C E S S VIII.

The Native Salt of Plants procur'd from their fermented Juice, call'd Wine-Stone, or Tartar.

THE prefs'd Juice of ripe Summer Fruits, being perfectly fermented, and hence acquiring the name of Wine, by ftanding only, depofites its Lees, call'd the (*Mater*) Mother of the Wine, and becomes fine. If it is then drawn off into another Veffel, in time it generates little corpuscles, which move about in the middle of the Liquor, fhine, gliffen, are fharp and fubtil. And thefe being afterwards difpers'd from the center of gravity of the Wine towards every point of its furface, faften to the concave furface of the Cask, and by this means incruftate every part of it, where the Wine can come at it. The Wine then continues gradually to difcharge more and more of the fame matter, which very eafily adheres to, and is attracted as it were by the former, and this goes on till the Body of the Wine at laft contains no more of it. If the Wine, now, having thus depofited all the matter of this kind that is contained in it after Fermentation,

mentation, and being by this means grown softer, is drawn off into another Cask, and the former is fill'd again with Wine, not yet fined, this will still add more of the same matter, which will be sooner generated than the other was, being attracted to the sides in a shorter time by the efficacy of the crust already form'd. And this is the real Production of that surprizing Body, which is a true saline Chrystal of Wine, but not form'd only at the bottom, as other saline Chrystals are, but equally in every part of the surrounding Vessel. This, in a great many of its properties, is perfectly distinct from the Lees of Wine, tho' it comes in its nature pretty near them. This is more subtil, purer, less terrestrial, not so foul and oily, is dissolved in Water with more difficulty, and is of a more acid Taste. This the *Germans*, by a very expressive Term, call Wine-Stone; The Chemists, not so properly, Tartar. There is a vast deal of difference now in this, according to the various Wines from which it is generated. Acid and rough Wines yield more of it; sweet, soft ones, less. Wines that are prevented from thoroughly fermenting, too, produce a smaller quantity; those which are become very subtil, by means of a perfect Fermentation, a greater; as we see in the *Rhenish* Wines. Red Wines generate Red Tartar; White ones, White.

U S E.

THIS is a second Method then of obtaining the Native Salt of Vegetables, which is always acid, oily, and very easily converted into an Alkali. It will dissolve neither in Water, Wine, nor Vinegar, without the assistance of Heat, but remains like a Stone unaffected; nay, in the same manner as a strong Vessel does, it contains the very Wine from which it was generated. If you wou'd dissolve it in Water, in order to do this, you must make it boil, and then as soon as ever the Water grows a little cooler, it hardens again in the Water, and acquires the name of Cream, or Chrystals of Tartar. And even when the Water does boil, it requires twenty times its weight of Water to dissolve it, otherwise it will remain at the bottom. Whilst it is burning in the Fire, it produces more elastic Air than any other known Body, and generates a Vapour that is absolutely incoerceable. Where a Person is troubled with a bilious, acrid, putrid disorder, it is an excellent Corrector; and hence in acute Distempers it proves a valuable Medicine. It gently opens and purges the first Passages, without causing any considerable disturbance in the internal parts. If it is mix'd with an acrid putrid Matter, it loses its acidity, and becomes a noble Aperient. Its other properties will appear, when we come to treat of it in Process 54, and 55. Thus then we see, what Sort of Salt is found in the native, and fermented Juices of Vegetables. But in the 55th Process, I shall demonstrate before you, that these Salts may be easily resolv'd into a vastly elastic Air; an acidish Water; an acidish fetid Spirit; a volatile Oil, the most penetrating of any we are acquainted with, and exceeding volatile; an Oil thicker, and more fix'd; a black alkaline Coal; an excellent Alkali; and an Earth. Salts, therefore, do not exist simple in Plants, but are temper'd by the admixture of other Bodies: And thus you begin to understand the Chemical *Analysis* of Vegetables.

P R O C E S S IX.

Salt procured from green Rosemary, by burning it after the Method of Tachenius.

A P P A R A T U S.

1. **I**NTO a large and pretty deep iron Frying-pan, I put a quantity of clean, dry, fresh, green Rosemary, both Leaves, and Stalks. Upon this I put an iron Plate, which must lay upon the Rosemary in such a manner, as to press it down, and perfectly cover it all over. This being thus disposed, I place the Pan upon a gentle Fire, which I increase by degrees till the Pan grows perfectly red hot. The Plant, by this means, will smoke, diffuse a Smell, and be converted into a Coal. I then add more fresh Rosemary to the former, cover it, press it down, and proceed as before, till this is turned into a Coal likewise: And this I repeat, till I have got a quantity sufficient for my purpose. And during this Operation, I take all possible care that the Herb shan't take Fire, and flame, which is best prevented by covering it in such a manner, that it has no communication at all with the Air, for if that comes to it, it breaks out into a Flame, which in this case does harm. This is call'd the Ustulation of a Plant, and the slower and more gradually it is perform'd, the Operation will be proportionably more perfect. When this caution, then, is observed, the Herb will be very black, brittle, and bitter; and if it is boil'd in Water, it will yield a Decoction, that scarcely yet discovers any Salt in it, but tastes burnt and bitter, and proves a sudorific: So that in the Ustulation of a Plant into a Coal, there hardly appears any Salt, either by making a *Lixivium* of it, or by applying it to the Tongue.

2. The first part of the Operation being properly perform'd, take away the iron Cover, and let the Frying-pan, with the ustulated Herb remain on the same Fire; upon which, as soon as ever the Air comes to it, the Herb, which is now become black, will take Fire, and would very easily rise into a Flame; but this must here be carefully prevented, and the ignition only must be kept up with a moderate Fire. You see then, when the upper part, which is contiguous with the Air, has for some time sparkled and shined, its Fire goes out, and then it presently grows white. The parts, however, that are cover'd with these white Ashes, will still remain black, and on fire, and therefore all the Herb must be gently stirr'd about with an iron Rod, that every part may be successively exposed to the Air, and become white, till the whole being thoroughly on Fire, and by this continual agitation being a proper time exposed to the Air and Fire together, is converted into one homogeneous white Mass, which is then but in small quantity, heavy, and equally white. And when this is the case, there is no such thing as raising a Spark in it again, by any Fire whatever; tho' if there is but one black leaf in it, that, as soon as ever it comes to the Air, will take Fire in the same manner as the rest did. When the whole Herb now is thus reduced to a whiteness, it has then an acrid and somewhat urinous saline Taste, which never appears in the Herb, as long as that black part, which is a pure inflammable Oil, continues to adhere to it; but as soon

as ever this is intirely consumed, then the Salt, which is unaffected by the Fire, begins to discover itself. Hence then it appears again, that the consumption of the Oil is necessary, before the Salt can be procured.

3. Let the Ashes thus prepared, be left an hour or two upon the Fire, and let them be kept constantly red hot, and continually stirred with an Iron Rod; and this compleats the Calcination of Herbs for *Tachenius's* Salt. In this Operation now the action of the smothering Fire in the first step, after it has expell'd the Water, intimately unites the saline and oily principles into a sulphureous saline Concrete, to talk in the Language of the Artists, which is in some measure of a saponaceous nature, but which, at the same time, has a large admixture of a very subtil Earth.

4. If you put these Ashes into a clean Iron Vessel, with six times as much pure Rain-water, and boil 'em, stirring 'em now and then with an Iron Ladle, then the Liquor that swims at top will be acrid, lixivious, and saline, and will have drawn great part of the Salt out of the Ashes, leaving the Earth at the Bottom. Let this be poured off and filtered boiling hot, till it becomes perfectly limpid, and then let it be set by, under the Title of a *Lixivium* of *Tachenius's* Salt. If the Earth that remains at the bottom of the Vessel, or in the Bag, is boiled again with fresh Water, it will still yield a farther *Lixivium*, but the Taste of this will more resemble the Acrimony of Lime, and will contain less Salt: This may be filter'd too, and mix'd with the former. Let the Earth that is left behind be boil'd with more Water, and the Liquor poured off as before, and this be repeated till the last Water comes off as insipid as it was put on. These last *Lixiviums*, too, may be depurated and kept, or you may throw them away as of little consequence. Let the Earth that remains be shook about with Rain-water, let this, when it is become turbid, be poured off, and proceed in this manner, till the Sand, which alone will sink to the bottom, is perfectly separated from the true Ashes which will be dispersed through the Water. Let these turbid Waters be mixed together, and suffered to settle, and there will fall an Earth to the bottom, which being dried, is a pure Vegetable, Elementary Earth, almost a Virgin Earth, and exceeding fit for making Cupels with.

5. Let the pure *Lixivium* abovementioned be evaporated in a clean Iron Vessel, till it is become quite dry, keeping it continually stirring about towards the end, to prevent its sticking to the bottom; and by this means you will have a brownish Salt, that will be acrid and somewhat alcalious, and will gradually dissolve in the Air, but yet not so readily as a perfect Alkali: And here you may observe, that the browner this Salt is, the more properly will it be prepared; for it will have so much the more of the Oil in it.

6. If this Salt is put into a clean Crucible, and set in a Fire every way surrounding it, till the Crucible is red hot, it will easily enough flow like Water, much sooner than a true fix'd alkaline Salt; and then it must be pour'd out upon a clean brass plate in form of little cakes. And thus you have the pure fixed Vegetable Salt of *Tachenius*. If any person has a mind to render this still purer, he may expose it to the moisture of the Air, or dissolve it in Rain-water, and after he has depurated the Liquor by filtration, and letting it stand quiet, inspissate it 'till a pellicle appears on the surface, and then, by setting it by in a still place, it will shoot into saline glebules, which are the purest chrystals
of

of all, but sufficiently expensive. In these there is not contained an acrid Alkali, but the Oil of the Plant, being mixed with alkaline Salt, renders it more mild. You must not imagine, however, that the peculiar vertues of Plants is preserved in the Salt prepared in this manner; for the Fire has expelled this with the *Spiritus Rectior* which is too volatile to be retained in such a degree of heat. And hence the commonest Herb, if it has but a good deal of Salt, being treated in this manner, yields as good a Salt of this Kind as the most valuable: Its medicinal effects certainly will be found to be the same. But here let me caution you, that the colour of this Salt will be very easily chang'd, if a Coal happens to fall into it whilst you are melting it, for then it immediately acquires a leaden Colour, which will vary according to the quantity of the Coal that comes amongst it.

U S E.

1. **T**HESE Salts are not acrid, nor igneous, but are a saline composition of an Oil closely united by the Fire with an acrid Alkali; and they are so much the more distant from an acrid alkaline caustic quality as the Herb undergoes a longer ustulation, and as you more accurately prevent any Air's coming to it during the Operation: And then on account of their medicinal Vertues too, they are proportionably the more valuable.

2. They are not therefore in their nature so contrary to an acid, as to destroy so great a quantity of it, as pure Alkali's do, if they are mixed with it in the same proportion. Nay if they are properly prepared, they may in some measure supply the want of Sea and Fossil Salt for the common uses of Life; as *Varro* tells us of the Inhabitants of the *Rhine* who instead of 'em, made use of a Salt procured from the Coals of some sorts of Wood *de Re Rustica*. L. I. C. 7.

3. If these Salts are put into open Vessels, and are exposed to the external Air for a considerable time, they will melt with the Water they draw out of it, but slower and with more difficulty than pure Alkali's; but in Water they dissolve immediately.

4. They have this particular in them likewise, that they will readily mix with all the humours of the human Body, nay even with the pinguious Oil, and the inspissated Bile, that is to say, with the assistance of the vital warmth, and the action of the circulating Fluids.

5. Hence they are capable of penetrating into the sanguiferous, ferous, lactiferous, lymphatic, urinary, sudoriferous, and bilious Vessels; but they will not be admitted within the nervous.

6. When they are mix'd and diluted with the animal Fluids they are able by the concurrence of the natural Heat and vital Actions, to resolve various kinds of Concretions, nay, indeed, the principal that are observed in our Humours; especially if they are rendered more efficacious by Friction, Riding, or other moderate Exercise. Stones in human Bodies they don't easily dissolve by the proper power of a *Menstruum*, but they lessen them, by the mechanical Motion, and Attrition, which they increase in the Body, particularly in the urinary Passages. The Disorders in the Juices of the Nerves they are not able to reach, and hence cannot directly cure a true Gout; but otherwise, when they are diluted with

with warm Water, and assisted with motion, they become considerably penetrating, even into the most intimate parts of the Body.

7. When these Salts are received amongst, and mix'd with our Humours, they there act with an Acrimony that is not destructive, indeed, but that exceeds their natural softness, and hence they irritate the sensible parts of the Nerves, and by their stimulations, make them perform their vibrations with a greater *impetus* than usual; and on this account, they are of excellent service where a *Stimulus* is wanting in a languid habit of Body, in slow Hypochondriacal, and Hysterical Disorders, and others that arise merely from inactivity.

8. They prove admirably efficacious, therefore, in opening the obstructed Vessels of the human Body, both as they stimulate the whole nervous System, and at the same time, dissolve any of the Fluids that are grown too thick, and by their weight too, which is greater than that of our native Salts, urge all the parts with an *impetus* somewhat greater than what is natural.

9. Hence they have a power of promoting all the Secretions, and Excretions; for at the same time that they render those Humours sufficiently fluid that were not so before, they clear the Vessels too from their obstructions, and by their irritation stimulate them, and make them propel their contained Fluids with a greater velocity; and hence they equably excite the true causes of the motion of our Fluids through their Vessels, on which depend all the Secretions and Excretions in every part of the Body.

10. Hence, then, it appears, why these Salts are a Sudorific; for since it is evident, that the Sweat naturally contains in it the native Salts of the Body, and deposits them on the external surface of the Cuticle by means of little Arteries that open there, certainly this way will be ready for these Salts likewise, and here will they exert their power; and this is beautifully confirmed by Experiments. But these Salts, in particular, cause a more plentiful discharge of Water; for the Author of Nature has form'd the Kidneys principally to carry off the Salt of the Humours when it is in too great a quantity: This, the Urine, which of all the Fluids is much the saltiest, sufficiently evinces. And hence the efficacy of these Salts is never more manifest than in their Operation by Urine, and at the same time purging the Humours from any noxious impurities with which they are loaded. They help to discharge too the harder Excrements by Stool, inasmuch as they are able to resolve them, open the Passages, and stimulate the Intestines, when they perform their office too slowly. In hypochondriacal Persons, certainly, where the Body is very costive, you will scarcely find any Medicine more efficacious than these Salts, directed in a proper manner and quantity, and continued in for a sufficient time. And in this case, they have this particular excellence, that when you leave them off, the Intestines continue regularly to discharge their contents, without any costiveness, which is not the case with many other Purgatives. And as for the bilious System, the Liver, Spleen, Gall-Bladder, passages of the Bile into the Intestines, and *Vena Porta*, with what Medicine can they be more safely and efficaciously freed and purged from any Obstructions, or noxious Humours, than by this? By this lixivious *Sapo*, certainly, are resolv'd any tenacious concremented substances in the first passages, whence follows a thorough purgation without violence or danger; so that here we have, according to the advice of *Hippocrates*, a proper Coction, and Preparation of the Matter to be purg'd off.

11. Hence, therefore, these Salts prove of excellent service in all Chronical Distempers, where there is a mere *Torpor* of the Spirits, too great a laxity of the Fibres, and a sluggishness of the Fluids, without any putrid Acrimony, an acidity from a weakness of the vital Powers, or a *Coagulum* from an austere Juice, or an acid one. If Physicians, therefore, will but consider what a great number of Diseases depend upon these causes, they will make no scruple to believe that many chronical ones may be cur'd by the Salts prepared in this manner, which destroy Acids, convert them into neutral Salts, and then dissolve those Fluids which are grown too tenacious, and at the same time, by their moderate *Stimulus*, gently increase the actions of the Vessels. Do not hence, however, imprudently conclude, that the use of these Salts is always beneficial, and never hurtful. On the contrary, in cases where the Humours are putrid, bilious, alkaliescent, circulate too quick, and hence are too hot, these Salts only add Oil to the Fire: Nor are they less hurtful to Persons whose Constitutions are so tender, that they are not able to bear the effect of them; for then the motion they excite proves destructive. Where there is a great quantity of Salt too already in the Body, these, if they are superadded, prove detrimental.

The Method of using these SALT S in Physic.

1. **T**HEY ought to be taken when Digestion is compleated, and the Stomach is empty, and consequently, about ten hours from the last meal. As for the quantity, they may be given, according to the circumstances of the Person they are prescrib'd for, from four Grains to 2 Drachms, or more, which must be left to the judgment of the Physician.

2. They shou'd be diluted in a good deal of Water, lest, if they shou'd be drank too strong, they shou'd injure the *Fauces*, *Oesophagus*, and Stomach. Let a Drachm of this Salt, therefore, be dissolved in 9 Ounces of common Water, and then it will act like the medicinal Springs, which, in proportion to their Water, contain but a small quantity of Fossil Salt.

3. If the Physician has a mind to purge his Patient, let him take, going to Bed, 9 Grains of wash'd Soccatrine Aloes made into 3 Pills, or half a Drachm of *Pil. Ruf.* and the next morning let him rise pretty early, and walk about in a coolish Air, taking care he don't sweat, and whilst he is walking, let him take a proper quantity of these Salts divided into five or six Doses. This Method will have a very good effect, for the Body will be purged and lighten'd, and not much debilitated. This is the true Medicine for the Costiveness of sedentary learned Men, and extirpates disorders so deeply rooted, that they prove stubborn to all other Purges.

4. If you have a mind rather to purge the sanguiferous Vessels, and to have a discharge by the Kidneys, with the cautions first given, omit the Aloes in the Evening, let the Loins, and the Hypogastric Region be kept warmer than the other parts of the Body, and let the Patient now and then drink a draught of warm Tea or Coffee.

5. If Sweat is to be procured, let the Patient take these Salts in Bed, and after every Dose let him sup some gentle Sudorific, as a Decoction of Burdock Roots, the five opening Roots, Santals, Sassafras, Tea, or Coffee; and with
a sufficient

a sufficient quantity of Clothes upon him, let him sweat according to the nature of the Distemper.

6. If you want to cure Autumnal, Tertian, or Quartan Intermittents, this will be best effected by purging two or three Days successively, according to the third Observation. Then about 4 hours before the Fit, let the Patient be gently sweated according to the fifth; but with this circumstance, that the Sweat may be greatest about the time of the Paroxysm. In this manner, very stubborn Agues are happily cured. And in this respect, a *Lixivium* of these Salts excels even the *Acidulæ*, and *Spaw Waters*.

PROCESS X.

Tachenius's Salt procured by Fire from a dry Herb: Here from *Carduus Benedictus*.

APPARATUS.

IF this Plant, with the same *Apparatus*, as in the ninth Process, is ustulated over the Fire, and equably burnt into very black Coals, and you collect a large quantity of these, and set them upon the Fire uncover'd, and convert them into Ashes that are every where white, without the Herb's ever flaming; then by calcining these Ashes for a short time, making a *Lixivium* of them, depurating it, procuring a Salt from it, and then melting it, you will have the very same Salt from this dry Plant, as you had in the former Process from the green one.

USE.

AS in these Salts, the Oil and Salt, common to a great number of Plants, are combined without the native quality of the Plant's being preserv'd; hence it is evident, that it is of very little consequence from which they are prepar'd, the thing coming to the same at the end. For this purpose, therefore, one may make use of the commonest sorts of Plants, and those that are good for nothing else. Thus, if after you have gathered your garden Beans, you take the Stalks, slightly dry them, lay them in a large heap, press them down by laying iron Plates upon them, and ustulate them with a gentle Fire, you will procure a very good Salt of this kind, that will come very cheap, and will in virtue be equal to that prepar'd from Herbs that are more valuable. The making of these, therefore, I recommend, on this account only, not that it has any particular qualities, tho' *Paracelsus* extolls it mightily above others for its excellence against the Stone. Let me caution you, however, that the Plants you make use of are not too old and dry, for in that case they won't yield Salt enough to pay you for your trouble: Otherwise the Preparation of dry ones is more expeditious, easier, and cheaper.

PROCESS XI.

Salt prepared from burnt Vegetables, in the manner that is commonly practised by the Apothecaries.

APPARATUS.

TAKE any fresh Plants that abound with a saline Matter, as Worm-wood, *Carduus Benedictus*, Glass-wort, Fern, Bean-stalks, or the like; let them be dried in an Air that is hot and dry, and by shaking, be freed from the Sand and Mould that hangs about them; then let them be made up into large bundles, and be disposed into a Pile upon a flat pavement in the open Air, and so set on fire, upon which they will break out into a crackling Flame. When these are almost consumed, lay on some more bundles upon the hot Ashes, and proceed in this manner, 'till all the Matter you design for burning is by the Flames converted into Ashes that are equally white, which will soon happen, if you keep them constantly stirring with an iron Rod. These Ashes, when they are sifted, are what are sold about by those Persons, who cultivate physical Plants for the Apothecaries. In the burning of these, now, we must particularly consider all the *Phænomena*, tho' ever so common. In the first place, then, these Plants, when they are first laid on the Fire, emit a Smoke; and this Smoke grows gradually thicker and blacker, till it comes to be exceeding thick, and black, and is put into a very great motion, and then there immediately breaks out a Flame, in which there burns only a very lucid Fire, without the least appearance of any thing black or smoky. In the second place, the surface of the Flame, as well the top as the sides, sends forth a black Smoke, and is surrounded by it, as you may observe evidently by holding a piece of white Paper, or a clean Cloth over it. In the third place, it is observable, that the Smoke, when it is prodigious black and thick, and is whirled about with a very great rapidity, comes so very near to the Flame that presently bursts out, that there is scarcely any difference between them: Nay, if by any accident the Flame is put out, whilst there remain any black Coals in the combustible matter, there immediately succeeds a thick Smoke, which may be again converted into Flame, and so on for a great number of times. In the fourth place, so long as there is a good deal of black left in the burnt Plant, a Flame may be excited, particularly by the action of Wind, and there will be always so much less Smoke and Flame, as there is less black; nor will there ever arise a strong Flame, 'till there appears a blackness in the combustible Matter. In the fifth place, when the black begins to be considerably consum'd, there cannot be excited a Flame any longer, but there will then appear little fiery Sparks in every place, where there is the least blackness left; but then there will be no visible Smoke. Do therefore the Smoke, Flame, Sparks, Oil of combustible Bodies, and black coaly Substance, differ but very little, with regard to their Matter? Certainly, when the black is totally consum'd, neither Smoke, Flame, nor Sparks appear any longer. Perhaps, therefore, the quantity of Fire only, and of course the rapider rotation of the Oil makes the difference. The Salt now prepared from these Ashes, is more acrid, alcalious, and caustic than the former,

former, and hence it corrodes more, resists an Acid more powerfully, and excites putrefaction.

U S E.

HERE then we see particularly the difference there is in Salts produc'd by Fire, according to the various manner of applying it; and at the same time we have here new instruments both in Physic and Chemistry, more alkalious indeed than the former, but yet not quite so. From what has been laid before you too, you evidently observe, that the Salts produc'd by this last Method, will differ much the least from one another, and consequently may be prepared from any dry Herbs mixed together that are fit for the purpose; for these Salts, when they are blended together, can't possibly be distinguished from that procur'd from any single Plant whatever: The commonest, therefore, are equal to the most valuable for this Operation.

P R O C E S S XII.

An acrid, alkaline, fix'd, igneous, vegetable Salt, and a Liquor from it, called Oil per Deliquium.

A P P A R A T U S.

LET a full grown, fresh, succulent, green Plant be burnt to Ashes in such a manner, as to produce the *Sal Tachenianus*, according to the ninth Process; for these Ashes, in proportion to their quantity, will afterwards produce more Alkali than others: And to chuse, let this Operation be perform'd in the Spring season.

2. Or, as this greater quantity of Alkali, will not make amends for the extraordinary trouble and charge, let it be burnt only according to the eleventh Process.

3. Let these Ashes be put into a large earthen Vessel, and be exposed to a strong Fire, so as to be perfectly red hot, taking care at the same time that they don't melt, for then they would run into Glafs, and yield no Salt: But if this don't happen, the longer they are burnt in this manner, the stronger will be the Alkali that they yield afterwards. By this long continuance in the Fire, however, the acrid Alkali that is produc'd, is the more disposed to dissolve its social Earth, to unite strongly with it, and run into Glafs, and thus instantly to destroy all the Alkali: For the Fire is capable of converting the fix'd part of Vegetables, when it is melted, into a fix'd, pellucid, and perfectly insipid Gem, which then becomes greatly immutable, and appears exceeding simple. And hence the most antient Commentators upon the Sacred Writings have told us, that the whole World, when it shall be destroy'd by Fire at the general Conflagration, will be turn'd into Glafs. And, indeed, in this Operation, if you protract it too long, or raise your Fire to too great a degree, there is often some true Glafs found at the bottom of the Vessel.

4. Let the Ashes calcin'd in this manner, be boiled in an iron Pot, with four times as much Rain-water; and then let them stand quiet for half an hour,

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that

that the *Fæces* may subside to the bottom, and the *Lixivium* be clear at top. Take this *Lixivium*, and filter it through a thick Cloth, till it at last becomes exceeding limpid. Boil the *Fæces* up again with fresh Water, and keep them continually stirring with an iron Rod, and when you have procur'd a clear *Lixivium* as before, mix this with the former. The *Fæces* being flung away, put these *Lixiviums* into a clean iron Pot polished within, and boil them till they are inspissated almost to the thickness of Honey; and then you must keep them continually stirring with an iron Ladle, and that strongly too, that they may not, as they begin to grow dry, stick to the Vessel, for if they once do, there's no getting them off again. When they are just become dry, the Water being almost all expelled by the violence of the Heat, and the Mass, on account of the separation of the Water, now growing hotter, it on a sudden rarefies and puffs up, and if you don't take care to keep it constantly stirring, the Matter will boil up and run over the Pot, and thus you will lose a great part of your Profit and Labour. This agitation, therefore, must be continued till the Salt in the Pot grows perfectly dry, and then it will be white, alcalious, and sufficiently pure. The ultimate dryness of it, however, is difficult to procure, and more difficult still to preserve.

5. Let the Salt thus prepared, whilst it remains very dry and hot, be put into a strong Crucible, and be melted in an intense Fire, and for an hour or two let it be kept in that condition. At the same time take care to have by you a clean, dry, metal Mortar, made very hot, into which cautiously pour the melted Salt out of the Crucible, be sure taking care to hold your Tongs very fast. As soon as ever the Salt is in the Mortar, let it be briskly rubbed about with a hot Pestil, before it hardens, and thus it may be reduced to a very dry Powder, which cannot be effected in any other manner, as it will grow moist from the Water in the Air. Whilst the Powder then continues solid, and is exceeding hot, let it be put into a very dry, hot Bottle, made of green *German* Glass, with a pretty large Neck, and wide Mouth, stop this as soon as possible with a dry new Cork, drive it in very tight, and then dip the Cork and Mouth of the Bottle into melted Pitch: And thus you will have a pure alkaline Salt.

6. The longer this Salt is kept melted in the Fire, and the intenser the Heat is, the more acid and igneous you will find it. And then too it will change from one Colour to another; for in the beginning it is greyish, then white, then successively bluish, blue, greenish, and brown, and at last reddish like Marble. And the succession of these Colours produced only by the strength of the Fire, expresses constantly a greater degree of Acrimony, and more perfect alkaline disposition. And here there seems always to remain so much less Oil united with this Salt, as it has for a longer time been exposed to a greater degree of Heat. If any Person now has a mind to observe nicely all the different states of this Salt, he may divide this Process into as many parts as there are variety of Colours, and degrees of Acrimony just mentioned: Let the Operator, however, be very careful, that he is not deceived by any Colour that may arise from the falling in of a Coal, attending only to that which is produced by the intense action of the Fire.

7. In the same manner, the Juices of Plants, their Extracts, and native Salts, the tartareous Salts produced from fermented Liquids, and *Tachenian* Salts, yield such an alkaline Salt as has been described, if they are exposed to the same Fire.

8. In

8. In the mean time, however, there is observed a considerable diversity in the production of these Salts; for some Vegetables afford a larger quantity of an alkaline Salt that becomes immediately very acrid, than others. Vine branches cut off in the beginning of the month of *March*, and burnt with an open Fire, yield abundantly an exceeding acrid alkaline Salt; and this Alkali, *Basil Valentine* seems, in the preparation of his Antipodagric, and Lithontriptic Medicines, to have preferr'd to all others. The *Egyptian Kali* too, contains a great deal of a Salt that becomes alcalious, if it is exposed to the Fire in this manner. But there is nothing from which this Salt is sooner and better prepared than from Tartar of Wine: This certainly *Paracelsus* and *Van Helmont* look'd upon as the chief of all Alkali's. The Glass-makers observe, now, that the Glass that is made from the alkaline Salt of Fern, is greenish, and not so transparent, as that which is made from the *Kali*, which is exceeding clear; and hence this only is esteemed by the *Venetians* for making the finest sort of Glass. Upon this head consult *Neri*, and *Dr. Merit*. And by some nice Observations that were made at the *Tuscan Court*, there was discovered likewise some difference in the Chrystals produc'd from such alcalious Salts; as there appear'd too a variety in the Colours arising from the mixture of different Alkali's with *Mercurius Sublimatus*, and *Vitriolum Martis* dissolved in Water. See *Tach. Hipp. Cb. C. VII.* and *XVI. Borrich. contra. Conring.* from p. 350, to 361. Hence, therefore, it appears, that there is in reality some difference in this Salt, arising from its natural origin, tho' but an inconsiderable one, in comparison of that which proceeds from the various methods of making it.

9. In the Salt now prepared in the manner described, are observed the following Qualities:

1. The Taste of it, if one may be allow'd to express one's self so, is igneous; for if a particle of it is laid upon a moist, sound Tongue, it impresses such a sensation on it, as would arise from a small Live-coal, and there is immediately produc'd an Inflammation, and an Eschar, which leaves behind it a slight Ulcer. But when by diluting it in Water, you have weaken'd it so, that it may be held in the Mouth without any inconvenience, you then have a Taste like that of putrefied Urine; and hence these came to be called urinous Salts: But this Taste is not properly in the Salt itself, but arises only from the Acid of the *Saliva's* being absorb'd by the Alkali, by which means its other part becomes volatile and occasions it.
2. This Salt, so long as it remains pure and unmix'd, sends forth no Smell that the Olfactory Nerves are capable of perceiving; but if it is mixed with any saline Substance, that is of the nature of the Native Salts of Animals, or *Sal-Ammoniac*, then the Acid of these being attracted into the Alkali, the other part is freed from this Acid which fix'd it before, and by this means becomes volatile, and discovers itself by a urinous, fetid, and, as it were, putrid Smell. And for this reason, again, the Artists, deceived by this sudden alteration, called this a urinous Salt, attributing this Smell to the fix'd Alkali, because this is not perceived in either of the Salts before the mixture, but upon the application of the Alkali to our Humours, they immediately acquire it.
3. The Colour of this Salt is various, white most frequently, or bluish. See No. 6.

4. If

4. If you take it in your Fingers, it seems to be oily, and when it melts in the Air, it produces a pinguious Liquor, which the Chemists therefore, have called an Oil.
5. If it is applied to the moist Skin of a Person in Health, and is covered in such a manner that it shan't fall off, but shall remain fixed to one place, it will then soon be dissolved by the natural Moisture of the Body that is continually transuding, and being agitated by the vital Heat will cause an Itching, Heat, Redness, Pain as from Fire, a shining Tension of the Skin, a true inflammation, and a gangrenous, hard, black Eschar, which will penetrate into the most internal parts of the Body, so that it acts upon the solid Parts in the same manner as Fire does. And as this changes the colour of the Bones, and turns them white; so these, if they are boiled according to Art in an alcalious *Lixivium*, grow white, likewise. And again, as Fire makes the Parts of Animals putrify in a short time; so this Salt, if it is sprinkled upon them and mixed with them, soon excites a fetid putrefaction. And hence, in this respect, this Salt, when it is pure, like poison, destroys the whole animal Machine, and that without remedy; for which reason it is a Salt dangerous to the human Body, and therefore not so prudently cried up among the modern Physicians for a very safe Medicine.
6. If this Salt is mixed with an Acid dissolved in Water, it for the most part immediately produces an ebullition, hissing noise, and intestine motion, and at the same time generates and diffuses a large quantity of elastic Air; but being combined with the Acid in a certain proportion, it then becomes quiet, nor, though you add more afterwards, will it cause any farther effervescence. And this is always observed to be the case sooner or later; for tho' the most acrid Salt of Tartar does not immediately cause an ebullition upon the affusion of a small Vinegar, yet it does in a short time after.
7. Such an Alkali mixed and agitated with our Humours, and acted upon by our natural Heat, will be united pretty intimately with them all, will resolve them, and attracting their Acid into itself, will change their saline part from a neutral ammoniacal disposition to an alkaline one, from a soft to an acrid one, from a semi-fixed to a very volatile one, from a saponaceous to a less oily one, and from an inodorous to a fetid putrid one. If it is boil'd with Milk, however, that will be coagulated by it, whilst the other Fluids of the human Body are rather resolved by it. When therefore, by the action of Circulation, it is carried with our Humours into the minute Vessels of the Body, it then corrodes them by its Acrimony. And as the Lungs first receive it into their capillary Arteries, after it is taken into the Body, and discharged by the Veins into the Heart; hence these are particularly affected by it. The gummy, resinous, gummy-resinous, oily, and viscid parts of Animals and Vegetables, it dissolves pretty well likewise; nay, and it opens, attenuates, and resolves too the Oils of Fossils, Sulphurs, and the tenacious Substances produced from them.
8. By Coction, or a long-continued Digestion with any sorts of Oils in a proper degree of Heat, it becomes intimately united with them, and being managed according to Art, is converted with them into a true Soap, miscible with Water, and detergent: And as by this means its own Acrimony

is diminished, so it destroys likewise the tenacity of the Oil, and renders that dissoluble in Water.

9. If this Salt is mix'd in a certain proportion with Sand or Powder of Flint-Stones, and is kept in fusion with them for a considerable time, it melts those Bodies, unites them intimately with itself, and produces Glass, in which there is not then discoverable the least indication of Salt. A surprising *Metamorphosis*, which was it not so evidently confirmed, one could never believe to be possible! This Glass, however, if it is melted with three times its weight of the strongest Alkali, and dissolved in it, may by this means be diluted with Water, and then if you drop a strong Acid into it, the Alkali will be absorbed, and a Powder of Flints will be precipitated to the bottom, as was formerly observed by *Van Helmont*. The Production of this Glass, *Tachenius* was of Opinion, was owing to a latent Acid in the Flints; but perhaps this speculation was a little too subtle; for though we are certain, that this union does happen betwixt the Alkali and the *Calx* of these Stones, yet that this depends only upon the vegetable Alkali, and an Acid of the Flint, we think is a precarious Hypothesis, not sufficiently confirmed.
10. This Salt is a true Magnet to Water, and being impatient of dryness, attracts the Water out of the Air, swells, grows spongy, and soft, unites it to itself, dissolves with it, and runs into an oily thick Liquor, that is somewhat tenacious, and is called an alkaline Oil *per deliquium*. If this is filtered through Paper, supported by Linnen, it becomes very pure, and among all Salts comes next in weight to Oil of Vitriol. If the Water is again drawn off from this by Fire, it returns pure Water. But the Acids likewise that float about in the Air are attracted into this Alkali along with the Water, and alter it according to their particular disposition; and hence when this Salt has been moistned and dried in this manner a good many times, it becomes intirely changed from its former Nature, and approaches to that of the Salt which produced the Acid. Thus if the Acid of burning Sulphur predominates in the Air to which this Alkali is exposed, it will acquire the Disposition of a vitriolated Tartar: If Spirit of Nitre abounds there, it will come near to the Nature of Nitre: If the acid Spirit of Sea-Salt, it will produce Sea-Salt: If the Vapour of Vinegar, a regenerated Tartar; and if Oils very minutely divided, it will form a Salt, that is something of the nature of a Soap. So long, however, as this Salt remains of a pure alkaline nature, it will retain its Water very tenaciously, and will not suffer itself to be dried, without a great deal of difficulty.
11. It will remain fixed a good while in the Fire tho' kept in fusion, if it is contained in a Vessel that it won't run through. If you keep it however melted by itself for a long time, it will at last exhale; but more particularly if you mix it with three times its weight of calcined Bones, or Earth that won't vitrify, and then expose it to an intense Fire; for then, as it won't easily melt on account of the Earth, nor will run into Glass, it will become volatile, as the Great *Boyle* observ'd long ago.
12. When it is perfectly saturated with a pure Acid, so that it won't take in any more, and by this means neither the Alkali nor Acid, in the least, predominate,

dominate, then by Dilution, Filtration, Inspissation, and Chryftallization, it will produce a true compound Salt, of the Nature of that which yielded the Acid. Hence these compound Salts have been supposed to be actually generated in this manner; and for this reason the Alkali has been looked upon as the Mother that receives the feminal Acid; as of itself, empty, and barren; and as a Chaos, and the universal *Matrix* of all Salts: And hence the Alkali has been called the Female, the Acid the Male.

13. By attracting Acids into itself, it separates them from other Bodies, and by this means brings about in Nature an infinite number of singular effects. Hence, for instance, it comes to pass, that by the admixture of an Alkali, Native Vegetable Vinegar, the same prepared by Art, and Spirit of Alum, Nitre, Salt, Sulphur, and Vitriol, are converted into Water, all their Acid being by this means absorb'd. And the Salt thus generated is a fixed one, except only that that from the Vinegar is volatile, the Alkali itself being by this Union rendered so.

14. If it is fused with a proper Fire, it becomes capable of penetrating thro' earthen Vessels, and even metalline ones too, transfusing through the former, and corroding those made of Brass, or Iron. Nay, I found, that Iron was eat away with it, when I only covered the crucible in which it was kept melted, with an Iron Plate; for by this means it became brittle: Brass it consumes in a shorter time.

15. It precipitates Metals that are dissolved in Acids. If it is dropped into a solution of Mercury corroded by an Acid, called sublimate, it precipitates the Mercury to the bottom of the Water, and the red colour of the subliming Powder is so much brighter as the Alkali is stronger and purer: Hence therefore we have a pretty certain Method of trying the purity of an Alkali.

16. The Juices of the Turnsole, Roses, and Violets, it changes green, which grow red with an Acid.

17. This Salt never naturally appears as such, either in the Animal, Vegetable, or Fossil Kingdom, being produced only from Vegetables by the assistance of an intense Fire. It is a proper Creature of the Fire therefore generated from Vegetables burnt to Ashes: And thus it is generated always. With these Ashes it sinks down into the Earth; and yet it never appears there afterwards. There, therefore, it must lose its alkaline, and put on some other Nature, and thus produce a new Body, which by a natural revolution may, in time, come to be converted into an Alkali again.

18. If this Salt runs *per Deliquium* in the Air, is then dried, and melted in the Fire, and afterwards exposed again to a moist Air, and dried, and so on, and these Operations are sufficiently repeated, it will at last be resolved into a volatile part, and earthy *Fæces*. The Nature of a fixed Alkali, now, you formerly understood from the most undoubted Experiments, when I described it theoretically in our Doctrine of *Menstruums*, Vol. I. p. 440, & seq. If you will but compare therefore what you find there with what we have now delivered here, you will be able to form a true judgment of alkaline Salts, which have been so famous both among the Chemists and Physicians, for the two last Centuries; and upon examination you will be surprized to find how little those Persons truly knew of them who have

written so largely about them in both these Arts. If you have a mind, therefore, to have a true and particular account of the virtues of Alkali's in the human Bodies, consult what has been said before: Or if you had rather have a brief recapitulation of them, take it as follows. 1. They in a short time destroy all the Acid in the Human Body; for there is but a little there, and that a pretty mild vegetable one, and only in the first passages. 2. If they meet with an Acid there, they cause an Effervescence, generate Air-Bubbles, Wind, and *Flatus's*, stimulate by their activity, and are converted together into a neutral Salt, which is then harmless, penetrating, aperient, diaphoretic, diuretic, and antiseptic, and produces new effects, depending upon the new Salt thus generated, and consequently not so properly to be ascribed to the Alkali's, tho' they appear indeed after the taking them. 3. By means of the effervescence thus excited they stimulate the Nerves, put the animal Spirits in agitation, and alter the motions that the Nerves and Spirits were in before: Hence they often remove Hypochondriacal, and Hysterical Spasms; and cure Distempers depending upon them, as we see in the famous Anti-emetic of *Riverius*, viz. an Alkali mixed with Juice of Lemons, which being drank in the very act of Effervescence, cures *Cholera's*, and most stubborn Vomitings, not to be subdued by any other method. 4. This Salt dissolves any substances coagulated by an Acid; and hence where Milk curdles upon the Stomach, if it is prudently given, it has a very good effect: Other tenacious Bodies too it resolves, and pretty successfully. 5. It attenuates glutinous, oily, and pinguious substances, and renders them more easily miscible with Water, on which depends the cleaning of Bodies, and hence the Fullers, Scourers, and Dyers find that the scouring them from any pinguious viscid matter is particularly effected by a Lye of these Salts. If they are moderately used, therefore, they will free the Chylopoietic System from any glutinous impurities. 6. They resolve the *Coagulums* of the Bile, Lymph, Blood, and *Serum*, when they are admitted into the more internal parts of the Body, and are rendered active by the vital Powers. 7. By their acrid *Stimulus* they put in motion the Bodies that are inactive, and hence they promote Urine, Sweat, and Perspiration, and for this reason are ranked amongst the Diuretics, Diaphoretics, and Sudorifics: The Intestines too they empty by Stool. 8. In Diseases, therefore, where an inert, viscid, mucous *Pituita* prevails, and hence an acidity of our vegetable Food in the first Passages, where there appears an austere acescent Matter, or its effects, manifest by coagulation, where an aqueous *Serum* abounds, or a tenacious, pinguious Matter predominates, or where we find Distempers which have been produced by these causes, as the Dropsy, Jaundice, *Leucophlegmatia*, Gout, Rheumatism and Scurvy; there this Salt is of excellent service, if it is given, well diluted, in a small quantity, and is continued in the use of a sufficient length of time. That kind of Gout at least which owes its origin to an Acid will scarcely perhaps be cured more successfully by any method, than by small doses of this Salt sufficiently repeated. We must take care however, not to cry it up immediately as an universal antipodagric; for it will certainly be prejudicial to those Persons who are troubled with hot, bilious Juices,

and whose Humours spontaneously tend towards a putrid alcalious Disposition. 9. To the Surgeons likewise these Salts prove of excellent Service: By their caustic power they raise an Eschar when you want an Issue; with a *Lixivium* of them are successfully clean'd, putrid foul Ulcers; if Parts that are gangrenous are scarified almost to the quick, and then fomented with a *Lixivium* of them, they contract into a Crust, and suffer a separation from the living part, by which means the mortification is prevented from spreading any further, and a happy cure is effected; they extirpate Warts too, and safely enough eat away small Cancers; and if they are sufficiently diluted, will take away Spots in the Skin very efficaciously. 10. We must add, however, in the last place, that the use of these Salts is very pernicious in every Disease where the native animal Salts begin to degenerate towards an acrid, alcalescent, putrid, volatile nature; or where the natural Oils are tending to an acrid, fetid, putrid, rancid, and volatile Disposition, discovering itself by a disagreeable Smell, and the red colour of the Urine. But these Salts become particularly destructive, where the Bile is degenerated in this manner, and where the Humours of the Patient are too much dissolved, fluid and putrid; for which reason in the Plague they are almost a present Poison, their pernicious Quality evidently remaining even in the Soaps that are made with them. Hence, therefore, in Inflammations, Suppurations, Gangrenes, *Sphacelus's*, continued putrid Fevers, and Diseases that arise from too swift a circulation, the internal use of these Salts ought to be absolutely avoided. 11. And, indeed, where it does appear proper to use them, let it be done with caution. Let a Drachm of 'em be diluted in twenty times its weight of Water, and let scarcely ever more than this quantity be given at a time: Let the Physician too in the repetition of them carefully attend to all the Symptoms that occur, that they may be left off as soon as ever their assistance is no longer necessary; and by this means he may use them successfully without any fear of danger. And lastly, let him take care to determine them to such parts of the Body, and make 'em produce such particular effects as the circumstances of the Patient require, as we mentioned before in the use of the *Sal Tacbenianus*.

P R O C E S S XIII.

A very acrid, alkaline, igneous Salt made with Quick-Lime.

A P P A R A T U S.

TAKE Lime made of burnt Stones, that is quite fresh, very dry, solid, not affected by any moisture, nor as yet cleft asunder; of this, put 1 part into a clean iron Pot, and lay upon it 2 parts of the purest Pot-ashes, in such manner that the Lime may be covered all over with this Alkali. Let these be then left together in the Pot, with a Cloth flung over them, till the Lime begins to crack and split asunder. When you observe this, add 4 times their weight of Water, and boil them for the space of one or two hours. When the *Fæces* are subsided, pour off the Liquor, and let it be strained through

through *Hippocrates's* Sleeve made of thick Linnen Cloth, till it at last passes through as limpid as pure Water. Put this *Lixivium* into a large iron Ladle over the Fire, and taking care that it don't boil over, evaporate it till it becomes perfectly dry. Then increase your Fire till the Ladle grows red hot, and as soon as ever the Salt has done smoking, it will melt. When it is in this state, pour it out upon a hot brass Plate, and whilst the Matter continues very soft, make it smooth, and cut it into such pieces as are fit for chirurgical uses. Let these be immediately put into a very dry, hot, strong, glass Bottle, by the Fire side, and instantly stop it with a choice dry Cork: Let the Mouth of the Bottle be then dipp'd into melted Pitch, and be very accurately secured, that no Moisture may possibly get through it, which is attracted by the Alkali prepared in this manner with an incredible power, nay, even through Corks and Bladders: But if you observe these cautions, it may be kept pure for years. When you want to take a bit out for use, it must be done in a dry hot Air, or near a good Fire, and then the Bottle must be immediately stop't again as before.

U S E.

1. **T**HIS Salt, from the truly igneous vertue of the Lime attracted into the fixed igneous Alkali, acquires a most acute and quick corroding Power, which was neither in the Alkali nor the Lime when they were separate. The Acrimony of it exceeds that of all other Salts hitherto known: For if you cut a round hole in a sticking Plaister, and apply this to the human Body, and then put a bit of this Salt upon the Skin in the vacuity, and cover it over with another Plaister that it shan't fall off, it will in a very short time consume the Skin, and the *Membrana adiposa*, and hence is valued by the Surgeons, for what they call their Potential Cautery, above all others.

2. If almost any parts of Animals are thrown into a fresh *Lixivium* of this Salt whilst it is boiling, they will in a short time be converted into a liquid Matter, as will likewise most vegetable Substances, and the sulphurs of Fossils. A poor Man unfortunately falling into a boiling Copper of such a *Lixivium*, had his Clothes, and all the soft parts of his Body consumed, so that there was found nothing of him left but his Bones. Hence this *Lixivium* is of incomparable service, where the parts are gangrenous to a great depth, and almost sphacelated, as it disposes them to a happy separation; but it requires the prudent application of a skilful Surgeon.

3. This Salt melts with a pretty moderate Fire, and then it runs like Wax. By this easy fusion, therefore, it is capable, without the assistance of an intense Fire, of dissolving a great many Bodies, that otherwise are not dissolved without difficulty, as Gum Myrrh, Sandarach, and others. The ancient Chemists wrote a great deal about the Art of making Alkali's melt in the Fire like (*Cera*) Wax, and hence they called the Operation *Inceration*. Might they not possibly mean the Process we have just described? Certainly the Salt produced by it has this property.

4. If Lime is first slack'd, or extinguished either in the Air, or with Water, as almost all old Lime is, or is converted into a fine Powder, then if it is thus managed with a fixed Alkali, it will not produce this acrid kind of Salt:

Nay, and this Salt, when it is once melted in the Air, or is kept by a good while not carefully stopt, loses this singular Vertue; and then it deposites a large quantity of inactive, stoney *Fæces*, which did not appear before. Hence, therefore, we learn, that Fire communicates to inert Stone, and Shells of Fish, an Acrimony that is not easily procurable in any other manner. When a native, vegetable Salt, therefore, from a neutral, soft, saponaceous one, is converted into a fixed Alkali, does it not acquire this Acrimony from the Fire?

5. The Salt thus prepared obtains this singular property, that it becomes vastly disposed to a union with the express'd and distill'd Oils both of Vegetables, and Animals, and thus to form a Soap. And this seems to arise from its being rendered so exceeding penetrating, that it becomes capable of intimately dividing these Oils, and uniting with them, which without the Assistance of this sharp Lime can scarcely be effected conveniently. Nor without the Lime would the Alkali run so easily in the Fire; for that melts with a great deal of difficulty.

6. And here terminates the Power of the Chemical Art upon fixed alkaline Salts, which cannot, as far as I am acquainted with them, be carried to any greater perfection. Let us therefore to these Demonstrations subjoin a few Corollaries.

C O R O L L A R I E S.

1. **F**IXED vegetable Salts are produced only by Fire, from Vegetables that are fit for this purpose. Some Plants, when they are burnt, scarcely yield any of this Salt: And even those that are naturally disposed to do it, if they are exposed a great while to the Air, and are alternately dried, and moistened for a considerable number of times, lose at last all that Matter, which in burning wou'd have produced an alkaline Salt, and therefore, if they are then burnt they yield none at all: For the Air, whilst it affects Vegetables by its warmth and moisture, acts upon the Matter of the second Process, and carries it up into the Atmosphere, and thus evidently makes it appear, that that part, which the Fire thus fixes into an alkaline Salt, was spontaneously volatile.

2. Fixed alkaline vegetable Salts are generated only by Fire, whilst it actually consumes Plants, that are disposed for this Operation: For in the matter of the second Process there is never discovered any such Salt; nor does ever any appear in the seventh: But it is solely and purely the effect of a burning Fire. And here we observe, that according to the degree of it, and the different length of time it is applied, the Salt becomes stronger, more fixed, and more alcalious. I confess, indeed, that in Mustard Seed there naturally exists somewhat alkaline, as appears by its effervescence with Acids; but this is volatile, and vanishes when the Mustard Seed comes to be burnt. In order, now, to a demonstration of these two Corollaries, it was necessary to go through, in order, all the preceding Processes; and thus at length it evidently appears, that this fixed Alkali is a creature of the Fire.

3. A fixed alkaline Salt, therefore, is not a native, vegetable Salt. A native Salt, I call that which by the particular nature of any Plant is generated from the common nutritious Juices of the Earth, and which of consequence will always remain

remain in it so long, as it is left to itself, and has no violence offer'd to its natural Disposition: But this is destroyed by the Fire, and is converted into something of a quite different Nature. Does not the larger Garden Sorrel abound with a native acid Salt? This the seventh Process sufficiently evinced; and yet if you burn even this in an open flaming Fire, you will have a fixed Alkali from it, though before it evidently contained an Acid. This Alkali, therefore, is not native to Plants, but is changed by the Fire from a Non-alkali to an Alkali.

4. Hence we understand then what an *alcalescent Vegetable* properly is: For by this name are meant, first, such as contain a Juice that abounds with an Acid, and almost *alcalious Halitus* or Vapour, but which, at the same time, is always volatile; as we see in Garlick, Onions, and others: Secondly, those that by their *acrimonious Stimulus*, increase the circulation of our Humours through their Vessels, and by this means cause our native Salts to degenerate towards an alkaline disposition: Hence the warmest aromatics, though they are not *alcalious* in themselves, yet occasion the Salts in the human Body to incline that way: And, thirdly, those from which the Fire will produce a great quantity of a fixed alkaline Salt.

5. Betwixt the native vegetable Salt, therefore, of the seventh Process, and the most acrid, alkaline, fixed one of the twelfth, there are a great number of *Species* of fixed Salts, all which, as they differ in their physical action, and consequently in their internal nature, ought to be properly distinguished from one another. Let us take, for instance, the best *Rhenish Tartar*: This is the native Salt of the Wine, perfectly acid, and in some measure sharp; and hence in *alcalescent*, bilious, putrid Distempers it is of excellent service. If this is distilled in a glass Retort, with a gentle Fire, it yields a small quantity of an aqueous, acidish, light Liquor, which asswages thirst. When this is drawn off, the Body that remains in the Retort begins already to be *alcalescent*, and if a Person takes a proper quantity of it, it will make him hot and droughthy. If you then urge the remainder with a Fire a small matter stronger, there will arise a fragrant, penetrating, bitter, heating Oil, of a golden colour; and this being separated, the remaining Mass will appear black, will be more *alcalious* than it was before, will heat the Body more, create a greater Thirst, and being boiled with Spirit of Wine, will yield a noble, aperient, detergent, diuretic, anti-hydrotical Medicine. If you still go on to increase your Fire, you will have a thicker, tenacious, fetid, bitter Oil, and at the bottom of the Retort there will be left a very black Coal, which will be much more *alcalious* than the former: And if this is then taken out and put into a Crucible, and exposed to the most intense Fire it will at last produce a fix'd alkaline Salt, which, according to the strength and duration of the applied Heat, will be continually changed in all its properties, becoming constantly more and more acrid, as the action of the Fire upon it is longer continued, and more intense. Here, therefore, we see a Salt in its native state, truly acid, but after it has passed through various changes at last extremely *alcalious*.

6. There seems now to be three causes, in particular, that produce a difference in these Alkali's: For, in the first place, this appears to depend upon the quantity of the combustible Oil, that still adheres to the saline Matter; for the greater this is, the less acrid will the Alkali be in proportion; and the contrary.

But in the second place, this arises likewise from the artificial combination of this Oil with the Alkali; for if the Plant is only ustulated with a slow smothering Fire, according to the ninth Process, it will yield a greater quantity of Salt, but less acrid, and alcalious; but if it is once exposed to a strong open Fire, it will produce less, but the Acrimony will be greater. And in the third place, the proper action of the Fire itself seems to add something of an igneous quality to the Alkali, whether this arises from the fixation and accretion of the very substance of the Fire itself to the Salt, or only from a power it possesses of altering it in this manner; as I just now explained in this Process. This certainly is indisputably certain, that the longer Lime is burnt, and the intenser the Fire is that is made use of in the Operation, the more Heat, or which is the same thing, the more true Fire it will excite in cold Water. Nay, and even fixed Alkali's themselves will generate more Heat in cold Water, as they have been exposed to a greater Torture of the Fire. But in the fourth place too, perhaps we may here add the original seminal property of Plants, which is not very easily destroyed. One Plant shall yield a great deal of fixed Salt; another, nothing at all; not that this last naturally contained less Salt than the former, but because it was of such a nature, that it wou'd not bear to be fixed, by the Oil, or Earth, or both together?

7. From what has been said then we understand the origin of alkaline Salts in Animals, so far as they regard the matter of their Food, Drink, and the common Air they breath in. For Animals that live solely upon Vegetables and Water, take into their Bodies the very Matter, from which the alcalious Salts we have been describing are produced; though no body indeed cou'd naturally suspect, that such an insipid Body as soft, moist Grass, shou'd, only by being burnt, yield an acrid, igneous Alkali: Or who can possibly discover any thing of this kind in Ale or Wine? and yet Experience abundantly demonstrates, that an Alkali may be produced from them. The Action now of the Animal Body brings this latent matter to light, and makes it manifest. A Child that is fed with nothing but sweet Milk, which does not discover the least degree of saltiness in it, makes constantly a salt, acrid Water, not by actually generating any Salt, but by setting that at liberty, which before lay concealed; and the Urine of a Bullock, living only upon Vegetables, is found to be exceeding salt, for the very same reason. How this Salt, however, comes to be volatile in Animals, will appear hereafter, when we come to treat of Animal Salts.

P R O C E S S XIV.

An acrid, fix'd, vegetable Alkali yields a bitter, chryselline, hard, fix'd Salt, that is subvitrescent, and not alcalious.

A P P A R A T U S.

OF the best Pot-ashes I take 6 Pounds, and putting them into a clean glass Vessel, pour upon them 20 Pints of cold Rain-water, and then stir them well about with a stick, and in this condition set them by. When the Parts that will not dissolve have settled for a sufficient time, I gently pour off

off the clear *Lixivium*, and together with the *Fæces*, there will be found at the bottom a great number of very small Masses, of a grey Colour, and bitter Taste, that have almost the hardness and brittleness of Glass, and in which one can discover nothing of an Alkali: And this is the manner of preparing this Salt. But I'll make the same here in a neater manner before you. I take then 6 pounds of the best Pot-ashes, and dissolve them in a brass Kettle, by boiling them with four times their weight of Water. This *Lixivium*, whilst it is boiling hot, I strain through a linnen Bag that it may be nicely depurated whilst it is in this degree of Heat, and in this condition, put it into a hot, damp, clean glass Vessel, and so leave it. In a short time then, an opakish Crust, of a brownish grey Colour, begins to fix itself to the bottom and sides of the Vessel, which increases, and grows thicker continually: When the *Lixivium* has stood thus for some time, nor does deposite any more of this Salt, I very gently pour off all the pure Liquor that swims at top, and at the bottom there remains a Salt, like that procured by the former method, but purer, and in a greater quantity, as you yourselves are witnesses. If I take now the *Lixivium* thus freed from this Salt, and inspissate it a little, and set it by, it will yield perhaps a small matter of the same kind of Salt, but it afterwards will produce no more, so that there is but a certain limited quantity of this Salt in the Alkali.

If the Salt separated in this manner, is shook with cold Rain-water, it will not be dissolved by it, but then the Alkali that adheres to it, will be thoroughly wash'd away, so that by this means it will become perfectly pure; and if you then gently dry it, it will be simple, and may be preserved so, under what title you please.

The NATURE and USE of this SALT.

1. **S**OME Persons well skill'd in the Chemical Art, formerly asserted, that a proper fix'd alkaline Salt can scarcely be reduc'd to chrystalline Glebes; and this assertion has a good deal of truth in it. When the more modern Chemists, therefore, have shewn the Salt thus separated from an Alkali, as an alkaline Salt, they have not distinguish'd so carefully as they ought to have done; and indeed, when an Alkali is well freed from this Salt, it is difficult to form it into Chrystals, tho' it is possible, however, to do it.

2. This Salt never spontaneously dissolves in the Air. In cold Water it does not melt very easily. In hot Water, and a good quantity of it, it will at last be dissolv'd, but as soon as ever the Water grows cold again, it hardens into little Glebes. It is hard, and brittle, and may be reduced to a fine kind of mealy Powder, which will continue dry. It has an exceeding bitter Taste, which remains in the Mouth for a considerable time. In the Fire it crackles, and flies about pretty violently. It is neither acid, nor alcalious, nor indeed, like any other Salt that we are hitherto acquainted with, but a perfect new one. It seems, however, to come nearest in nature to that Salt which is thrown up in making of Glass, and being collected at top, goes by the name of the Galk of Glass. Does the Fire now, whilst it is producing the Alkali from Vegetables, generate this Salt with it likewise? And does the Fire, when it combines together the Alkali, and the *Calx* of Flints in the production of Glass, separate again this Salt, and throw it upwards? Certainly this does not seem improbable.

And

And hence we may in some measure understand why no such Salt is procured from the Alkali of Tartar; for Tartar is generated in exceeding fine Particles, from a subtil fermented Liquor. A farther application of this Salt to various Bodies in different degrees of Heat, will discover the other properties of it, which as yet lie concealed.

3. A fix'd Alkali, when it is perfectly freed from this Salt, differs intirely from the same when united with it. Whenever, therefore, I want to make any Experiments with a pure Alkali, I always take care first to separate this from it; otherwise it often destroys the true alkaline vertue, or renders it less efficacious.

PROCESS XV.

A common distill'd Water from green Rosemary, per Vesicam.

A P P A R A T U S.

1. **H**AVING in our five first Processes seen what parts those are which remain in Plants, after they have been exposed to as great a degree of Heat as can be communicated to them by the mediation of Water, we must now examine what part that is which evaporates from the Plant whilst the Water is boiling, and is dissipated into the Air; for thus shall we proceed most methodically. And this will be best effected by closely fitting on an Alembic to a Still, which by this means will collect all the exhaling Vapour, condense it, and discharge it into the Receiver.

2. In the Processes 32, 33, 34, 35, 36, 55, 86, it will hereafter appear, what volatile parts may be separated from Vegetables by a degree of Heat, beginning from that of boiling Water, and increasing to the greatest almost that the Vessels are able to bear without melting; but, now, if we wou'd avoid confusion, we must collect all that which will exhale from a fresh Plant, with all the degrees of Heat, from the natural one in Summer, to that of boiling Water. And here, again, we must make use of the same Herb Rosemary, that, by this means, we may be able to compare the production of this Process, with the different parts procured from it by the preceding.

3. Instead of Rosemary, however, you may substitute any of the Vegetables mentioned, as proper for the first Process, which distinguish themselves particularly by their Smell and Taste, as will appear by examining those few of which I have there given you a list: In which we see by the former Processes, there is contained an oily inflammable Matter, and a saline one that will bear to be fixed; as also an oily saponaceous one arising from the combination of these two together.

4. The Plants, designed for this Operation, should be gathered at that time of their growth, when they are just come to maturity, and the Plant is just disposed to put forth its Flowers, and yield its Fruit, before either the Seeds or Flowers are perfect; for that vertue of Plants which we seek in their Water, is often found to be rendered effete, when they have produced their Fruit, a languidness, and disposition to wither frequently succeeding. The Morning too is particularly proper for gathering these Plants, as the volatile Particles collected

collected by the cold of the Night, and entangled by the viscosity of the Dew, are not then dissipated by the Heat of the Sun. These cautions, we mean, should be observed when the virtue of the distilled Water resides in the Leaves of the Plant, as in Mint, Marjoram, Penny-royal, Rue, and a great many others.

5. But the case is otherwise, when there is an aromatic virtue in the Flowers, and in no other part of the Vegetable, of which the Rose, Lily, Lilies of the Valley, and many more are instances; for then we chuse the flowering parts, when they diffuse the most fragrant Scent. Let the Flowers, therefore, designed for this Process, be gathered when they are almost full blown, but not at all withered, and in the Morning whilst the Dew is still upon them. Sometimes too the Seeds of Vegetables are preferable to all the other parts of them, as we see in the Caraway, Anise, and Cummin, and others, where the Flowers and Herb are inactive, whilst the Seed contains a singular virtue discovering itself by its fragrant Scent, and warm pungent Taste. These Seeds, now, seem to possess this in its greatest perfection, just when they are come to be thoroughly ripe, at which time, therefore, they ought to be gathered. Nor must we omit taking notice, that the most excellent qualities of some Vegetables reside solely in the Root, witness the *Caryophyllata*, or Avens, and Orpine, whose Root has the Smell of a Rose. These Roots, therefore, when they are design'd for stilling, shou'd be dug up at that time of the year, when their virtue is greatest, which is generally when they are just going to put out Leaves; and these too should be taken up in the Morning. If the properties we want reside particularly in the Bark, or the Wood, then of course we chuse those for our purpose.

6. With such a Plant, either pounded or cut, as is most proper, fill a Still two thirds full, taking care not to squeeze it down hard. Pour upon it as much Rain-water, as, together with the Herb, will fill the Still to the same height, viz. two thirds. Let an Alembic or Head be then fixed close on the Still, so that none of the Vapour shall be able to escape, which, as the Workmen contrive them, is done very easily; and let the Beak of the Alembic where it goes into the Worm be luted with Linseed-flower work'd with Water into a very stiff Paste, taking care at the same time, that the Worm is well clean'd, by pouring boiling Water through it, that it may not taint your distill'd Water. To the lower extremity of the Worm, then, apply a Receiver, and thus none of the Vapour exhaling during the boiling will be lost, but being cool'd and condensed in the Worm, which is fix'd in a Tub of cold Water, will be all collected in the Receiver, in form of a Liquor, especially if you take care now and then to put some cold Water into the refrigeratory, which will grow otherwise hot in the distillation.

7. Every thing being thus prepared, digest with a gentle Heat of 150 degrees for the space of four and twenty hours: Then increase your Fire till the Water and Herbs in the Still boil softly. This may be known from a kind of hissing noise one may hear from the bursting of the bubbles form'd by the boiling; from the end of the Beak of the Alembic, or the beginning of the Worm's being so hot that one can't bear ones Hand upon it; from the Water in the Refrigeratory's beginning to smoke with the Heat of the Worm; or lastly, from the drops following one another so fast into the Receiver, that

there is almost one continued little stream. By all these signs, then, you may know when you have got the degree of Heat you want, which, being less than what will make the Decoction boil gently, you will not be able to raise those virtues you are in pursuit of. And on the other hand, if your Fire is too strong, the boiling Matter will be forced up into the Alembic and its Beak, and thus will spoil the distill'd Water; and besides the Herbs likewise being carried up with the Water, will pass into the Cavity of the Worm, and stop it up, and spoil it. For this reason, therefore, I usually fasten a piece of thin loose Cloth upon the Mouth of the Alembic where it goes into the Worm, that if the Fire should happen to be so strong as to make the Herbs rise thither, they may be prevented stopping up the Worm. But even then, there sometimes follows a greater inconvenience, for the Herbs by this means being collected in the Beak of the Alembic, stop the passage of the Water and Vapour into the Worm, which being by the Fire rarified in the Alembic, sometimes throws it off with a vast *impetus*, and pours out a scalding Steam, which if it is at once received into the Face, Eyes, or Lungs, may do a vast deal of damage, nay, may prove instantly fatal. Every Person, therefore, ought to be very cautious the first time he performs this Operation. And here let him observe, that the more oily, viscid, gummy, and resinous the Herb is, the more Spume of consequence will be generated in the boiling, and hence the danger of this accident will be proportionably greater.

8. The degree of Heat then being by the signs abovementioned very carefully observ'd, it must be kept up so long as the Water that distills into the Receiver, is white, thick, odorous, sapid, frothy, and turbid; for this must by all means be kept separate from that which follows. For this reason, the Operator must often change his Receiver, that he may be sure when this first Water ceases to come over. After this then is drawn off, you have another Water, which is pellucid and thin, and has not the proper Scent of the Plant, but generally smells a little acidish, nor the natural Taste of the Plant, but is somewhat upon the acid, is scarce frothy, but limpid, except that is rendered in some measure impure, by little white kind of strings and flakes that swim about in it: And if the whole inside of the Copper Head is not well tinn'd, this last Water, by its acidity, will corrode the Copper, and by this means will be tainted by it, become greenish, and excite *nausea's*, and vomiting, and thus proves a poison to those Persons that make use of it, particularly to the Infirm, and Children, whom it will work both upwards and downwards, with very painful gripings. If such an accident, therefore, should unfortunately happen, let the Patient drink very plentifully of Milk sweeten'd with Honey, or some emollient Decoction.

9. The first of the Waters, which we just now described, contains in particular, the Oil of the Plant, and *Spiritus Rectior*, and always at the same time somewhat saline, which in most is of an acidish nature, but in the acrid antiscorbutic Plants, of a volatile alkaline one: For the Fire, whilst it boils the Herbs, dissolves, and attenuates their Oils, reduces them to their smallest particles, and with the assistance of the Water, carries them up together with all those parts of the Plant which are disposed to become volatile with this degree of Fire. And if your Vessels have been kept accurately close, then all these will be united together, and be discharged into the Receiver, without any dissipation or loss,

or much alteration. This certainly is the case, if we can at all trust our Senses; for the proper Smell, Taste, and singular vertues of the volatile parts of Plants, are found to be abundantly contained in these distill'd Waters. If the Botanist, therefore, would give us a true account of the vertues of any Plants, so far as they reside in that part of them that becomes volatile by boiling, then the Chemist wou'd be able to exhibit those separate from all the rest. This *Tournefort* attempted in his Treatise *Of Plants growing about Paris*; *Ray*, in his, *Of the Native Plants of England*, and *Dodonæus*, in his, of *All in general*, an attempt perhaps a little too bold, and in some places but indifferently executed, especially in the last Edition, *Ann. 1644. at Antwerp*. In this first distill'd Water, now, of Plants, I designedly cautioned you, that we have nothing but those vertues which reside in some part, that will become volatile in this degree of Heat: For the proper and singular efficacy of Plants, consists in a mixture of all their Juices together, and hence will depend not only upon this Water, but upon this, and the Liquor that remains after this is drawn off, mixed together. Thus the express'd Juice of fresh Mint, for instance, besides the distill'd Water, contains likewise a great many other parts that are perfectly distinct from it; and hence the vertues of the distill'd Water, and native Juice will be very different; which is worth the Physician's notice.

10. The second Water, now, wants the volatile part of the Plant we have been treating of, and at the same time scarce carries up the more fix'd, except that it contains somewhat acidish, and vapid. If after this is drawn off, you put fresh Rain-water upon the *residuum* of the Herb, and boil it pretty strongly, there will come over a more acid Water, but which will contain hardly any thing of the proper vertue of the Plant, the very same acidity rising at last from almost every sort of 'em. This I have so evidently found to be true by Experiment, that I'll venture to say, that the anthelmintic vertue, which some very famous Physicians have observ'd in some of these distill'd Waters, was owing to the Water's having, by its acidity, corroded the Copper, and thus having acquir'd a power that did not properly belong to it. In the mean time, however, we learn from this Operation, that there is an acid Salt in Plants, which may be separated from them, and render'd volatile in 215 degrees of Heat. And we learn from Experience, that this Water has no other vertue than a cooling one, as appears by making use of a glass Head instead of a copper one, for then the Water will not be tainted.

11. This is the best method of preparing the common distill'd Waters of the Shops, if care is but taken not to mix the second Water with the first, for then it will be spoil'd. It will lose its vertue too, with keeping, scarce holding very good for a year, but degenerating in the manner that has been already mentioned.

U S E.

1. FROM this Operation then, we learn, what parts those are that are separated from Vegetables by the Heat of boiling Water, *viz.* 1. The Water of the first Process. 2. The volatile Oil of the Plant with its inherent Spirit. 3. A saline Acid.

2. We hence understand farther too, what remains at the bottom of the Still when

when these three are drawn off, *viz.* the Extract of the third Process, and all the Substances produc'd from it by the Processes, 4, 5, 6, 7, 9, 10, 11, 12.

3. We hence see, likewise, in what part the Smell and Taste of the Plant reside, *viz.* in the Water of the first Process, the volatile Oil contained in this Water, and the Spirit, whose seat is in this Oil.

4. And by this means, we easily perceive what it is that exhales from Herbs, by boiling, either when they are design'd for Food or Physic. Thus, for instance, if Costmary, Chervil, Baum, or Smallage are boiled in Broth, they lose their proper Smell and Taste, and the virtues that depend upon them, and retain nothing but what is common, and not very grateful: But if you cut them very small, and put them in when the Broth is ready and boiling hot, and then stew them a little in a close Vessel, they will communicate to the Broth their proper virtues. That fine Spice Cinnamon, yields a very grateful Water, that wonderfully warms and enlivens, which being drawn off, there follows an acid one, and there then remains only a refrigerating, acid, rough Decoction, which one wou'd take for a Decoction of Oak.

5. Hence it evidently appears, that virtues directly contrary to one another, rise from the same Vegetable, by the very same action of the Fire; for so long as an aromatic Plant gives out a Water that is milky, this attenuates and heats; whereas the clear thin one that comes off afterwards, is acid, and cooling.

6. And lastly, hence we see the proper method of distillation; for if you desist, as soon as ever this white Water has done running, you will have a good valuable Liquor; but if you then, out of greediness to have a greater quantity, still proceed, you will mix this last acid Water with the former, and by this means spoil it. In the mean time, however, let me caution you, that the distill'd Waters of Vegetables that have but little Smell, nor any of this warm aromatic virtue, may nevertheless be endued with qualities that are very efficacious, tho' Persons generally think otherwise. But upon this head, you may consult if you please what we took notice of p. 11. Nor that the native properties of Plants are somewhat altered by boiling, do I at all deny. These then are the Uses of this Process. The Rosemary that remains now after the Operation is over, is green, and retains intirely its proper figure, but is depriv'd of its natural Smell and Taste.

PROCESS XVI.

Common distill'd Rosemary-water, distill'd again with fresh Rosemary, call'd Cobobation.

A P P A R A T U S.

1. **F**ROM the last Process we learn'd, what it is that Fire and Water are able to separate from Vegetables in close Vessels, and what they leave behind: In this we shall shew you a method of opening them more efficaciously, and managing them in such a manner, that their distill'd Waters shall be much more impregnated with those virtues which we recommended in the former.

2. To

2. To this purpose we take all the Herbs and the Liquor that remain in the Still after the Water is drawn off by the former Distillation, and putting them into a Cloth, squeeze them very dry, that we may have all the Decoction without any loss. With this then we mix all the distill'd Water prepar'd by the preceding Process, and put them again into the Still, with as much more fresh Herbs as were used in the first Operation; and then, if there is occasion, add as much Water as is necessary to keep the proportion there assign'd.

3. Let this Composition be digested in very close Vessels, with a Heat of 150 degrees, for three Days and Nights, that the Plant being macerated for so long a time in its own Liquor, may be open'd, resolv'd, and dispos'd to give out its proper vertues very easily: And this is call'd *Digestion*; which if it is continued for this space of time, is of great service, but if it is protracted too long, induces a change tending towards putrefaction.

4. The Distillation must then be performed in the same manner as the former, except that a little more caution is necessary, and you must proceed more gently at the beginning; for the Liquor of the former Herbs is now thicker, and therefore produces more Air, and rises up higher when it comes to be exposed to the Fire, by which means when it comes to boil, it more easily runs over into the Worm. When about half the Water, however, that is to be drawn off is come away, you may then prudently make your Fire stronger.

5. If the Distillation is carried on, according to the cautions given before, so long as you have any of the first Water described in the last Process, and you then desist, this Water will be whiter, thicker, more scented, sapid, frothy, and turbid, than the former; and it will then be able to retain its vertues, which are stronger than the former, for a longer time. And hence the vertues proper to any particular Plant, so far as they reside in this volatile odorous part, are procured more efficaciously by this method, than the preceding: And the Decoction too that remains after this second Distillation, is much stronger than the first. And as this Operation may be repeated as often as you please, you may thus constantly procure a more generous Liquor than you had before, and a stronger *residuum* at the bottom, by which means one may at last obtain a very choice Water. In this manner I distill'd some Baum this year 1730, fourteen times, that I might learn with certainty what wou'd be the consequence, and I found that the last Water that was drawn from it, had an exceeding fragrant sweet Smell of Baum, and a very grateful Taste, so that both the Smell and Taste of it was really reviving. Nor was this at all to be wonder'd at, as all the volatile vertue of a great many baskets of Baum, was now collected within the compass of one Bottle, whilst the other inspissated part that remained at the bottom of the Still, which was of a rough, pleasant Taste, and very corroborating, wou'd only fill another. By mixing together therefore these two Liquors, one might have the particular vertues of a very large quantity of Herbs in a very small compass. This Operation, from *Coaptando*, perhaps, is by the Artists call'd *Cobobation*. By this method, now, not only the most valuable distill'd Waters, but the best medicinal Extracts are prepar'd likewise, from a proper mixture of which may be obtain'd such a *compendium* of almost the intire vertues of Plants, as is scarcely imitable in any other manner: For their native powers are not much alter'd by this Operation, less certainly than they are by others. I am sensible, indeed, that there will be

some alterations occasioned by the long boiling; but still, that the proper Nature and Vertues are very considerably retained, the Smell, Taste, and Effects sufficiently demonstrate.

6. And hence we are certain, that aromatic Vegetables, whose medicinal Vertues are particularly sought after, and reside in that part of 'em which becomes volatile in boiling Water, I say, we are certain, that these Vegetables may have their Vertues so collected together, and reduced into so small a compass, as to become much more efficacious than they are in their natural state. Nor are there here any known limits, but, by a repetition of the same Operation, their powers may be increased as long as ever the Operator pleases: Which is certainly a valuable Property of the Chemical Art. *Paracelsus* formerly asserted, that he had discover'd by Experiment, that there was a peculiar Vertue residing in Baum, called by him the *virtus specificata*, which, shou'd it insinuate itself into the Humours of the Human Body, wou'd in the decline of Life restore them to a youthful Vigour, and by this means radically extirpate the Gout: And honest *Isaac Hollandus* promised as great things of it. If what these Persons tell us therefore is true, I thought I cou'd collect this Vertue best, and render it most efficacious in the Water describ'd, and have taken of it myself in the morning fasting, with excellent success. In Hypochondriacal, and Hysterical Disorders, in *Chloroses*, and Palpitations of the Heart, when these arise rather from a Perturbation of the Spirits, than from a collection of any morbid Matter, certainly, you will scarce find any Medicine of equal service, though it's true, it's a pretty expensive one. By cohobating some crisp Mint, three or four times I procured from it a balsamic, penetrating Liquor, which, in strengthening a weak Stomach, in cold, viscid, mucous, pituitous Disorders of the Stomach, in vomitings arising from this cause, and Lienteries, proved an incomparable Medicine, giving such speedy relief, as nothing exceeded it. Nor can I enough commend the Water that I prepared in this manner, from Lemon-peels, which though taken but in a small quantity, by the fragrance of its Smell, and penetrating sweetness of its aromatic Taste, proved of excellent service in *Flatus's*, *Syncope's*, Languors, and Palpitations of the Heart. Wormwood-water likewise, prepared from the green Herb by frequent cohobation, has very happily supplied the defect of the Bile, assisted the languid chylopoietic Organs, destroy'd Worms, and discharged them out of the Body. The tops of Savine, which I here cohobated before you, yield a Water too, which at once puts all the Nerves in motion, with such an *impetus*, as is scarcely credible. And hence, for assisting the expulsion of the *Fætus*, promoting a discharge by the uterine and hæmorrhoidal Vessels, and warming the Body, it is an excellent Medicine, if it is but given at a proper time. And as to the Water procured from Rue, by the same Operation, can I sufficiently extol its Vertues? In Epileptical and Hysterical Disorders, expelling of Poisons, and promoting Sweat and Perspiration, is there any thing more efficacious? Not to mention the Water distilled in this manner from Juniper-berries, and the *Arbor Vitæ*, which do such service in Dropsies; or that from Camomile-flowers, so beneficial in Tertians; for of these things there wou'd be no end. Many of these Waters I have here left therefore for your own Examination. From what has been said then, I think it is abundantly evident, which is the true, and consequently

frequently the best method of preparing chemical distill'd Waters. There are a few Rules, however, that contain some cautions, by the knowledge of which, the Operator will be able to apply these two instances of Distillation and Cohobation, given in general, to any other Vegetables that may require some particular management: These therefore I'll now lay before you.

1. Aromatic, balsamic, oily, resinous, and gummy-resinous Plants, those that smell strong, and retain their scent a great while, such, for instance, as the *Arbor Vitæ*, the Orange, Hyssop, Juniper, Bay, Marjoram, Baum, Mint, Origany, the Pine, Penny-royal, Rosemary, and Sage; such as these, I say, being gently dried in the shade, and then digested in a close Vessel for 70 hours, in a Heat of 150 degrees, will, if they are then distilled according to Art, yield the best Water.

2. But when you want to draw a Water from Barks, Wood, Roots and Seeds, that are dense, heavy, resinous, hard, or tenacious, these must be macerated in a sufficient quantity of salt Water, for three, four, or more Weeks, in a Heat of 90 degrees, and in very close Vessels, that by this means their substance may be opened and disposed to an easier distillation. And in this case a pretty deal of Sea-Salt is added, partly to open them, but more particularly to preserve them from putrefaction, which, in so long a time, and in such a degree of Heat as the Operation requires, wou'd certainly happen, and intirely destroy their Smell, Taste, and Vertues. In this manner, for instance, must be treated Aloes-wood, Rose-wood, Box, Cedar, Juniper, and the like.

3. Vegetables that diffuse their Scent plentifully, and lose it in a short time, must be gathered in a proper time, and be distilled immediately, without being at all digested. Thus Borrage, Bugloss, Jessamy, White Lilies, Lilies of the Valley, the *Philadelphus*, Roses, Lime-flowers, and the like, will not bear heat, digestion, or long keeping. And there are some Woods of this kind likewise; for Shavings of Sassafras, if you boil them in Water, soon lose their Strength, Smell, and Taste; but *Guaiacum*, by being boil'd a great while, makes the Decoction better.

4. The astringent, nutritive, anti-alkaline, anti-septic, consolidating, demulcent, emollient, mealy, gelatinous, refrigerating and styptic Vertues of Plants can never in this manner be communicated to these Waters, but must be sought for in the whole Body of the Plant, or in some more fixed part of it. Pharmacy, therefore, may be eas'd of the unnecessary trouble of preparing distill'd Waters for any of those purposes; and the Physicians shou'd remember to look for these Vertues, in Infusions, Decoctions, *Deferutum's*, *Sapa's*, and such kind of Preparations. Wou'd it not be an idle thing to expect the very least degree of nourishment, in the inert, vapid Water distill'd from Barley? Or who wou'd not be laugh'd at, that hop'd to find the same in the nauseous Water drawn from the chopp'd Flesh of a Capon? Who wou'd seek for the Vertues of Sorrel, which are so excellent in a hot, lax, putrid, bilious habit of Body, in the Water distill'd from this Plant? Nor will you be less disappointed, if you hope to find the inimitable Vertues of Plantain there. Let all these things be banished out of the Art, therefore, as puerile and trifling. In serious affairs let us be serious.

5. But

5. But the case is vastly otherwise in those Plants where the peculiar Vertue resides in that part of 'em, which will be separated from the Plant, and become volatile in a Heat not exceeding 214 degrees; for in the Waters rightly prepared from these is contained all this Vertue, which is lost if you endeavour to obtain it in their Decoctions, or Extracts. Certainly the efficacy of Lavender-flowers, Lilies of the Valley, and Rue, so much extoll'd in that kind of Epilepsy, that arises from a disordered *impetus* of the animal Spirits, is preserved in their distill'd Waters, but lost intirely in their Decoctions, and Extracts; though, on the other hand, the anti-epileptic Vertue of Piony is found in its decoction, and not in its Water.

6. But there are some Plants, which contain medicinal Vertues in that part of them that is volatile in the degree of Heat abovementioned, whilst, at the same time, after these are separated from them by distillation, they still retain other efficacious ones in the *Residuum*, and its Decoction. In this case, therefore, the Decoction ought by no means to be thrown away, but shou'd be inspissated in a broad Vessel with a moderate Heat, that it may be fit for keeping; and then these two may be afterwards mixed upon occasion, and so you will have the united Vertues of the Plant. Wormwood, Mugwort, *Carduus Benedictus*, the lesser Centaury, Germander, Camomile, Ground-Pine, Rosemary, Sage, Water-Germander, and many others, are referr'd hither. These Herbs, now, by a previous fermentation, are dispos'd to yield better distill'd Waters, but then if their remaining Decoctions are inspissated, there is less of the Juice of the Plant in them, or it is more degenerated from its native disposition.

7. An acid, bitter, rough, sweet, or flat Taste seldom rises from Plants in Distillation, but generally remains in the Extracts. In Wormwood, Camomile, and a few others, it does ascend. The Colour of Plants too is hardly ever carried up with the Water: In Camomile-water, however, there appears a blue Colour, and in a Wormwood-water, a green one; but this resides more properly in the Oils that are in them, than in the Waters themselves. But the saponaceous qualities of Plants arising from their Salt and Oil combined together never rise in Distillation, but remain in the Extracts.

8. Vegetables, therefore, endued with the last mentioned properties, are not made use of for this Operation. See the Catalogue annex'd to the second Process, and what was said under the fifteenth. Thus Sorrel, Ladies-mantle, Berberries, Bete, Cabbage, Cherries, Succory, Endive, Strawberries, Lettice, the acid Juices of Oranges, Citrons and Lemons, Purslain, Currants, Elderberries, Viper-grass, and Ripe-grapes, give out scarce any thing valuable in their Water.

9. But in the last place we may take notice, that the very same Vegetable sometimes contains very contrary properties: Thus, the first Water drawn from Cinnamon opens, warms, moves, quickens, stimulates, and stops vomiting; the second is astringent, cooling, and nauseous; whilst the Decoction that remains in the Still, which is of a brownish-red colour, opaque, thick, without any Smell, and of a rough Taste, has an astringent, coagulating, corroborating and binding quality.

PROCESS XVII.

Common distill'd Rosemary-water, drawn from the green Plant, fermented according to the method of Ludovicus.

APPARATUS.

1. **T**HE effects of Distillation, Digestion, and Cohobation taken notice of, having sufficiently discover'd to us the action of such a Fire upon Vegetables, as is determin'd by the degree of heat of boiling Water, in Distillation and Cohobation, and of a softer assisted by Water in Digestion, I here always, for the use of the Physician, explain another elegant and useful method of treating them, by which their medicinal Vertues are very little altered from their natural disposition, and yet are rendered more penetrating and volatile. To this purpose then take green Rosemary, in such circumstances as are directed in Processes 1, 15, 16; let it be cut and pounded, if it appears necessary, and then fill an upright oaken Cask with it, till it reaches within four fingers breadth of the top. Upon this pour as much Water as is requisite to fill the Vessel to the same height with the Rosemary, and to this add about an eighth part of Honey, if it is in the Winter, and the Weather is cold; about one twelfth, if it is in the Summer: Or if, instead of Honey, you use the same quantity of common, fat, brown Sugar, the effect will be the same: Or, in the room of these, you may add half an ounce of Ale Yeast to every pint of Water, and by this means too you will be able to procure a good Liquor: The *Mulsa*, however, with the Honey I prefer to the others. Let a sufficient quantity of this Water and Honey, therefore, made warm, be poured upon the Herbs in the Cask, and let the Bung-hole at top be slightly cover'd with a wooden Bung. Let the Cask then, with its contents, be set in another wooden Vessel, and put a Pan in with it, with a live Coal thinly covered with Ashes, that to the Liquor and Herb may be communicated a Heat of near 80 degrees. When you observe this to be the case, cover the whole over with a Blanket, and, by moderating the Fire, let it be constantly kept in this degree of Heat. Hence, in a cold Winter season, more Fire is necessary, and more care requir'd, that it don't grow cold, whereas in the heat of Summer, you will want but very little, if any assistance from the Fire. These cautions being properly observed, there will, the second Day, begin to arise in the Liquor a hissing Noise, with Bubbles, and a frothy Head, and there will be diffused a fragrant Smell of the Rosemary, which will then rise to the top of the Liquor; and this Motion is called Fermentation.

2. When this Fermentation has proceeded so long, that the Herb, which before was brought to the top, begins to subside, and sink to the bottom of the Cask, it has then continued long enough for this Operation, for which reason you must then let the Vessel cool, and stop it up closer: For if the Liquor is kept any longer in so great a degree of Heat, in an open Vessel, the Spirits, and Oils, which are now rendered more volatile, will fly off, and by this means you will lose the Vertues you are seeking for; and hence, when the Herb is thus prepared, the sooner it is distilled, the better.

3. Take as much then of this Herb, and its fermented Liquor, as will fill your Still to two thirds, and distill cautiously at the beginning; for as this Liquor still contains a great deal of fermenting Spirits, hence it easily rarefies with the Heat, produces a Scum, puffs up, rises into the Still, and thus disturbs the Operation. And as these things are more apt to happen in this case than the preceding, hence, the not attending to 'em will be here of worse consequence, especially at the beginning. This caution then being observed, there will first come over a limpid, pinguious, penetrating, scented, sapid Liquor, which must be carefully kept by itself. When this is drawn off, there will succeed a milky, opaque, turbid Liquor, that will still retain some Smell and Taste of the Rosemary. After this you will have a thin, acid Liquor, without any Scent, and that will contain scarce any thing peculiar to the Rosemary; and in the Still there will remain an extract, with respect to the Herb pretty effete, but containing a great deal of the substance of the Honey. And this will be always found to be the case, if the Fermentation is carried on just till the Herb spontaneously sinks to the bottom, which generally, in the degree of Heat directed, happens the fifth or sixth day. This first Water, now, or rather Spirit, if you do but keep it in a close Vessel, may be preserved for years without alteration, nor will so much as grow mucilaginous. The Scent and Taste of its Plant, it retains excellently well, though a small matter altered. But if you either mix less Honey with your Water, apply a gentler degree of Heat, or continue the Fermentation for only two or three days, then, in the Distillation, the first Water that comes over will be white, thick, opaque, pinguious, and frothy, having intirely the Smell and Taste of the Plant, less alter'd than in the former case, but, at the same time, not so penetrating, nor so warm. After this is drawn off, you will have, as before, an acidish, limpid, inodorous Water; and the Decoction remaining in the Still will have much more of the peculiar properties of the Rosemary than the former had. And in this case, too, there almost always appears some Oil in the first Water, which there did not in the former Spirit. But again, if you ferment the Herb for only one day, or a day and a half, then in Distillation, the Water that rises first will have a great deal of Oil swimming at top of it: In other respects, it will proceed pretty nearly as the others: The longer, therefore, the Fermentation is protracted, the less discernable will the Oil be in the Distillation, and the first Water will be always so much the clearer and stronger; but then if you mix it with fair Water, it will in an instant become milky. Hence therefore these Waters will be found to be very different from one another, according as you prepare 'em by one or other of these methods.

4. If in the first more perfect Fermentation, after you have drawn off the first clear Water, and the second milky one, you boil the third, acid, limpid, thin one strongly, and too long, you will have a Water that will be almost as sour as Vinegar.

5. The Extract that remains in the Still will be always so much less impregnated with the native Vertues of the Plant, as the preceding Fermentation has been longer protracted, and is more perfect; and the contrary.

6. The Oil likewise of the Plant, which in the 15th and 16th Processes evidently swam at top, in distill'd Plants, first thoroughly fermented, becomes so attenuated as intirely to disappear, and in the first distill'd Liquor is so minutely divided

vided as to lie concealed: Hence, therefore, these are more properly Spirits, than Waters. And that this is the case, appears evidently, by pouring them into a large quantity of Water, for then by the whiteness that they immediately acquire, they discover that they contain a latent Oil, nay, sometimes, to such a degree, that the Oil thus regenerated, swims at top of the Water in form of Drops.

7. Hence, therefore, it is evident, that if this Fermentation is continued for a proper time, with a large quantity of Yeast, and then the whole is kept for some time closely stopp'd up in a wooden Cask, then the Water that is drawn from it will be exceeding clear, warm, aromatic, odorous, sapid, and penetrating, without the least of Oil in it. But then in proportion as these qualities are more exalted, the proper characters of the Plant are found to be altered, so that if the Fermentation is suffered to be quite compleat, they are so destroy'd, as scarcely to be distinguished from one another. And hence it appears farther, that the peculiar virtues of Vegetables are not so much advanced and perfected by Fermentation, as they were by the preceding repeated Cohobation; and on the other hand, that by a repetition of that Operation, the Waters were not rendered so spirituous, as they are here by one single Fermentation. And the reason of this seems to be, that by the active motion of a long protracted Fermentation, the volatile *Spiritus Rectior* is set free from the opened parts of the Plant, the attenuated Oil in particular, and so exhales; for the tenacity of the Oil is the principal *Vinculum* which holds down, and retains this Spirit in its proper Body. In the mean time, however, a gentle and moderate Fermentation, that is not great enough to dissipate the Spirits, and yet is sufficient to dissolve the impeding Viscidities, wonderfully quickens these Waters, makes them durable, preserves them from corruption, growing thick, or mucilaginous. This that excellent Chemist, and candid Writer *Daniel Ludovicus*, elegantly observed in his Pharmacy, to which we ought in the present Age to have a proper regard. The Water, certainly, drawn from *Carduus Benedictus*, prepared in this manner, is vastly extolled for promoting of Sweat and Perspiration.

8. The Smell and Taste, therefore, of Plants with which distill'd Waters are impregnated, depend particularly upon the *Spiritus Rectior* proper to the Plant. But as this Spirit is retain'd in its Body by a tenacious sulphureous *Vinculum*; hence the more of this Oil there is mixed with these Waters, the more scented and sapid will they be in proportion. This Oil, it's true, by Distillation, Digestion, and Cohobation, grows gradually thinner, less tenacious, more spirituous, and more easily miscible with Water, and by this means the *Spiritus Rectior* is more disengaged, becomes more volatile, and is ready to fly off; but then, as the Digestion and Distillation may be performed in very close Vessels, it may be retain'd, mix'd with the Waters, and render them exceeding efficacious. Fermentation, on the other hand, now, takes up a considerable time, requires a free admission of the Air, and must be carried on in an open Vessel; and hence at the same time, that by its intestine motion, it attenuates the Oils, renders them capable of being diluted in Water, and of supporting Flame, it must necessarily dissipate the native Spirit. It disposes the Oil, therefore, to mix more readily, and intimately with our Fluids, and to penetrate more easily into the minutest Vessels, but then it always deprives the Plant of its singular

distinguishing quality. In the mean time, however, this Water stimulates the Nerves in a manner not disagreeable, those particularly of the Nose, Mouth, Fauces, *Æsophagus*, Stomach, and Intestines.

P R O C E S S XVIII.

Distill'd Rosemary-water drawn from the green Herb per Descensum.

A P P A R A T U S.

1. **D**ISTILLATION was by the ancient Chemists defined to be the motion of Bodies, by the help of Fire, out of one Vessel, containing the Matter to be changed, and exposed to the Fire, into another Vessel applied to the former; and that, whether Liquids were treated in this manner, or solids; or whether Liquids were separated by this means from liquid Bodies, or solid ones. And this they said might be performed after three different manners: For either, first, the Fire carries the distill'd matter upwards out of an upright Vessel; or secondly, raises it to a small height, and then carries it off laterally, as in Distillation with a Retort; or thirdly, the Fire being placed at top, or about the sides of the Vessels, occasions the distill'd Substances going downward, which they called Distillation *per Descensum*. This in former Ages was made use of for the separation of Mercury from its fossil Glebes; and this *Paracelsus* afterwards applied particularly to the Distillation of Vegetables. This Operation will best appear by an Example. Take then a cylindrical Vessel, of what breadth you please, but pretty deep, and made of such matter as will neither imbibe the Liquor, let it perspire, or taint it. Near the top of this Vessel, on the inside, let there be a rim to support a round iron Plate full of Holes, which must fit the Vessel exactly, and when it is placed within it, be two inches from the top. Upon this, then, lay a fresh, green, succulent Plant, cut, or pounded, so that it may rise just even with the top of the Vessel, upon which lay a flat Cover exactly fitted to it, and let the cracks between be stopp'd up close with Clay, that none of the Vapour may be able to make its way through: Upon which head you may consult *Andreus Libavius*. If you have occasion to use this instrument often for distilling such Waters, it is best made of plates of Iron; otherwise, just for one Demonstration, an earthen one is sufficient.

2. Every thing then being thus disposed, upon the Cover spread a thin *Stratum* of Ashes, and upon this lay some Fire, that by the Heat of it, the moist parts of the Plant, may be dissolved into a Vapour, and its Juices being fus'd, may descend into the Vessel underneath, where they will be condensed by the Cold, and distill in drops. And thus, if you prudently increase your Fire, the humid parts of the Plant will be carried downward, and there collected, *viz.* the Spirit, Water, Wax, Gum, Oil, Resin, and a saline saponaceous Matter, which cou'd not be so easily separated by the preceding methods of Distillation.

3. In this Operation, however, you must be very careful you don't make your Fire so great to burn the Plant; for if you apply a strong one at first, you confound all together, and the oily parts are burnt, by which means the

Liquor

Liquor drawn off acquires an empyreumatical, sooty, bitter Taste and Smell, which makes it very nauseous, and not fit for medicinal purposes; which happens particularly in Vegetables that are dry, and oily: And yet it must be confess'd, that a small Heat has but little effect.

4. But when Plants are very succulent, as the *Petala* of Roses, for instance, and you manage them carefully without burning them, then the Waters prepared in this manner come nearest to the native Juices, as they even contain their saponaceous quality, and possess their proper virtues, tho' they are always indeed a little changed by the Fire, for which reason, as their express'd Juices are always more grateful, so for medicinal purposes they are best likewise. *Paracelsus* treating *Guaiacum* in this manner, converted it into an acid Liquor, and acrid fetid Oils, which nevertheless he commended both for external, and internal uses; and hence this Operation was in repute for some time among the *Germans*, tho' now it is almost out of use, as there are others that are neater. Let it suffice, therefore, that you have thus understood the nature of it, and just seen an instance of it.

P R O C E S S XIX.

Salt Ashes procured by burning the Residuum of the 15th, 16th, 17th, and 18th Processes, as in the 5th, 6th, 9th, 10th, 11th.

A P P A R A T U S.

1. **I**F the *Residuum* of the fifteenth Process, as well the Herb as the Liquor that remains after Distillation, is put into an earthen Vessel, and evaporated to a dryness, and is then taken out, and in an iron Frying-pan burnt upon an open Fire to white Ashes, as in the sixth Process, then from these Ashes may be procured a large quantity of Salt, such as might have been obtain'd by burning the crude Plant before the Distillation; both the Ashes and the Salt produced from it being perfectly the same, as you will find upon examining them in this Plate, which I shall here leave for you. And if you take the Decoction remaining in the Still without the Herb, and add to it all the Juice you can press out of the Herb, when it has been thus distill'd, then if you prepare a Salt from this Liquor, as in the fifth Process, you will have the same Ashes as in that Process, together with the same Salt, and nearly the same quantity. This Distillation, therefore, does not lessen the quantity of Salt.

2. If you treat the *Residuum* of the sixteenth Process in the same manner, taking either only the Liquor, or both the Liquor and the Herb, the Ashes you procure by this means will be twice as Salt as the preceding, and you will have the same kind of Salt, but in quantity twice as much. And if you repeat this Distillation sixteen times, as I mention'd in the Cohobation of Baum, the last Liquor that remains in the Still, if it is dried and burnt, will yield sixteen times more Salt than you wou'd have procur'd by one single Distillation. Hence, therefore, it appears, that by Cohobation the *Residuum* increases in its saline, and saponaceous virtue, as the cohobated Water does in its volatile part, abounding in Spirits and Oil. And hence is discovered a method of exalting the proper virtues of Vegetables, as much as the Operator pleases, so that here

it is true, if any where, that Art goes beyond, and excels even Nature it self. And from the whole too we learn farther, that Cohobation, tho' so often repeated, does not diminish the saline Matter that resides in the more fix'd part of Vegetables, provided we do but take a proper care that the Herb suffers no degree of Putrefaction.

3. But again, if you take Herbs that are fermented without Honey, or Sugar, and distill them according to the seventeenth Process, and in the same manner burn the *Residuum* to Ashes, as you see I have here done, you will by this means too, have the same quantity of the same Salt: So that here it appears too, that this kind of Fermentation does not render volatile that Matter of Vegetables, which when it is burnt, yields the fix'd Salt. This certainly now wou'd have appear'd very surprizing, had it not been already known, that Tartar of the most perfectly fermented subtil Wine, when it is burnt, yields a fix'd Salt in a very great quantity. But now, if when you have fermented Rosemary with Honey, you distill it, inspissate the *Residuum*, and reduce it to Ashes, you will then have such only as I have here set before you, which are scarcely acrid, nor will easily yield any such Salt: For as for the Coal that will be produc'd from the Honey, that will not be readily converted by the Fire into a saline Matter, but will remain spongy as it were, and not acrid.

4. And lastly, if you burn the *Residuum* of the eighteenth Process, you will be able to procure so much less Salt from it, as there is more of the saline saponaceous Matter gone down with the Water: If you have drawn off, therefore, but a very little Water, you will then have pretty nearly the same quantity of Salt remaining in the *Residuum*, as in a common Distillation.

5. All these things then being carefully attended to, and rightly understood, we shall be able to come at the knowledge of the true effects of the Distillations we have been explaining: For by means of these there rises from Vegetables, 1. The simple elementary Water of the Plant. 2. A Spirit in this Water described in the first Process. 3. The volatile Oil of the Plant, call'd by the ancient Chemists, their Sulphur; which being mixed with this Water, renders it white; which when it exists separately, will not mix with it, and when it is thus mixed with it, gradually disengages itself again; and which principally contains and holds down the former volatile Spirit, from which chiefly it receives its Smell and Taste, and often very singular and extraordinary vertues. This is what I chuse to call the (*Oleum primi generis*) first kind of vegetable Oil; as it is first and easily separable from them, being intermixed with their Juices, not tenaciously united with them, nor adhering firmly to, or being much entangled among their more solid parts, nay in many of them being disposed in proper distinct repositories. And when these three parts are separated from a Plant, there scarcely remains any of its native Smell or Taste in the *Residuum*. 4. But by this Operation there ascends likewise, a thin volatile acid Liquor, which being of a subtil saline nature, is not fix'd even in burning Vegetables with an open Fire, but flies off, and therefore may not improperly be called the native Vinegar of the Plant: This in the Distillation of Cloves and Cinnamon, rises with the last Water; and this is found to be produc'd from every Vegetable, the hottest not excepted, when the three former parts are perfectly drawn off. But in the part of the Plant, now, that does not become volatile by Distillation, but remains in the Still, we discover, 1. A more fix'd Oil, combin'd

combined more tenaciously with the *residuum*, nor to be raised by distillation; which is closely united with the proper Salt of the Plant into a *Sapo*; which by Decoction in Water may be separated from Vegetables, with its adhering Salt (Proc. 3, 5.); and of which a considerable part, when Plants are burnt in an open Fire, is thoroughly blended with this Salt, and intimately fixed with it into an Alkali. 2. An Oil, which for composing the solid parts of Vegetables is combined with the elementary Earth, by so intimate a union, that it cannot by any boiling whatever be separated from it. Proc. 4. 3. The greatest part of the native and proper Salt of the Plant. 4. That matter of the Plant which, by the action of a strong Fire, is fixed, and converted into a fixed alkaline Salt. 5. And lastly, the greatest part of the terrestrial Elements, as well those which were mixed with the Fluids, as those which entered into the composition of the Solids: The greatest Part, I say, because there is a considerable quantity of Earth to be procured even from the volatile Oils.

P R O C E S S XX.

A native Oil of Vegetables procured from them by Expression; here from Almonds.

A P P A R A T U S.

1. **I**N Plants there is a certain part, either spontaneously liquid, or readily melting with a gentle Heat, which is called their Oil. This may, however, by standing quiet a great length of time become thick, as we see evidently in the moist liquid Oil of Turpentine, which will grow gradually thicker and thicker. By Cold likewise it may harden and be reduced into spherical Bodies, resembling the Spawn of Fish. Nay, and farther, it may be converted into a solid Body, of which we have an instance in Wax. By whatever means, however, it has acquired a consistence greater than its natural one, upon the application of Heat to it, it will be again resolved. This Oil, now, when it is in a fluid state, is always pinguious; for it is very soft, and being handled, feels smooth, and lubricates other Bodies, and yet at the same time coheres with a certain tenacity, that is not found in Waters and Spirits. But this Oil too is always inflammable, properly disposed to feed and support both Fire and Flame, and even to be converted into Flame, itself; which is by no means the case of Air, Water, and Earth. And lastly, this Oil absolutely refuses to be intimately united with Water, but being mixed with it, repels it, and collects itself together, by which means they become separated again into two distinct Liquids. A vegetable Oil, therefore, is a pinguious, inflammable Liquor, that is not miscible with Water.

2. This Oil, now, is found in Plants to be of different Sorts. Thus the volatile Oil, which is drawn from oily Vegetables, in the distillation of their Waters, contains in it the *Spiritus Rectior*, which gives to every Plant its peculiar Smell and Taste. Hence you find in this Oil the singular properties of the Plant, so far as they discover themselves to the Senses, which being thoroughly separated, the *residuum* has nothing of its distinguishing Character. Thus, for instance, if a Person in this manner accurately extracts all this Oil from
Cinnamon,

Cinnamon, Mace, Cloves, or Nutmegs, he will see indeed the perfect form of the Spice in the remainder, by which he will be able to know it, but as for its peculiar qualities, he will find nothing of them, neither their Smell nor Taste distinguishing them from one another. The substance even of this Oil, however, does not properly possess this Smell or Taste, but receives it only from the abovementioned Spirit, which, whilst it resides in them, makes them different from one another; for when this is gone off, they can scarcely be any longer distinguish'd, but appear to be nearly of one and the same Nature.

3. But in particular parts of some Vegetables there is an Oil found quite pure, collected in little distinct repositories, or follicles, which may be properly call'd, adipose ones; but this case excepted, they are mixed with the other Juices of 'em, and by this means are divided, and scarcely appear as Oil, but the oily Particles lie concealed in the form of a saponaceous substance: These, however, as soon as ever they are separated from the other Bodies they are united with, and are collected together, discover themselves to be a true Oil. Of each of these we have abundance of Instances: Thus if the saponaceous Juice extracted from Vegetables, by the assistance of Water, is inspissated, and dried, by its burning it will demonstrate the admixture of a pinguious Oil. See Proc. 3, 5. And if you make an Incision in the Fir, Pine, or Larch-tree, you will have a pure Oil distill from the Wound. So if you take the Root of Masterwort, just dug out of the Ground in Winter, and clean it well, and cut it transversely with a sharp Knife, you may with a Microscope observe little drops of a golden Oil oozing out of its proper ducts, disposed in a very particular manner. Or if you split a Nutmeg with a warm, sharp Knife, and then examine the surface with a Microscope, you will evidently observe particles of a rich Oil. An Almond too cut and viewed in the same manner, discovers an exuding Oil, especially if it is first made warm, and then gently press'd after it is divided. But this Oil never appears more evidently, and in greater abundance, than in the seminal Cotyledons of Plants, where it serves to defend the tender embryo from any moisture that might injure it, and secure it from too great a degree of cold, which by freezing it might prove fatal to the curious *stamina*. This Oil, likewise, being by the æstival Heat, propell'd towards the Bark, and there depriv'd, in a good measure, of its watery part, is collected in great quantity, in the Winter season, in particular, especially in the Evergreens.

4. The Oils of Vegetables, therefore, abound chiefly in those parts of 'em that are to last longest, for the defence of others that are of the most consequence; and for this reason they are found in those parts particularly that are situated at the greatest distance from the absorbent Vessels of the Root, and consequently are farthest from the nutritious Juice drawn out of the Earth. Thus in Linseed, when it is ripe, you'll find more Oil than perhaps in the whole body of the Plant besides.

5. But sometimes this Oil is collected in so great quantity as to burst its repositories, run out, and appear in the true form of Oil; and this, in particular, is observed in the Bark, and the Fruit. This we see in the conical Fruit of the Fir, Cedar, Larch-Tree and Pine, and the Berries of the Juniper; but principally, as I hinted before, in the Evergreens, where the outer parts of the Bark

is

are often smear'd over with this Oil. In the northern Trees, that are exposed to severe Cold, especially if they stand on high mountainous places, or pretty high dry ones, this is remarkably evident. And hence one wou'd be apt to suspect, that this Oil is very necessary for their preservation against the freezing cold of the Winter.

6. But we observe farther, that these pinguious Oils are generated and collected in Vegetables particularly that are adult, and are just passing into a state of rest, or are growing old. For both the smaller Plants, and Trees themselves, when they first come up, discover very little Oil, but are full of a watery thin Juice; and yet when the same are come to maturity, they contain an Oil in great quantity. Examine, for instance, the Flax, and you see the whole Plant, like Grass, seems to be supported intirely by Water, and yet, when it grows mature, and changes its green colour for a yellow one, it is abundantly stock'd with Oil, particularly in the Seeds: And in a young and old Pine, the same thing is very evident. But it is farther observable, that your Trees and perennial Plants, as the Autumn comes on, gradually contract themselves, have the circulation of their Juices vastly diminished, scarcely perspire, draw hardly any thing out of the Earth, or disperse any thing into the Air; but on the contrary, as the Spring advances, have all their Juices put in motion, imbibe a great quantity of Moisture out of the Earth, and exhale it into the Atmosphere. If one might be allowed therefore to call their Autumnal and Winter stations their sleeping state, and their Vernal and Æstival, their waking one, then it will be almost universally true, that Plants abound with Oil in their sleeping state, with Water in their waking one. Examine the Root of Masterwort in the Winter, when it is deprived of all its Leaves, and lies inactive in the Ground, and is it not then properly asleep? And at that time dig it up, cut it, and view it, and it will appear full of a rich Oil; whereas, if you take it up in the Month of *May*, you will find it watery, saline, and by no means so oily: And the same thing is true in Trees, likewise. But lastly, as Vegetables grow old, they are often overcharg'd and destroyed by the abundance of their Oil, as we see in the Fir, Pine, and the like, which at last are suffocated by their own pinguious Juices, appearing in some in the form of a Gum, in that of a Resin, Oil, or Balsam in others. Hence the Gardiners have the mortification of seeing their Trees die so often from their Bark's being quite choaked up, just in the same manner as we sometimes see Animals, overwhelm'd, and suffocated with their own Fat.

7. When the Chemist, therefore, has a mind to extract the Oils from Vegetables, let him first learn from the Botanist, that there are seasons in which their Water and Salt are in greatest abundance, and then they contain a less quantity of Oil; and that, on the contrary, there are others, when their Oil chiefly abounds, and there is less of their Water and Salt. Thus, for instance, whilst Nature is forming new Leaves, Flowers, and Fruit in Vegetables, there is then carried on a circulation of watery Juices pregnant with Salt, and then the flow, tenacious Oils are deficient; whereas, on the other hand, when the Flowers are faded, the Leaves wither and fall, and the Fruit being perfected, and come to maturity, is ready of itself to drop off, likewise; then the more Juices being dissipated by the Heat of the Summer, the Oils are collected in greater abundance, discover themselves, and become predominant. And for

this Reason the Carpenters chuse that Wood for building which is fell'd in the middle of Winter, as being most durable, resisting Water most efficaciously, nor being so liable to rot: For the hardest and heaviest Woods, which scarcely feel the effects of time, are found to be replete with Oil, and that a very heavy one too. Thus if we examine Cedar or *Guaiacum*, what a quantity of Oil do we find in 'em, that is very ponderous, and compact? If the Chemist, therefore, wou'd most advantageously procure an Oil, or a Salt from any Plant, he must take it, for these different purposes, at various seasons of the Year.

8. The Oil which is most natural to 'em, the greatest number of Plants contain principally in their Seeds, when they are perfectly ripe, and ready to drop, and hence, from their maturity, are grown in some measure dry, being chiefly kept moist by their own Oil. These, therefore, being cautiously a little more dried, are pounded with their Skins into a kind of Meal; but if they happen to be so very oily that they cannot, on this account, be reduced to a Powder, then they are pounded only in a stone Mortar, by which means their Oil runs from them, as we see in Almonds, Pine-nuts, and Pistach-nuts. The Meal being thus prepar'd, it is expos'd for a little time to the Vapour of hot Water, and then gently dried again, by which means it is more and more open'd, and gives out its Oil more freely. The Meal, then, or the Paste, where the Seeds are very oily, is put into a hempen Bag, which being tied fast is placed betwixt two iron Plates, heated in boiling Water, and with a Press squeez'd very hard, by which means the Oil which is fus'd by this degree of Heat, which does it no harm, oozes through the Holes of the Bag, and drops into the Vessel placed underneath, never discovering any *Empyreuma*, but being nearly natural as it existed in the Plant. And by this contrivance an Oil may be drawn from the Seeds of the leanest Plants, as Hemp, Lettice, and Flax, in which no person living cou'd have believed such a pinguious Fluid cou'd have lain concealed. From the *Indian* Cloves, Mace, and Nutmegs too an Oil of this kind may be express'd in great quantity. In this Oil, however, the very warm, aromatic quality of these Spices is not predominant; for that press'd from Mace and Nutmegs is rather a pretty mild, thick Balsam, than such a caustic aromatic Oil as is produced from them by Distillation. I was formerly, I confess, very much surpriz'd, to see the express'd Oil of Mustard-seed prescribed with success in the severest fits of the Stone; but my wonder was at an end, when upon examination I found this Oil to be sweet and soft, though in distillation it appears so acrid, nay, perfectly igneous. For the reason of this, however, after much consideration, I am still at a loss. For why shou'd not the pungent Taste and Smell, so predominant in the distill'd Oil, appear in the express'd one likewise? Or why shou'dn't the Acrimony of the *Spiritus Rectior*, whose seat is in the Oil, be here remarkable? Certainly, whether you consider the Water, Salt, nay, Spirit itself, or its Oil, you won't perhaps satisfy yourselves so thoroughly as you may at first imagine.

9. This Oil contains but a very small quantity of Salt; and yet it has a good deal of the nature of the Plant, as is evident to the Senses. So long, therefore, as it is fresh, by mixing with our humours, it sheaths, blunts, and corrects their Acrimony, and being rubb'd upon the external parts, it removes any hardness and brittleness, and renders the Fibres, Membranes, Vessels, and *Viscera* lax, soft, and pliable. Dead, dry Eschars, it moistens and softens, and makes them separable from

from the Quick with greater ease by the vital Actions. In wounds, it secures the parts that lie bare from being dried too much by an Air that is dry. It prevents too the fine Fluids exhaling from the open mouths of the wounded Vessels, which wou'd otherwise destroy their extremities. In fresh incis'd wounds, therefore, it is of excellent service, as they will, by the help of it, be consolidated in a short time. And further, by mitigating any sharp Humours, and relaxing any parts that are too tense, it proves a wonderful Anodyne.

10. But how very remarkable is this property of these Oils, that in a Heat only of 70 degrees, they will so soon, without the admixture of any thing else, degenerate from their natural disposition? For by this means they lose their Consistence, Mildness, Sweetness, almost insipid Taste, Whiteness, and Anodyne and relaxing Quality, and become thin, acrid, bitter, rancid, yellow, corrosive, and inflammatory. And all these changes happen in a pretty short time, viz. a few Days, if they are exposed only to an æstival Heat. But how great is this Alteration? Oil of sweet Almonds taken in form of a *Linctus*, proves an excellent emollient, where the *Fauces* are grown rough with an *Angina*; and yet if the same should be taken by a Person in Health, after standing in such a Heat but a few Days, it wou'd corrode and inflame them. And the sweeter these Oils are when they are fresh, the more acrid they grow when they are old and rancid. Hence how abominable are Almonds, Walnuts, and Pistach-nuts, when once they come to be rancid, and how easily will they cause an *Angina*, and raise a Fever, by inflaming the Throat, *Oesophagus*, Stomach, and Intestines? For this reason, therefore, when Physicians prescribe Oil of Almonds in acute Diseases, they should take care that it is not press'd from bad Almonds, and that in hot weather it should not be above one Day old. The same thing is true likewise of the Butter, the crude Fat of Animals, their Lard and Marrow, which are their Oil in greatest perfection. How sweet are these when they are fresh? How abominable when they are exposed to the Heat of the Summer, without any Salt? Don't they by this means grow yellow, bluish, and greenish, and become vastly acrid, and in a short time acquire a fatal poisonous quality? And in fat Cheese, when it is very old, is there not a most corrosive Acrimony? Certainly there is, I have seen a Person's Lips, Gums, Tongue, Palate, and *Fauces* violently inflamed by it. What effect, therefore, it must have in the internal *Viscera* it is easy to imagine. Reflect only, Gentlemen, how soon this Oil, when it is boil'd over the Fire, grows yellow, red, black, bitter and acrid, and by this means becomes unwholesome, and then you will easily conceive how this, when it has been in the Stomach six hours, may grow exceeding bitter, and then rising into the Throat and Mouth, may be falsely taken for Bile; whereas if this Matter is spit out into the Fire, it will flame and burn. These Observations then, concerning the nature of this Oil, will help to give light into a great many things in Natural History, Physic, Pharmacy, and Cookery.

P R O C E S S XXI.

If Native Oils, together with the Bodies they reside in, are rubbed with Water, they yield a Chyle, Milk, or Emulsion: An instance here in Almonds.

A P P A R A T U S.

1. **I**F the oily Substances describ'd in the preceding Process are so far prepar'd as to be fit for the Expression of their Oil, then if instead of pressing them, you rub them in a stone Mortar, with a wooden Pestil, adding now and then a little Water that they may be thoroughly work'd into a Paste, they will be chang'd into a white Mass, which the longer it is rubb'd, the more homogeneous it will be, and the fitter for this Process; for the more minutely the matter is divided, and the more intimately it is mix'd, the more readily will the remaining part of the Work be effected.

2. Upon this Mass, pour so much clean hot Water as will just serve to cover it, and then upon rubbing it as before, there will be generated a milky, pinguious Liquor that will swim at top. After the Vessel has stood quiet for a little while, gently pour off this Liquor into a coarse thin Cloth, that by this means it may be strain'd into a clean Vessel.

3. Upon the thick *Residuum* remaining at the bottom of the Vessel, and in the Cloth, pour more Water, and rub as before; and you will again have a white, thick, oily Liquor, which strain, and mix with the former. Add then more Water to the remainder, rub, and strain as before, and so proceed patiently to the end. The Liquor, by this means then, will grow gradually less white, thinner, and not oily, but at last perfectly watery, nor will acquire any further Oiliness by being rubbed ever so long; and then there will remain in the Mortar but a small quantity of the former Matter, and that will be branny, lean, without any Juice, not dissoluble at all in Water, even by long rubbing, but appearing almost intirely terrestrial, without the least quantity of Salt, or indication of any remaining Oil. Thus, then, those parts of Vegetables that abound in Oil, are divided into two different kinds of Bodies, one of which will bear to be diluted with Water, the other not. And here it is particularly to be remarked, that this very Operation may be perform'd with the *Residuum* of the former Process after the Oil has been express'd, with this limitation only, that you will procure so much less of this white, thick, pinguious Liquor, as you expressed more Oil before. When you have got out, however, all the Oil you can by Expression, you may always prepare an Emulsion from the remainder, and that in considerable quantity.

4. The Emulsion thus prepared, in a great many of its properties, resembles the Chyle of Animals, produced from Vegetables by Manducation, Rumination, and the action of the Stomach, before it is mixed with the Bile in the *Duodenum*. The white Colour, soft Smell, sweet Taste, thickness, oiliness, and easy disposition to turn sour in both of them, prove this sufficiently. If this Liquor, too, is suffered to stand quiet for some time in a tall cylindrical Vessel, it will spontaneously separate into a very white, thick, and almost quite oily Liquor, swimming at top, and a thinner, clearer, bluish one underneath.

And.

And in this particular it perfectly resembles Milk, which in the same manner divides into a Cream, and a Skim-milk. And again, if this Emulsion is exposed for some time to a warm Air, it grows sour, and acquires a considerable Acrimony, but not an oily rancidness, which we described as proper to the express'd Oil of the former Process; and in this property again it agrees intirely with Milk, which grows sour in the same Air, but then recedes from the nature of pure simple Oil degenerating in the same Heat. This *Phænomenon*, therefore, which is well worth taking notice of, may serve as a Hint to the Physician, that it is safer in acute Diseases, to prescribe this Emulsion than express'd Oils. I cou'd never, however, by Coagulation, procure Cheese from this Liquor, as one may from common Milk: And hence there is this difference betwixt the natural Milk of Animals, and this artificial one of Vegetables. The reason now that the Emulsion of this Process differs from the Oil of the preceding, seems to be this, that the particles of the Bran are by continual rubbing very minutely divided, and dispersed through the pure Oil, by which means they so attenuate its particles, and separate them from one another, that they lose their oily tenacity, and suffer themselves to be mix'd with Water, and then appear in form of a Milk, consisting of Oil diluted in Water; whereas, when the pure Oil is express'd by itself, the Particles cohere in such a manner with one another, that they won't admit any Water between them, and consequently will not be mix'd with it. And then again, the large quantity of Bran that is distributed amongst the Oil, in making the Emulsion, is the occasion that it won't afterwards grow rancid, but will turn sour. Hence, therefore, we see, why this Liquor appears white; for this is always the case when Oils are so minutely divided, as to lie concealed in Water. This you may see evidently by taking some Water in a glass Vessel, and pouring some Oil upon it; for then, tho' both Liquors will be distinctly clear, yet if you shake them briskly together, they will be mixed for some time, and so long the whole will appear white; tho' upon standing quiet again, the Oil will disengage itself, and rise to the top, and the whiteness will immediately vanish. And this is the case in common Milk, oily distill'd Waters, and these Emulsions. Nay, and it is farther certain, that the more Oil there is, the whiter the Mixture will appear, and the more it will be inclined to grow rancid; and that on the contrary, the less Oil there is, the less white it will be, and it will be more disposed to turn sour. In the Summer time, now, these Emulsions will scarce keep above ten Hours; but in the Winter they'll be good longer. This method of making Emulsions, then, teaches us what is properly the effect of Manducation in the human Body. For any Corn food that is full of a latent Oil, being moisten'd with the *Saliva*, and work'd upon the rough, broad surface of the *Dentes Molares*, or Grinders, yields a Liquor that comes near to these Emulsions, and the more so, the longer it is chewed, and which at last is always white, when the *Saliva*, Salt, and Oil, come to be thoroughly mixed together. And then this work, which is thus begun in the Mouth, is farther promoted in the Stomach, and carried to greater perfection in the Intestines, the Liquor still retaining its original disposition, except that by the constant affusion of the Animal Juices to it, it is more and more assimilated to the animal Nature, whereas in artificial Emulsions, we have nothing but the assistance of Water. Hence then we see the proper distinction betwixt the first Chyle, and the Milk of Animals.

P R O C E S S

P R O C E S S XXII.

Native Oils of Vegetables procured from them, by simply boiling them in Water.

A P P A R A T U S.

1. **W**HEN Plants, or those parts of them that are most oily, are by Expression, according to Process 20, deprived of all the Oil that you can in that manner separate from them, let them be sew'd up in a linnen Bag, and be kept for some time in boiling Water, and then part of the remaining Oil will be dissolv'd and swim at top. Let this be taken carefully off with a thin Spoon, and be put by itself, and repeat this so long as any pinguious Scum arises. By this means then, you will have all the Oil that remained after the Expression, as you had in the preceding Process, in the Emulsion. The Water too in this case, by its milky Colour, oiliness, and thickness, demonstrates that it contains a good deal of Oil.

2. But if you take the Substances, prepar'd for the Expression of their Oil, according to Process 20, before their Oil is express'd, and boil them in Water in the manner just described, and continually take off their Oil, you will by this means be able to collect a very large quantity of it. A pound of the best Cacao-nuts being pounded and boiled with eight pints of Water to the thickness of a pulse, and the Fat being taken off, and collected together, yielded seven ounces of such an Oil, which when it came to be cold, was almost of the consistence of Tallow, as we learn from an Experiment of *Monsieur Homberg's*, mention'd by *Du Hamel, Hist. de l'Ac. Roy. des Sc. p. 371. An. 1701.* And even then, if you take what remains after the boiling, and dry it, pound it, and press it, it generally affords some more Oil. Hence then we see, what a surprizing quantity of Oil is actually contained in Seeds.

3. In the mean time, however, there are some Seeds that are leaner, and by Expression, or Coction, with Water, yield scarcely any Oil; such, for instance, as Beans, Lentils, Pease, and the like. But even these, if, they are gently roasted when they are dry, will both ways give out something of an Oil; and the Oil that is then procured from them by boiling, will retain a good deal of the nature of the Seeds, without any considerable alteration.

U S E.

1. **T**HESE three Operations then being rightly performed, carefully compared together, and duly considered, teach us in the first place of what kind that Oil is, which naturally exists in Vegetables. And hence we see likewise the origin of that Fat which is found in Animals that live upon Vegetables; for in these there is always an Oil, which by Manducation, Rumination, and the action of the chylopoietic Organs is extracted from them.

2. From what has been observed, we sufficiently discover the nature of that Oil, and its use in Plants.

3. And

3. And we learn, likewise, in what manner from Oil and Water mix'd and combin'd together by a certain Law, may be prepared a Liquor very much resembling Chyle and Milk; and thus we see the method which Nature makes use of to produce Chyle and Milk in the human Body.

4. We shall now, therefore, be prepared for the Examination of the Oils called Essential Oils, which we shall treat of in the following Process.

5. Physicians who are acquainted with these things, won't be surprized to see Persons grow so fat, that are well, and use no exercise, even tho' they live chiefly upon Vegetables that discover in them nothing pinguious, since by Expression and Emulsion it is easy to procure from them a great deal of Oil. When these therefore are sufficiently chewed and mixed with the animal Juices, they yield an oily Emulsion, whence is prepared a Chyle, and a Milk, which deposits an Oil into the *Folliculi adiposi* that are joined to the Arteries.

6. And hence at the same time we see the origin of the Chyle and Milk of Animals.

7. As likewise the nature of those Elements which make up the Composition of the Chyle and Milk, viz. some of the animal Juices, as the *Saliva*, and the fine exhaling arterial Vapour and *Mucus* of the Mouth, *Fauces*, *Oesophagus*, Stomach and Intestines on the one part; and the aqueous, saponaceous, oily, and spirituous Particles, that, by the action of Manducation, Deglutition, Digestion of the Stomach, and peristaltic motion of the Guts, can be reduced into the form of an Emulsion, and separated from the grosser parts of our Food, on the other.

8. Who, therefore, from these Principles, don't see the true physical reason, why the Milk of Animals, generated from vegetable Food, and that of an acedent nature too, shou'd, when it is out of the Body, be so disposed to turn sour. Fresh green Grass, certainly, if it is chew'd for a good while with the *Saliva*, begins, in the Mouth, to put on the appearance of Milk, and discover the separation of its Oil. Hence the human *Species* will grow fat with only Bread and Water; Brutes with Water and Grass.

9. Having rightly understood these things, therefore, don't let us give any credit to those Persons, who pretend, by their Art, to procure more Oil from any Vegetable, than what naturally exists in it; for we do not artificially generate Oils, but only extract those that pre-existed before.

10. And lastly, let me caution you not to look upon these Oils procured by Expression, Emulsion, and Coction, as pure, simple Liquors; for when they come to be examined by Distillation, in the manner to be hereafter described, they are resolv'd into a large quantity of Water, Soot, a true essential Oil, and Earth; as that very accurate Chemist, Dr. *Stare*, long ago observed, *Phil. Trans. Abr.* Vol. III. p. 361. And hence it seems to come to pass, that the Oils prepared in all these three ways, will so easily change if they are exposed to the Air, as they consist of so many, and such different principles. In Oil too procured by Coction, there is contained some Salt; but more in the Water it is boil'd in.

PROCESS

P R O C E S S XXIII.

Distill'd vegetable Oils per Vesicam, commonly call'd essential Oils: An instance in the Leaves, or green Tops of Savine.

A P P A R A T U S.

1. **A**LL Vegetables whatever, are more or less fit for this Operation. Those, however, are particularly so, in which there is a remarkable aromatic Vertue, which we described under the Process 1, 15, 16, 17. But of these again, those are the most eligible for this purpose, that distinguish themselves by a fragrant Smell, and a pungent, warm, grateful Taste. In this first Process, now, upon these Oils, we shall treat particularly of the Leaves that are fittest for Distillation. And these are procured either from the Ever-greens, or those Vegetables that naturally cast their Leaves.

2. The Leaves of the Ever-greens, as the Fir, *Arbor Vitæ*, Orange, Box, Cedar, Citron, Ivy, Juniper, Bay, Lemon, *Marum Syriacum*, Myrtle, Pine, Wild-Thyme, Rosemary, Savine, Sage, and Thyme, are always full of Oil, but principally in the Autumn, and towards the Winter. The directions about these, therefore, and the method of treating them, is nearly the same.

3. But the annual aromatic Leaves, which naturally wither and drop, but when they are green, have a rich spicy Smell, must be gather'd when they are come to full maturity, and are just beginning to have their vigour abated; for then the watery Humour, and acidish Salt being dissipated, there is left a more tenaceous, oily, balsamic Liquid behind. The chief of these Plants, now, you have in the Catalogue annex'd to the first Process.

4. And by Experiment it has appeared, that these Leaves gathered at the time mentioned, have yielded more Oil in Distillation, when they have been gently dried in the shade, with a moderate Wind, than when they were immediately distilled, whilst their watery Juice still remain'd in them. Does this happen, now, because the Oils, when the Water is dissipated, are more closely united, and so come out in their proper form, whereas when they are divided by the interposition of the aqueous Particles, they impregnate the Water indeed with their virtues, but don't appear as Oils? You must take a great deal of care, however, that they are not dried in too great a Heat, lest the oily parts shou'd fly off likewise. There are some Leaves, in the mean time, which contain so large a quantity of a balsamic Oil, that they will yield a great deal of Oil in distillation, tho' they are made use of green; as we see evidently in Rosemary, and Mint. And there are others again, which are very difficult to dry without their losing that noble Spirit, which gives the Oil its whole excellence; of which sort are Agrimony, Calamint, and others: There are always some Exceptions, therefore, to these general Rules.

5. With the green Leaves, then, that naturally diffuse a fragrant Smell without being bruised, let your Still be filled two thirds full, and pour upon them the distill'd Water of the same Plant, and then you may begin your Operation as soon as you please. Thus Southernwood, Agrimony, Dill, Calamint, Scurvey-grass, Dittany, Fennel, Lovage, Marjoram, *Marum Syriacum*, Mint, Baum,

Origany, Savine, Sage, Savory, Wild-Thyme, Tanfy, Thyme, and the *Arbor Vitæ*, yield their Oils very readily. Others, however, require a long digestion and maceration with Sea-Salt, or rather Spirit of Vitriol, in a very close Vessel, by which means they will be disposed to give out their Oil in greater abundance. Thus if you want to draw a large quantity of the finest Oil from the Leaves of Fir, the Orange, Box, Cedar, Sweet-cane, Camomile, the Citron, Hyssop, Juniper, Bay, the Lemon, Myrtle, or Pine, take any of these, and after you have gently dried them, put them into the Still in the manner above described, pour their distill'd Waters upon them to the same height, adding to every pint, half an ounce of Sea-Salt, or a drachm of Oil of Vitriol, and then leave them very close stopt for the space of three Weeks in a Heat of 90 degrees, before you begin your Distillation. And here, the more tenaciously any Leaves retain their Oil, the more Acid is necessary, and the longer Maceration; for that Acids disengage these Oils, nay, and perhaps, in some measure increase them, *Boyle, Hoffman, Homberg, Le Mort*, and others, have long ago observ'd.

6. Proceed then to distill in the manner which I sufficiently describ'd, Process 15; but with this circumstance, that you must make the contents boil as fast as you can, and so carry on the Distillation briskly; for by this means, the Oil you are seeking for will presently ascend with the first Water, whereas if the Distillation proceeds slowly, the Oil being dissolved and separated by the great Heat, but at the same time not being carried up, will be agitated among the Leaves and Water, and by this means be divided and attenuated, and hence will wonderfully impregnate the Water, but of consequence will rise in less quantity. And the Distillation, with this degree of Fire, must be continued so long as the distill'd Water carries up any Oil along with it, for which reason you must often change your Receiver, to see if you have still got any Oil; and when this ceases to come off, you may proceed, as long as the Water that distills possesses any valuable virtues of the Plant, according to Process 15, 16, for that will serve again for preparing fresh Oil.

7. In this Operation, therefore, the Pellicles of the little Repositories that contain the Oil being soften'd by the Maceration, are burst by the included Oil, when it comes to be dissolv'd, agitated, and rarefied by the Heat and Action of the boiling Water, and now therefore runs out, and is thrown up to the surface of the Water, especially in *European* Vegetables; and the oily Particles being afterwards raised with those of the Water, are carried into the Worm where they are condensed into their proper form, and so distill into the Receiver, pure, nearly in their natural state, and without any empyreumatical Taint, strongly retaining the Taste, Smell, and peculiar Qualities of the Plants they are drawn from, and efficaciously containing them in a very small compass. And when the Oil is thus separated from any Vegetable by Distillation, the *Residuum* is found to be absolutely deprived of it all, and then retains scarcely any marks of its proper nature. Thus the Oils of Wormwood, Box, and Calamint, distinguish themselves perfectly by the same Scent and Taste as the Vegetables do; but when these are quite drawn off, the remainders can hardly be known from one another. These Oils too may be kept for a considerable time without growing rancid. From the consideration, therefore, of all these properties, the Chemists have distinguished these Oils by the name of Essential Oils.

U S E.

1. **T**HESE Oils have a pretty considerable acrid quality, which heats, inflames, stimulates the Nerves, and attenuates cold pituitous Viscidities, but which at the same time is grateful to the Smell and Taste, and raises the Spirits. Their Acrimony they discover by being applied to the Membranes and Nerves when they lie bare in Wounds, for then they excite a very acute pain. Their power of heating we learn from the actual Heat they raise when used internally, which is greater than that produced by almost any other simple Bodies; so that the too liberal use of them will bring on and keep up an inflammatory Fever, and if it is persisted in, will heighten it to the utmost degree of Heat and Violence: And if they are applied externally to the Skin of a Person in Health, and are well secured that they can't be driven outwards, they excite a less, and then a greater degree of Heat, with pain, redness, a shining tension of the part, and pulsation, and separate the Cuticle into a Blister, and if kept on, will produce at last even a Gangrene itself. Hence, then, Physicians may infer, how powerfully these Oils act by this inflammatory quality, when they are imprudently taken inwardly, where being applied to the Membranes of the *Viscera*, they excite such topical inflammations. But on the same principles, when they are rendered active in the Body by the vital Powers, they stimulate the Nerves most efficaciously. Hence, therefore, when there are any Viscidities in the Body arising from mere inactivity, and that wou'd be dissolv'd by a greater degree of motion, they wonderfully attenuate, and discuss them. By the fragrance of their Smell too, and the agreeableness of their Taste, they prove a very grateful relief to the languid Spirits. In all these cases, however, these Oils don't operate so much by their oily tenacity, as by the assistance of those subtil Spirits, which being inviscated, and retained in them, give every Plant its particular and distinguishing Smell and Taste; but of this we have treated already, in Proceſs 1, 15, 16, 17. These Oils, therefore, when they are prudently managed, yield a most noble medicine, in all those Diseases where the animal, natural, or vital Spirits are either deficient or inactive. Hence in cold watery habits of Body, where there is a simple *Leucophlegmatia*, or in a mucous *Pituita*, arising from a mere *Inertia* of the Solids, without any inflammatory Obstructions, they are of excellent service; as they are likewise in perfect, cold, Winter intermittents, if they are taken betwixt the Fits, particularly when the cold Fit is just coming on. Persons in years too, from a moderate use of these Oils, find a considerable advantage. Nor to those Hypochondriacs, who have such a *Lentor* in their Blood, that it is scarcely fit for the production of Spirits, and who hence are so inactive, dull, forgetful, and lethargic, and upon every little occasion are ready to weep like Children, are they less beneficial. And those of the other Sex too, who are troubled with hysterical Disorders from the same cause, are relieved by these Oils likewise: But let me caution you at the same time, that those who are disordered in this manner from a fulness of Blood which ought to be discharged, and hence have their Vessels quite choak'd up, are vastly the worse for such kind of Medicines. And so in Apoplectic cases, arising from a lethargic disposition in Persons in years, and where there is a *Torpor* for want of Spirits, these Oils do Service; whereas

whereas in those that are caused by an extravasation of Blood within the Skull, an inflammatory obstruction, or a distension of the Vessels from a *Plethora*, they are almost fatal: And hence, to these last, the apoplectic Balsams made of these Oils, prove so often prejudicial, tho' they are every where so mightily cried up without distinction. But in no cases are these Oils more extoll'd, than in colicky Pains, the iliac Passion, and where the Stomach is troubled with Wind: There is need of some prudence however in the administration; for as these disorders may arise from an Inflammation, plethoric spasms, and the like, these Oils may here prove very hurtful, tho' when they are owing merely to a cold habit of Body, a slow circulation of the Blood, and a cold viscid *Mucus* in the first passages, they prove a beautiful Medicine.

2. In a chemical view, now, from what has been said, it is evident, 1. That in aromatic Plants, there is an Oil, which becomes volatile in the heat of boiling Water. 2. That in this Oil resides chiefly their proper Spirit, which rises with it in distillation, and will afterwards remain united with it for a great many years, if it is but well secured in a close Vessel. 3. And that this Oil exists in Vegetables, but in a certain quantity, which being drawn from them, there is not the least portion remaining. 4. If the Water, however, which you add in the distillation of Vegetables, is saturated with as much Salt as it will take up, then, when it comes to boil, it will have a greater degree of Heat in it than simple Water has in the same circumstance, as was formerly demonstrated in our Theory; and hence by an addition of Salt there will be more of the vegetable Oil dissolved than there wou'd be without it. You will be mistaken, however, if you imagine you shall by this means obtain more of that noble spirit which gives the Oil its whole value, for this will certainly be separated with the heat of simple boiling Water. 5. But hence we learn farther, that these Oils of Vegetables are more volatile than that saline Matter, which, with a stronger Fire, rises in form of a volatile, oily, acid, or alkaline Salt, or than that which by an open Fire is converted into a fixed Alkali. 6. And again, we here observe, that the peculiar Vertues proper to particular Plants, are found to be more efficaciously contained in these Oils, than in any of the other simple parts; though this indeed depends intirely upon the *Spiritus Reſtor* that resides in them. Neither the Water, the more fixed Oil, the *Sapo*, nor even the Salt itself of a Plant possesses its peculiar properties; nor will any person, by the examination of these separately, be able to discover what Plant they were procured from; it is this Oil alone, which by its Smell and Taste will certainly distinguish them from one another. Or if the Oils drawn from two different Vegetables are found to be very much alike, then these generally obtain the same name, as we see in the Oil of Roses, and the *Lignum Rhodii*, which is therefore called Rose-wood. And thus the affinity betwixt the Oils of the *Cassia Lignea*, and the Bark of Cinnamon, has occasioned the true Cinnamon Tree's being called the *Cassia Lignea*, the other the *Cassia Fistula*. 7. And hence we see lastly, how great, and how excellent a part of Vegetables is lost in boiling.

PROCESS XXIV.

Distill'd Oils from dry Leaves per Vesicam: An instance here in Mint.

APPARATUS.

1. **W**E must now perform the same Operation upon Herbs that are dried. The Herb Mint, therefore, gathered at a proper time, dried in the Shade, and then kept six Months, I digest with its own distill'd Water, and distill as in the preceding Process: But here it is necessary to observe, not to fill the Still above half full with the dry Herbs, because when you pour the Water upon them, they'll swell a good deal, and so be apt to burn, and rise into the Head. From the beginning then of the Distillation to the end, you will have an Oil in considerable quantity, that will swim upon the distill'd Water, and remarkably distinguish itself by its Smell, Taste, and Vertues.

2. If, when the Operation is over, you take the *Residuum*, press out all the Juice, and put this upon fresh dry Mint, and after you have carefully separated all the Oil, add the former distill'd Water, and as much more of the same as is necessary for the Distillation, and then digest and distill as before, you will by this means have more Oil in this second Distillation than you had in the former. And if you repeat this Operation some number of times, you will constantly have more and more Oil, for the Water itself, being often cohobated, at last becomes oily, and gives out an Oil plentifully. Hence we easily see, that these Waters must acquire the proper Vertues of the Plants they are drawn from, as we sufficiently explained formerly in Process 10. The use of the Oil, too, we treated of particularly in the former Process; and hence what is said there may be applied to this Oil prepared by cohobation.

PROCESS XXV.

Distill'd Oils from Flowers; here from those of Lavender.

APPARATUS.

1. **T**HE fragrant Smell of Plants sometimes resides in their Flowers alone, at others, in them particularly. But as this is exceeding grateful, so it generally easily flies off and is but of short continuance, on account of the curious and tender fabrick of the Flowers; though there are Flowers, it's true, that retain their proper fragrance for a considerable time, as is evident in those of Lavender. The method of procuring their Oil from them, however, is in almost all of them the very same. These then must be gathered at the time when they are most scented, which is commonly when they are just ready to open their Leaves, and they must be cropp'd whole, whilst the morning dew is upon them. They must then be put immediately into a Still to the height of two thirds, and as much Water, drawn from the same sort of Flowers by a former distillation, must be poured on as is sufficient for your Purpose, to which add so much Oil of Vitriol as will make it gratefully acid. Then proceed to distill in the manner

manner which has already been sufficiently describ'd, and by this means you will procure some Oil, that will swim upon the Water, and must be separated and kept by itself. Take the Juice express'd from the *Residuum* of this Operation, and put it, with the distill'd Water drawn off, and as much more as is necessary, upon more Flowers, and add a small matter of Oil of Vitriol, and distill again; and you then will have a greater quantity of Oil. And upon a repetition of the same Operation, you will constantly be able to procure every time more and more, repeat it as often as you please; for as the Juice that is pressed out of the *Residuum* grows thicker, and the cohobated Water stronger, the Oil will always rise in greater abundance, if you do but carefully separate it from the Water after every distillation. And the Waters, likewise, thus made use of, at last like the Oils, become exceedingly fragrant, and acquire excellent medicinal Vertues.

2. As this Oil is remarkable for its incomparable fragrance, and hence is very valuable, so the quantity of it that can by this means be procured is but very small. For this Reason therefore, the Artists have used their utmost endeavours to find out some method to obtain it in greater plenty, and at last it was discovered, that Flowers digested in close Vessels for the space of fifteen days, or longer, with a little Oil of Vitriol added to keep 'em from putrifying, yielded a third part more of this best Oil, of which you have an instance in the choice Oil of Roses, mentioned in the *Mem. de l'Ac. Roy. des Sc.* Vol. II. p. 208. The Flowers of Agrimony, garden Cloves, Camomile, the Citron, Jessamy, Lavender, White Lilies, Lilies of the Valley, the Lemon, the *Philadelphus* of *Athenæus*, Roses, Tansy, and the Tuberous Hyacinth, are the chief that are made use of for this Operation.

U S E.

THESE Oils, on account of their delightful Smell, are very much esteemed by Persons of figure, and therefore it is worth while to take some Pains about them.

P R O C E S S XXVI.

Distill'd Oils from Seeds: An Instance here in Fennel-Seed.

A P P A R A T U S.

1. IT has long appear'd, that the Oil of Plants resides in great plenty in the Cotyledones of their Seeds, and hence, from these, the aromatic ones in particular, it is frequently prepared. And here it is observed, that the hotter, more biting, and scented these Seeds are, the greater quantity, and the more valuable Oil they yield. In this affair, however, we find Nature don't always follow the same Law: For sometimes the Seeds alone contain the aromatic Balsam of the Plant, as we see evidently in Anise, Cummin, and many more; whilst at others it has plac'd the Oil in some other part of the Plant, and none of it at all in the Seeds, as in the Rose, for instance, which has a beautiful Oil in its Flower, but nothing of it in its Seed or Fruit. And

thus

thus too the Flowers and Leaves of the Orange, and the Peel of the Fruit, yield a fragrant Balsam, of which, in the Seeds, there is not the least appearance: There is, it's true, in these Seeds an Oil likewise; but not that fine one which is in the other parts. Nor do the Seeds of the fragrant *Ceylon* Cinnamon yield any of that choice Oil, which is contained in such abundance, in the Bark, Wood and Leaves. Hence, therefore, in this case, we can lay down no general Rule, but we must here again have recourse to particular Experiments if we wou'd come at the truth. The Seeds chiefly esteemed for this Operation are those of Garlic, Marjoram, *Amomum*, Dill, Angelica, Anise, Smallage, Onions, both Cardamoms, Bastard Saffron, Scurvygrafs, Coriander, Cubebs, Cummin, Rockets, Flixweed, Fennel, Masterwort, Juniper, Bay, Lovage, Spignel, Sweet Cecily, Mountain-Smallage, Origany, Pepper, Rue, Mustard, Tanfy, and Zedoary.

2. These Seeds must be gathered when they are perfectly ripe, and be dried for the Space of three Weeks, in a place where the Wind blows thro': Then digest them for three Days in a close Vessel with hot salt Water, and distill according to the Rules we laid down in the Distillation of Waters, unless that you must make them boil more strongly, as otherwise the Oil will not be so well separated, nor rise so easily. And here again a Brine being made use of instead of Water, communicates a greater degree of Heat to the Seeds, and so makes them give out their Oil more readily, and more pure in Distillation.

3. But here let me caution you, that some Seeds contain so great a quantity of Oil, that it collects together in the Worm, in the Refrigeratory, and when it comes to a part that is cold, hardens into a solid Mass, and so entirely stops up the Worm: By this means, then, as nothing can any longer descend, the Vapour of the boiling Water, and the Oil is confined, and being greatly rarefied, throws off the Head of the Still, and bursts forth with a great heat and violence, very dangerous to any body near it. It's absolutely necessary, therefore, to take care, that the Worm made use of for these distillations, is not too narrow, nor grows too cold, which is best provided against by not having it too long. And if ever, during the Distillation, you observe, that the Water and Oil does not come off, you must, without any delay, carefully take off the Head, and pour some boiling Water into the Worm, that the Oil may by that means be melted, and run through, and then you may proceed again with your Operation. The Seeds that are most liable to this inconvenience are those of Anise, Cardamoms, Bastard Saffron, Fennel, Bay, and Zedoary. These Oils, in nature, nearly approach to Camphire, which melts with a distilling Heat, but hardens again immediately when it comes to be cold; and here we may observe, that what thus stops up the Worm is pure Oil. In very hot Countries, the Aromatics are concocted to that degree by the heat of the Sun, as to have their Oils thus converted into Camphire.

U S E.

HENCE then we see, that in the Lobes of the Seeds of some Plants Nature has disposed a large quantity of an Oil, that is strongly impregnated with their proper distinguishing Spirits, to the end that within these the tender Embryo may be

be safely lodged, and lie secure till the proper season for its appearance is come about. And hence again we learn, that the vital Principle, when it is encompass'd with such a Balsam, may be preserved a considerable time, and indeed, that such a security is necessary, that on one hand it may not be destroyed by the Winter's Cold, nor, on the other, by an unseasonable Warmth and Moisture, be brought forth immaturely, and perish. And for this reason, in the Root and the Seeds particularly, we find this Oil. But as there are a great number of Seeds, now, whose distill'd Oil have no remarkable Smell or Taste, hence we are certain, that the Spirits of many Vegetables escape the notice of our Senses, though at the same time they give them all their peculiar properties, and so, accurately distinguish them from one another. To the sagacity of our Senses, therefore, though we may attribute a good deal, yet we must take care we do not ascribe too much. Perhaps, now, the more volatile the Spirit is that is contained in the Oil of the Seed, and the warmer Taste it discovers, so much the less time will such Seeds retain their prolific Vertue; whilst on the other hand those that possess one naturally less active, may be disposed for a long time to propagate their *Species*. Certainly the most fragrant aromatic Seeds, and those which distinguish themselves by the most biting Taste, soon become effete and incapable of producing new Plants. This we see plainly in the umbelliferous, balsamic Plants, and in the fine, aromatic, *Indian* Seeds, which are almost always spoil'd in this respect by that time they are brought to us, witness the Cardamons, Cubebs, Zedoary, and Ginger; whereas, on the other hand, those of the Thorn-tree, Sensible Plant, *Cassia*, *Senna*, and Tamarinds, may be kept a great while. The same thing we see likewise in the different Corn-seeds, which, after a great length of time, will disclose a fruitful Embryo. But in this Affair it is particularly remarkable, that the Oil of these Seeds, so long as they are kept dry, will retain its proper qualities intire a long while, and by a chemical management may, in form of a true Oil, be extracted from them; whereas, if they come to be moistened with warm Water, and begin to germinate, the quantity of Oil is immediately diminished, and they begin to be more disposed for the production of Spirits. Hence therefore, perhaps, it is not improbable that this seminal Oil may, by the prolific moisture of the Earth, the action of the Air, and saponaceous quality of the Juices of the Soil, and Seed, be dissolved, attenuated, rendered miscible with Water, and insinuate itself into the Canals of the little Root, implanted in the Cotyledones, and so be propell'd through the Vessels of the Embryo, cherish the tender Plant with its Spirits, imbrue its nutritious Juices with a particular quality, and impress upon them the Character of the Plant that produced it: Certainly, when Seeds have once been moistened so as to give signs of a vital motion, if they are kept afterwards, they won't be fit for raising new Plants.

P R O C E S S

PROCESS XXVII.

An Oil, distill'd from the Hypocarpia, called Clavi of the aromatic Moluccan Cloves.

APPARATUS.

1. **T**HIS wonderful *Species* of *Indian Aromatics*, both the greater, which bears its Seed almost at the top of its Branches, and the less, which has no Seed at all, abounds so plentifully with a very biting, balsamic Oil, that, if you warm them, and press them only with your Finger, or wound them with a needle, an Oil will spontaneously ooze out, which for its Scent, and caustic Acrimony has scarcely its equal. And, indeed, if these are examined, when they are just imported from the *Indies*, and are taken fresh out of the middle of a Bag, it is hardly credible how much Oil they will yield; certainly you can scarce procure so much aromatic Oil from any other Body whatever. Let these, then, chosen at such a time, be put whole into twelve times their weight of Water, and immediately distill them pretty strongly with a Worm, and you will have a milky, thick, turbid Water, and with this there will come off a large quantity of Oil of a golden colour, which will subside, and be collected at the bottom of the Water. When you have in this manner drawn off two thirds of the Water you made use of, change the Receiver, and upon the *Residuum* pour as much fresh Water as is come off, and then proceed to distill as before; and by this means you will again have a Water impregnated with the Vertues of the Cloves. And if you go on to repeat this Operation, you can hardly believe how long the Water will be somewhat aromatic; at last, however, after a tedious repetition, you will have a Water that is acid, cold, and scarcely odorous. Save, then, all the scented Waters, and they'll serve another time for the distillation of the Oil instead of simple Water. After the Operation is compleated, there will remain at the bottom of the Still a brown, thick, inodorous Liquid, of an acid-austere Taste, in which one can discover no indication at all of the original qualities of the Cloves. The Bodies of the Cloves, indeed, after the Distillation, retain so exactly their proper form and colour, that, when they are half dried, a Person that is not aware of it may take them for true neat Cloves. And indeed, if they are afterwards mixed with fresh Cloves that are very oily, they will be again impregnated with an aromatic Smell and Taste, and will in such a manner attract the Oil out of the others, that you can't then distinguish them from the genuine. In this way some Persons who deal in Spices, adulterate them, and basely make an advantage of it.

2. But if you want this Oil, which always, when procured in this manner, appears somewhat mucilaginous, I say, if you want this purer and brighter the first time; then instead of Water, for the first Distillation, make use of a strong Brine of Sea-Salt, and digest two or three Weeks before you distill: But then, however, the *Residuum* cannot be examined.

U S E.

THIS Oil heats exceedingly, nay, is truly caustic. Hence in cold habits of Body, and the coldest Distempers, 'tis an incomparable medicine. Where there is a *Languor* of the Spirits, too, this proves very efficacious in raising them, whether taken inwardly, or applied outwardly. This wonderful Oil, however, which is impregnated with such noble Spirits, if it is exposed in an open, broad, glass Vessel to a warm Air, soon diffuses its Spirits, and fills the place with a fine aromatic Smell, and in a little time is converted into a thick, tenacious, inactive Oil, though in the extreme heat of the hottest Climates it effectually holds them down, and secures them for so long a space of time. This Oil too, as it is heavier than Water, always falls to the Bottom, and whilst it is covered with that, will retain its Vertues. This is rarely found to be the case in *European* Vegetables, but is frequently observed in the hottest parts of *Asia*, *Africa*, and *America*, in the Aromatic Trees in particular, as the Clove, Cinnamon, *Guaiacum*, and Sassafras. This Oil, however, though it is so heavy, is carried up by the assistance of boiling Water, and with the Vapour of that rises in Distillation. And lastly, which is pretty remarkable, Vegetables that abound with this very hot Oil, do not, when they are distill'd, discover any alkaline Salt in their *Residuum*, but an acid, rough, cold, and pretty fixed one, which serves as a *Vinculum* to hold down the Oil, which of itself wou'd be too volatile.

P R O C E S S XXVIII.

An Oil distill'd from Sassafras.

A P P A R A T U S.

1. **I**F light, oily, aromatic Woods, cut in the Winter season, are rasped whilst they are sound and fresh, and boiled strongly in a Still with twenty times their weight of Water, there will distill from them a milky Water, and an Oil, which from the Sassafras of *America*, is nearly pellucid, and sinks to the bottom of the Water, though the Wood itself is pretty soft, light, and almost spongy. Proceed in your Distillation as long as any Oil comes over, or the Water appears considerably milky; and you will have then remaining in the Still an acid-austere Decoction.

2. If you then take some more fresh Shavings, and distill them with this Decoction and the former Water, you will the second Distillation have a larger quantity of Oil: And if you repeat it a third time with the cohobated Water, and twice decocted *Residuum*, it will by this means be farther increased.

3. This is the method we make use of to draw the Oil from all Woods that give it out easily; of which sort in particular, are Fir, Pine, and Sassafras: But here the Oil of the two first is light, and swims upon the Water, the last is heavy, and falls to the bottom.

4. But Woods that are very hard and heavy, must be rasped finer, and digested a good while with salt Water, and then be distill'd with a Brine of Sea-

Salt, for by this means at length their Oil may be separated from them. Of this kind is the Wood of the Orange, *Arbor Vitæ*, Benjamin, Box, Cedar, Citron, Snake-tree, Guaiacum, Rose-wood, all kinds of Juniper, the Lemon, Savine, Styrax, and the other balsamic Trees which produce the Balsam Capivi, Peru, Tolu, and Elemi: And the longer these are digested with Brine in close Vessels, the more easily they give out their valuable Oils in Distillation.

5. Those Woods that are oily, resinous, balsamic, gummy, and discharge a Pitch, are the properest for this Operation, especially if they are at the same time heavy, and solid. Those on the other hand which are light and spongy, and grow chiefly in wet places, as the Alder, Poplar, Willow, Elder, Vine, and the like, are unfit for Distillation, yielding scarcely any thing of this Oil.

6. Woods lopped at that time when the Juices are most in motion, yield less Oil, and what they do yield, is not so good, as you may procure from the very same, if they are cut in the middle of a sharp Winter. The Wood likewise of young Trees that grows apace, gives out less Oil than the same does when they have been a good while past their maturity, and are grown old. And lastly, the Ever-greens yield more, and a hotter Oil than those which naturally shed their Leaves. From these Observations, then, it is evident, why heavy Oak is chosen for building, and qualified too in the manner we have mentioned.

7. From what has been said then, we learn, that the weight of Woods is owing chiefly to a heavy compact Oil, closely connecting and binding together the other Principles; not this only which rises in Distillation, but that particularly which remains in them when the Operation is over: This, Cedar, Guaiacum, and Juniper, seem to evince. And their disposition to last a great while, depends likewise upon the same cause; whence we see that the most durable Woods are always the most oily, witness the Box, Cedar, Olive, and Oak. And lastly, it is their Oil in particular that gives them their excessive hardness; for the soft, fungous, spongy Woods are without it; the Box, Snake-tree, Guaiacum, Olive, and Iron-wood, abound with it. Hence then we have a notion of Oils, Balsam, Turpentine, Refin, and Pitch, which have all the same origin, but are concocted and inspissated with a greater or less Heat of the Sun. And hence we understand how Woods become carious, *viz.* by Worms feeding upon the subtil Oil contain'd in their little Follicles, and oily Ducts, whence they afterwards fall into a kind of Ashes; or by their being exposed to the alternate actions of a hot, cold, moist, and dry Air, by which means their Oil will be consum'd likewise, and there will remain nothing but a friable Earth.

P R O C E S S XXIX.

An Oil distill'd from the Bark of Cinnamon.

A P P A R A T U S.

1. **W**E formerly took notice, that in the Barks of Trees, the old ones in particular, and the Ever-greens, there is collected a great quantity of Oil, which appears there under the different forms of Oil, Balsam, Colophony,

ny, Camphire, Gum, Tears, Resin, and Gum-Resin, always presenting us with the native pinguious part of the Vegetable. For this reason, therefore, the Chemists have distill'd these in the same manner we mentioned of the Woods, and have drawn from them large quantities of the most beautiful Oils. Thus I take the choicest fresh Cinnamon, broke into such pieces as will conveniently lie in the Still, and distill as in the preceding Process. In the first place, then, there comes off a white Water resembling the best Milk, which elegantly contains the Smell, Taste, and Vertues of the Cinnamon; and at the same time there rises an Oil of a golden Colour, which falls to the bottom of the Water: And so long as this milky Liquor, together with its Oil, continues to run, so long you must keep up your Distillation; but as soon as ever, with the same degree of Heat, you observe a clear Water come off, you must then change your Receiver, and proceed again, by which means you will at last have a Water perfectly clear, and without any Oil, which you must carefully watch, in order to desist as soon as ever this ceases to have any Smell or Taste of the Spice. This second Water must be saved by itself, and will have somewhat of the Vertues of the Cinnamon. I generally, then, put some fresh Water upon the *Residuum*, and make it boil briskly, upon which there rises a light, clear, thin, inodorous Water, of a cool acid Taste, which often during the Distillation, corrodes the Copper head, and by this means grows greenish, nauseous, emetic, of a vitriolic nature, and hence proves of service against Worms. This however, has not the least mark of Cinnamon in it, and therefore, when it has served for this Experiment, it is of no farther use. The Operation being over, there remains in the Still a thick turbid Decoction, which is of a brownish red Colour, has an acid austere Taste, and is very astringent. And the Bark of the Cinnamon retains its true appearance so exactly, that if one does not examine it, either by smelling to it, or tasting of it, one may easily take it for the best fresh Cinnamon, especially if it is first gently dried. Nay, and if this is put for some time into a parcel of very good Cinnamon, it will by this means acquire new Vertues, which therefore will be proportionably destroy'd in the other.

2. If you carefully separate the two first Waters from their Oil, and make use of these with the remaining Decoction, to distill fresh Cinnamon, instead of common Water, you will by this means procure a good deal more Oil, and the Water that comes off first will be exceeding white and oily, and as grateful almost as the Oil itself. If you repeat this Operation, therefore, and always carefully separate the Oil, you will at last have a great quantity of an exceeding choice Oil: You never, however, will be able to procure but a certain quantity both of the Oil, and medicated Water, which it is not possible to increase by any method whatsoever.

3. But as this Oil is exceeding valuable, and yet in this manner of distilling it, there is always somewhat flocculent and mucilaginous adhering to it, which both renders it impure, and hinders its being nicely separated, hence the Artists have studied how this might be prevented, and they found, that if it was digested with a Brine of Sea-Salt, or Water made very acid with Vitriol, as we mentioned in the Cloves, before it was distill'd, then the Oil that came off wou'd be purer, and capable of being more accurately procured without any admixture of heterogeneous parts. Hence, then, by cohobating with this saline or

acid Water, and the former distill'd Waters of the Cinnamon, you will prepare a most beautiful Oil, and a Water equal in vertue to the Oil.

4. If the substance of the Cinnamon that remains after the Operation No. 1. of this Process, is burnt with an open Fire into Ashes, it yields scarcely any Salt, nay, I may almost say, none at all. But if the Decoction described No. 2. is inspissated, it produces a very rough extract, which being burnt according to Process 5, affords a little Salt, in which there remains nothing at all of the proper vertues of the Cinnamon. It is to no purpose, therefore, to prepare, with so much labour, this very small quantity of Salt, in order to mix it with its Oil, to make that costly Essential Salt, as it is called, of Cinnamon.

U S E.

THE Bark of Fir, Guaiacum, Juniper, Pine, Savine and Sassafras, are the principal that are made use of for this Operation. From Cassia, digested for a great while, you may procure something of the same nature. From what has been said then, we learn how vain the boasts of those trifling Chemists are, who pretend, by a secret Art of their own, to draw from this valuable and costly Spice Cinnamon, twice or three times as much genuine Oil as other People can; for it is prepared only by nature in a certain measure, which may be easily separated by the common method just described, and beyond which Art cannot produce the least drop more. In this Oil now, there is contained a perfectly igneous Spirit, which like true Fire, soon consumes the human Body, and which in Acrimony is exceeded by none, as is sufficiently confirmed by Experiments. If it is taken internally, therefore, or is applied externally, it heats, inflames, nay, and will immediately burn in such a manner, as to produce a gangrenous Eschar. In the mean time, however, with regard to its invigorating power, there is not any one thing in the whole *Materia Medica*, that can be compared with it. Certainly, if there is any Medicine that is of service in cold pituitous uterine Disorders, it is this distill'd Oil, when it is made use of by a skilful Physician. But there is one thing very remarkable in this Oil, which is confirm'd by a great many Observations, viz. that if a large quantity of it truly prepared in *Ceylon*, stands quiet for some years in a Vessel accurately stopp'd, then great part of it will be converted into a real Salt, which will dissolve in Water, and will be strongly impregnated with the proper vertue of the Cinnamon: This I have had from various Persons of Credit, and it is confirmed by the Observation of the famous Dr. *Slare*, who says, that in the space of twenty years, half such an Oil, closely secured in its Vessel, was changed into pure Salt, *Phil. Trans. Abr.* Vol. III. p. 362. This now is not found to be the case, when the Oil is kept negligently stopp'd so that it loses its Spirits, and hence becomes vapid and inactive, whence it seems to appear, that this Spirit has a power of generating Salt from its own Sulphur, which well deserves a careful Examination.

PROCESS

P R O C E S S X X X .

Distill'd Oils per Descensum: An instance here in Cloves.

A P P A R A T U S .

IT being observ'd, that when Vegetables abounding with Oil were put in motion by Fire, they sweated out their pinguious Fluids, which might then be easily collected, a method was contrived for procuring Pitch from the Wood of the coniferous Trees by ustulation. *Axtius de Coniferis.* And this afterwards was applied to the very oily Seeds, which discharged an Oil in the same manner when it came to be fused by a gentle Heat, as we see evidently in Almonds. And lastly, the aromatic Plants by the same method were made to give out their Oils likewise. The Oil, however, procured in this manner, differs intirely in Smell, Taste, and Vertue, from that express'd according to Process 20. To let you see an instance of this then, I take some choice Cloves pounded till they are reduc'd to an oily Pulp. This I spread to the thickness of a quarter of an inch, upon a piece of very close linnen Cloth, which is tied over a cylindrical glass Vessel in such a manner, that it can't possibly fall in: And here the deeper the Vessel is, the fitter it is for this Operation, as the cavity underneath the Cloth being by this means so much the bigger, will more readily cool and condense the oily Vapour. I then take this iron Cover, which is a little Concave, has a flat rim, and is made of such a size, that the Rim may rest exactly upon that of the glass Vessel, whilst the lower Convex part goes just within its Cavity; and here the depth of the Cover in the middle need not be above four lines. This then I lay upon the Cloves, and press it down a little, that its Convex part may force down the Cloves, and cloth, a little way within the Mouth of the Glass. These things being thus disposed, I fill the hollow of the iron Cover with clear Ashes, and upon those lay a few live Coals, the Heat of which penetrating to the Cloves, agitates and dissolves them, by which means their native Oils and Water being resolved into Vapours, float about in the Cavity underneath, till being condensed upon the cold sides of the Glass, they run down in drops to the bottom, and there form a very hot Water and Oil. If you carefully then continue your Fire, you will be able by this means to draw out almost all the Oil; and when you perceive that nothing comes away with the same degree of Heat, then your Operation is over. But here you must be cautious not to increase your Fire too much, for fear of giving the Water and Oil an empyreumatical Taint; and yet, on the other hand, if it is too gentle, you will hardly get any thing out. The middle Heat may, however, be easily obtained, by beginning with a very little Fire, and then gradually increasing it. By repeating this Operation then with fresh Cloves you may procure what quantity of Oil you please.

U S E .

FROM this Experiment, we learn the natural disposition of the proper aromatic Oil. And that now which is procured in this manner, discovers

vers the same Smell, Taste, and Vertues, as the distill'd essential Oil does, in every particular, so that it can scarcely by any means be distinguish'd from it. There is less Oil indeed procured from the same quantity of Spice by this method, than by distilling it with Water; but then the *Residuum* may be still used for Distillation, and other purposes, for it retains a great deal of the original aromatic Vertues. This Operation is chiefly made use of, when one wants to prepare the Oil in a very short time, or to shew this Experiment; otherwise the Distillation with Water is preferable. By this method, such an Oil may be drawn speedily from Orange, Citron, and Lemon-peel, Mace and Nutmegs, and from other Substances too that are very oily, when they are prepared in the manner abovementioned. Hence then we see what effect this degree of Fire has upon Oils, as they naturally exist in Vegetables, viz. it melts them, and separates them in such a manner, as to make them spontaneously, as it were, sweat out. But when the Bodies made use of for this Operation are very dry, they must be pounded and put into a Cloth, and be exposed to the Vapour of boiling Water, till they are penetrated with it quite through, and then if they are made use of, they will yield more Water and Oil, and it will be drawn from them too with less difficulty. It's surprizing now, how much these Oils differ from those procured by Expression, being these *per Descensum* are abundantly more aromatic.

S C H O L I U M.

THIS Experimental History of Oils prepar'd from Aromatics by the Chemical Art, especially by Distillation, treated of from Process 22, to this 30th, contains a great many things that are both curious and useful. With an Eye therefore particularly to the service they may be of to you in Chemistry, Physics, and Medicine, I shall take notice of the chief of them, as carefully and succinctly as possible.

1. All the aromatic vertue of Vegetables, then, consists in their essential Oil alone, which being perfectly separated from them, the remaining Substance has not the least of this quality remaining.

2. But in this Essential Oil, again, it is an exceeding subtil, volatile, pungent Spirit, so little in quantity, that its weight is scarcely perceptible, that contains all that vertue which gives the Oil its efficacy, and which therefore being dissipated, the Oil becomes absolutely vapid and effete. In these Oils, therefore, we must always carefully distinguish the Sulphur from the Spirit, or the resinous part, from the acrid igneous one. From its natural volatility, the Spirit soon exhales, and then the sulphureous part remains inactive. And in the open Air this Oil will, in a short time, in a close Vessel, in a longer, be inspissated through various degrees, and so be gradually changed from a liquid Oil to a thicker, from this to a Balsam, from this again to a more tenacious Body, and at last by age into a brittle Resin; which again by a new Distillation, may be converted into a thin liquid Oil. Hence some famous Authors have been of opinion, that distill'd Oils are actually melted Resins, and Resins only condensed Oils. *Bohn. Dis. Chem.* p. 29, 319, 326. The Sun certainly does change the Oils of Vegetables in this manner; for if you make a puncture in the Fir, Cedar, Larch-Tree, or Pine, there will in a short time distill from

them a liquid limpid Oil, and how strongly this is impregnated with a rich aromatic Spirit, I have often observed with admiration : But when this comes to the Bark, by the heat of the Sun it begins gradually to lose its Spirits, and at the same time is inspissated, and becomes a thick Turpentine, more dense than the former Oil, but less pregnant with Spirits. And even this very Turpentine, when it is longer exposed to the action of the Sun, and farther concocted, puts on the nature of a Resin, losing gradually its aromatic Spirit, till it at last retains very little, either Smell or Taste. And hence, when we say that a Resin, by Distillation with Water, may be resolved again into an Oil, this must be understood only of the sulphureous part, and not of the sulphureous and resinous together, for the Spirit is not regenerated, or returns again, but only the fluidity of the Oil. And the aromatic scented Tears, too, of Benjamin, Gum-Eac, Mastic, Olibanum, and Sarcocolla, have lost a great deal of the Spirits which were contained in them whilst they were fluid Oils. Hence, therefore, the fresher and more liquid these are, the more beautiful are their medicinal effects, for by age they become quite effete. Nay at last, when the Spirit is quite gone, the inactive oily *Residuums* scarcely differ from one another. And for this reason, I can hardly help thinking, that the substance of essential Oils is very nearly the same, the Spirits giving to each its peculiar and distinguishing qualities. Does their particular specific gravities depend upon their Spirits likewise ? This, if you chuse to engage in it, is proper matter of Inquiry. We here, however, must carefully observe, that the acrid Taste and power of a Plant may be owing to the Salt ; but then the private proper Character does not depend upon that, but upon the Spirit of the Oil, as in the History of the Production of alcalious Salts, and the separation of the native Salts of Vegetables, has appeared already : When these lose their Oil, their distinguishing qualities perish likewise.

3. The more pungent the Smell of any vegetable Substances are, or the hotter and more biting their Taste, the more igneous will be the power of the Spirit that resides in the distill'd Oil. Those too that are come to full maturity, and are gently dried, yield a thicker, stronger, and deeper colour'd Oil : Those that are fresh and moist when distill'd, afford a smaller quantity, and the Oil is thinner, clearer, and less igneous ; but at the same time it is more fragrant. Does the Spirit itself of Vegetables, therefore, gradually increase in vigour, till it arrives at last at his highest state ? Certainly, in most of them, the Scent and Taste, which are the effects of these Spirits, are not strongest in the beginning, but when the Plant is in its full perfection. But here again we must take notice, that in some Plants there seems to be contained a larger quantity of Spirits in a less of Oil, whilst in others there is a less quantity in a greater. Thus one pound of Nutmegs will yield an ounce of Oil, tho' you can procure but the same quantity from five and twenty pounds of *Calamus Aromaticus*, whence it appears, that there is not in them both the same proportion betwixt their Oil and Spirits. But there is a particular Acrimony too in these Spirits which thus distinguish the Oils ; for in Oil of Cinnamon, like Fire it burns any part of the Body it is applied to, nor can it be wash'd out under a long time. Savory too, and Thyme, yield a very hot Oil, nay perhaps the most acrid of all. Hence then we see the wonderful nature of these Spirits, which when they have exhaled from their Oils, scarcely at all diminish their weight, and yet

yet deprive them of their vertues, and leave them effete, thick, of a terebinthi-naceous, and at last of a resinous Nature. I have examined into the weight of these Spirits, but never cou'd discover any.

4. Distill'd essential Oils are found to be of different Colours, as they are procur'd from different Plants: Thus that of Mint is brown, of Lavender yellowish, of Cinnamon of a gold Colour, of Wormwood a black-green, of Camomile and Yarrow bluish, of Anise almost white, and of Camphire quite so. Does this variety arise from a difference in the Spirits, or from the Oil, or from some third Principle that rises likewise from some Vegetables in Distillation? This certainly, which hitherto is not sufficiently clear, deserves to be inquired into.

5. Some of these Oils again are exceeding liquid, nay almost spirituous, of which we have an instance in the essential Oil distill'd from the Peel of *Lisbon* Oranges, than which scarcely any is thinner. Of this kind too is that from Lavender, and that very heavy one that is drawn from Sassafras. Others on the contrary, are thicker, as those of Fennel and Roses; some thicker still, as that of Anise; and yet another sort exceeding these in thickness, as Camphire. The thickest, however, melt with a gentle heat, the next thick with a gentler, and the least thick with the least of all? Whence again is this?

6. But these Oils differ in a particular manner in their specific gravities, some of them being even heavier than Water, and that too by a considerable excess of weight. Of this kind are the Oils of Cinnamon, Cloves, Sassafras, Nutmegs, and I imagine of other Aromatics that grow in the hot Countries betwixt the Tropics; and these require a stronger Fire, and a lower Vessel for their Distillation, and that only one fourth part of it should be empty. But other essential Oils, on the contrary, are very light, as that distill'd from Lavender. This excess, however, of Weight, don't of consequence render the heaviest Oils the thickest; for as I hinted just now, Oil of Sassafras is exceeding heavy, and at the same time very thin; Camphire is very thick, and yet very light: This therefore must be sought for somewhere else. Oil of Anise will often keep suspended in Water; that of Juniper-berries sometimes sinks to the Bottom.

7. In these aromatic essential Oils, there is an inimitable vertue depending intirely upon the Spirit we have so often mentioned, which is acrid, heating, and inflaming, but which at the same time is grateful and reviving, invigorates the animal Spirits, stimulates the Nerves, and thus dissolves cold viscid Humours. By these qualities, therefore, they are of service to Persons in years, in cold, watery, pituitous habits of Body, in cold intermittents, in moist cold hypochondriacal and hysterical Disorders, in cold, watery, mucous Flatulencies, and in cold acid pains of the Bowels, both Iliacal and Colicky. And, indeed, if they are used in these cases by a prudent Physician, they prove a noble and very safe Medicine. When they are given, however, in Diseases, where there is too much Motion, Heat, and Inflammation, by the unskilful application of them, they prove perfect Poisons. The Chemists have wisely observed, that Oils act by their Spirits, and that these Spirits being entangled and retained by their Oils, may be so applied to any part of the Body, as to exercise their proper Powers, which, were they at liberty, on account of their volatility, they would soon lose the capacity of exerting: Being thus united, therefore, they act with more constancy,

constancy, tho' at the same time, indeed, in a milder manner. But that you may enter thoroughly into a notion of this matter, let me observe, that in these Spirits, and consequently in the Oil that contains them, there is an Acrimony, which discovers itself evidently by a Sensation like that which Fire impresses on the Tongue, which is immediately succeeded by pain, and that a considerable one too, and of the same kind with that which Bodies excite when they are applied to the bare Nerves. If they are laid on the Skin, they soon run through all the steps of an Inflammation, and in a short time produce a gangrenous Eschar. And when they are applied to the Lips, the inside of the Nose, and the *Velum Pendulum Palatinum*, where the Nerves are cover'd with an *Epidermis* only, without the *Cutis*, they there have the most violent effect of all, and hence they soon excite there most terrible Inflammations. Hence it appears then, what sad effects, in the *Fauces*, *Oesophagus*, Stomach, and Intestines, may follow the taking these Oils imprudently. These, therefore, with the greatest justice, are called inflammatory Oils. In the mean time, however, as I took notice before, there is nothing that more immediately revives the languid Spirits than these Oils do, by the grateful influence they exert upon them, not so easy to be explained from any common principles, as to be learnt from the event of Experiments. In these certainly there is a power of soothing, comforting, and invigorating the animal Spirits. But they have a power of heating likewise; for whether they are taken inwardly, or applied outwardly, they immediately begin to warm the human Body, and when the Heat is once begun, increase it by very swift degrees. The colder, however, the Body is from a *Languor* of the animal Powers, the less effect they have upon it in this respect, and the contrary; and hence if they are rubb'd upon a dead Body, they communicate to it no degree of Heat at all. With what imminent danger, therefore, are these prescrib'd in a burning Fever? They put the Nerves too into action, by stimulating them, and propelling the animal Spirits, and perhaps by soothing both of them with a grateful sweetness. And whilst they act in the manner thus explained, they attenuate and resolve any Viscidities that can be dissolved by an increase of the vital Motion. But there are other vertues likewise, and those too not less remarkable, which are proper to certain Spirits only, and of which we treated sufficiently under the head of distill'd Waters, particularly cohobated ones. The Oils of the *Arbor Vitæ*, and Savine, are strong Emmenagogues, where the retention is owing to a languid habit of Body. Oil of Rue is of excellent service in Epilepsies arising from a cold lax Constitution, as it is likewise a good anti-hysterical, where the disorder is produc'd by a cold Cause. In a cold Scurvy, and the heaviness, and pains that proceed from it, Oil of Juniper-berries is wonderfully efficacious, and happily too removes those obstructions of the Kidneys that are occasioned by this *Inertia*. Oil of Mint overcomes the languid Disorders of the Stomach, even tho' it is almost paralytic. Palsies, Giddiness, Lethargies, and other Affections of the Brain, arising from a cold cause, are beautifully relieved by Oil of Lavender; whilst Oil of Roses, by its delightful fragrance, without any inconvenience from its Heat, gratefully revives and exhilarates the Heart. But in Women with Child, in Labour, or that have lately lain-in, where their Spirits are much sunk without any Inflammation, or Vessels burst, or open, there is nothing equal in vertue to Oil of Cinnamon. If the Oils of Wormwood, *Cardus Benedictus*, lesser Centaury,

Camomile and Tanfy are made into Pills with some Crumb of Bread, and taken upon an empty Stomach, about 2 Hours before eating, what a certain Remedy are they in Worms? And lastly, those choice and noble Oils of Baum and Lemon-Peel are greatly serviceable in Palpitations of the Heart arising from a cold, watery, inactive, *mucus*; as those of Marjoram, Rosemary, and Sage are singularly so in viscid, cold disorders and discharges of the *Uterus*.

8. If these Oils are rubb'd strongly, and for a good while, with twice their weight of the purest, driest Sea-Salt, and are then distill'd again *per Vesicam*, they become pure, and limpid, and are freed from the gummy Mucilage, as it were, of the Water, and hence are fitter for keeping without losing their Vertue, if you put 'em into glass Vials, with narrow Necks, that han't too much Salt in their composition, stop 'em well with Glass Stopples, nicely ground to the Necks, and set 'em in a dry, cool place. In this Purification, however, the quantity of the Oil is lessened, as a good deal of the viscid part remains at the bottom of the Still, which, on account of its tenacity is not able to rise. And their Vertues, which depend upon their Spirits, are by this Operation diminished likewise; for some of these remain in the Water in the Still, and some are dispersed through that which rises in the Distillation. This *Monf. Homberg* demonstrated by an elegant but costly Experiment, whilst he distilled such an Oil six and twenty times with fresh Water, by which means he had left at last only one quarter of the Oil, three quarters being converted into an insipid, tenacious Liquid. And Water being cohobated four and twenty times with such an Oil, acquired a very aromatic, saline, or spirituous Acrimony. *Du Hamel. Hist. de l'Ac. Roy. des Sc. p. 143.*

9. If these Oils, when they are pure, are distilled in a glass Retort, without the addition of any thing else, and you gradually increase your Fire, there always exhales from them something of Water, and they become clearer, thinner, lighter, and more penetrating; and when you have urged them with a very intense Fire, they leave a fixed, black, spongy, terrestrial Matter, at the bottom of the Retort. And if you patiently repeat this Operation in the same manner, you will at last convert the greatest part of the Oil into such *Fæces*, call'd by the Artists, the *Caput Mortuum*. The great *Boyle*, by this method reduced almost a whole pound of distill'd essential Oil into Earth. See the Observations at the end of his Treatise *de Noëtiluca Aeria*.

10. Five ounces of this Oil being cohobated 8 times upon 15 ounces of the purest Chalk, in very clean Vessels, was reduced to 2 ounces and 1 drachm of Oil, 2 drachms and 45 grains of Salt, and 1 ounce and a half of a very strong, saline Water, in which there was a volatile Salt of the Oil. This we have upon the Authority of *Monf. Bourdeline*, mentioned by *Du Hamel, Hist. de l'Acad. Roy. des Sc. p. 413.*

11. These Oils, by being distilled from quick Lime, that is slaked in the Air, and afterwards rendered exceeding dry, are so alter'd, that 1 pound of Oil being 6 times cohobated with a very great degree of Fire upon fresh Lime, there were drawn off 15 ounces and a half of Water, and 1 ounce of Oil. *Homberg, ib. p. 372.* It is supposed therefore to be absolutely certain, that these Oils consist chiefly of elementary Water, Earth, a small quantity of Oil, and some Spirit and Salt (*Mem. de l'Ac. Roy. des Sc. 1703. p. 37.*) and consequently,

quently, that this distill'd essential Oil is not a simple Element, but is actually compounded of these different Principles, united by the action of the Fire into one Body, called an Oil. Whether this, now, is really the case, or whether the Event of some other Experiments don't make it more probable that these Oils are really transmutable into these Principles, I won't at present undertake to determine.

12. But this, in the mean time, I can assert with greater certainty, that if the choicest of these Oils are dissolved in Alcohol of Wine, and are then distilled with the gentle Heat of 100 degrees, they will give out their *Spiritus Rectior* with the alcohol, the oily, tenacious part remaining at the bottom. And if the *Residuum* is then treated in the same manner with fresh Alcohol, it will again impregnate it with more Spirits; and if this is sufficiently repeated, there will at last remain at the bottom an inert, inodorous, insipid, thick, tenacious Oil, quite depriv'd of all its Spirit. Nay, if pure Water is well shook together with such an essential Oil, it will attract its Spirits out of it, and be richly impregnated, and if this is long enough continued, there will at length be left only such an Oil as we just described. Upon these Principles now are made some very beautiful Preparations: And hence we see, that these Oils are resolv'd into an Oil and a Spirit; as they are likewise into a small quantity of Salt, a Water, and a great deal of Earth; at least these are produced from them by Distillation. But there is nothing in this Affair that seems more surprizing, and a greater Paradox, than that Water shou'd be so intimately united with these Oils, as not to be separated from them, even by 20 distillations.

13. In the last place then, from this whole History of essential Oils, it again appears, 1. That the peculiar Smell, and Taste of Plants resides only in their *Spiritus Rectior*. 2. That the proper Smell and Taste of distill'd aromatic Waters, drawn from different Plants, is contained, likewise, in this Spirit alone. 3. That it is this Spirit intirely, that gives essential Oils their distinguishing properties. 4. That the volatile Oil of Vegetables serves principally to entangle and retain this Spirit; whilst the more fixed is a *Vinculum* to hold together the more solid parts; on which account they differ as much as possible from one another. 5. That the express'd Oils, and the distill'd ones we have just been treating of, are natural enough to the Plants they are procured from. 6. And lastly, that the principal difference betwixt the Oils consists in their Spirits. See, by all means, upon this head, the Observations of Mons. Homberg, in the places above cited, and Hoffman's *Desert. Phys. Chem.* from p. 1. to 63.

PROCESS XXXI.

A Rob prepared from the Residuum of the Processes 23, 24, 25, 26, 27, 28, 29.

APPARATUS.

WHEN the Oils are perfectly separated from Plants by the help of Water without the addition of any thing else, then the Decoction that remains in the Still is exactly the same as wou'd have been produced by boiling the

Plant in Water, for the same time, in a common Vessel. Hence therefore those other Vertues of Vegetables, that do not depend upon these Oils and Spirits, will remain in these Decoctions, unless they have undergone some Alteration by being boiled so long in close Vessels. But when these residuary Decoctions, with the Waters drawn off, are made use of a second time, with fresh Plants, for preparing the same Oil; then this second Decoction will be stronger than the first; and so on. And hence by a frequent repetition of this Operation, these decoctions at last become richly impregnated with those Vertues, as I took notice before in our account of distill'd Waters prepar'd by Cohobation, where I endeavour'd too to determine what those Vertues chiefly were. Thus the Decoctions from Wormwood, Betony, Germander, Ground-Pine, Fennel, Juniper Berries, Tansy, and many others retain considerable Medicinal Vertues; for they have often a saponaceous quality, and a saline Acrimony by which they are capable of doing a great deal of good. And *Van Helmont* very justly informs us, that the Decoction of Juniper Berries, that remains after the Oil is drawn off, has an excellent purging quality, if it is but drank in sufficient quantity. If these strong Decoctions now are diluted with a good deal of Water, and whilst they are boiling hot are strained through a woollen Bag, and then inspissated in an open Vessel with a clear Fire, strong enough to make 'em just ready to boil, they will be converted into a *Rob*, which will possess their Vertues, retain them uncorrupted for a great length of time, and in a small Dose, will have a considerable effect. And if these Decoctions are inspissated, and burnt, according to *Tachenius's* method, they will yield a great quantity of the Salt that goes by his name. But if they are very nicely purified by straining 'em, and then inspissated to a proper thickness, and set by in a Vessel, with some Oil poured upon them, they will then yield the native Salt of the Plant, which will more readily shoot, now the essential Oil is separated.

U S E.

THUS the Chemist then, for the use of the Physician, procures vegetable Oils, Waters, Extracts, native Salts, and calcin'd ones, almost by the same Operation, by compounding which afterwards together are prepared very beautiful Medicines: For if the Oil of Juniper, for instance, is rubb'd well with its native Salt, and this Composition is accurately mixed with its *Rob*, and the whole is diluted with its distill'd Water, you will then, in a small compass, have almost all the Vertues of the Juniper, nothing hardly but its terrestrial part, which impeded its activity, being taken away. From all that has been said then we learn what the various parts are that the chemical Art is capable of extracting from vegetable Substances, and how much one forwards or hinders the production of another.

P R O C E S S

PROCESS XXXII.

Distill'd Oils, Vinegar, Spirits, a twofold Oil, a Coal, and Ashes from Guaiacum-wood, distill'd in a Retort without the addition of any thing else.

APPARATUS.

1. **T**HE Vegetables which I have hitherto examined by a chemical *Analysis* seem reducible to 2 distinct *Classes*, the first of which contains those that, being distill'd dry, yield an oily, volatile, acid Salt, together with some other parts; the second, those which being treated in the same manner, besides other volatile parts give out an oily, alkaline one; with this limitation, however, that both *Classes*, through various degrees, yield more or less of either, according to the diversity of the Plants contained in them. Of both these, now, I will give you an Example, beginning first with the Acid, for which purpose I shall make use of the Wood *Guaiacum*.

2. With the raspings of the best sort of this Wood then, *viz.* that which is green, close, heavy, and pretty fresh, I fill a clean glass Retort almost to the Neck, taking a great deal of care however that none of it can drop out of the Neck into the Receiver. This Retort I put into a Sand Furnace, and applying a very large Receiver, lute the Joint very close with a Lute made of Linseed Flower. I then begin the Distillation with a degree of Heat not greater than that of boiling Water, and keep this up as exactly as possible, as long as any Moisture comes away with this Fire; and by this means I have a thin, acidish Water that is very strong scented, which must be removed, and kept by itself. The Receiver being luted on again, if the Fire is gradually increased, there will come off another Liquor, still pretty thin, more acid, oily, and of a reddish colour, which must be carefully urg'd with the same degree of Fire, so long as it rises. This too may be kept by itself, and is pretty strong and odorous, smelling exactly like Herrings that are dried in Smoke. The Fire being rais'd still higher, and so kept up, will force out a red, pinguious Liquor, that is very acid, and with it a red Oil, which will swim upon that Liquor in pretty great quantity. And lastly, if you increase your Fire till the iron Pot of the Furnace begins to be red hot, there will then rise a Fume, and at the same time a thick, black, tenacious Oil, which will sink to the bottom of the former Liquor; and though you keep up your Fire to as great a degree as the Glass is able to bear without melting, yet still there will be Fumes floating about, urge it ever so long. Then lay some live Coals upon the Sand over the Retort, which is called (*ignis suppressionis*) a suppressing Fire, and let this be kept up so long as any Oil comes off, the Fumes however still remaining in the Receiver. This being done, let the whole spontaneously cool, and by this last extreme torture of the Fire you will yet have a small quantity of a very thick, black, heavy Oil, not unlike Pitch.

3. Make a little Bag of Filtering-Paper, place it in a glass Funnel, and pour into it the Water that comes first off from the *Guaiacum* without any Oil, that the Bag, when it comes to be wet, may transmit this Water, to be kept by itself.

This

This is acidish, thin, penetrating, and has somewhat of a burnt Smell, resembling that of Herrings dried in Smoke. Let the second Water then be filtered thro' the same Bag, and it will pass through reddish, limpid, acider, and much more acid, having a disagreeable Smell, coming much nearer to that of smok'd Herrings, and exhaling somewhat empyreumatical: And if there happens to be any Oil amongst this second Water, that will be stopp'd in the Bag, for when it is once thoroughly wetted with the first Water, it will not suffer any Oil to pass through it. When this is done, pour in the Vinegar, and third Spirit with its light Oil, and the Vinegar will immediately run through, red, limpid, acid, and acid, having a burnt empyreumatical Smell, and the Oil will swim at top of the Liquor in the Bag, for which reason it is necessary to keep the Bag always full, by continually pouring in more of this oily Liquor, that the Oil may be kept from sinking down to the bottom, by which means you'll be able to prevent any of it from running through with the acid Liquor. When almost all the Liquor is thus filter'd, move the Funnel and Bag immediately into another Vessel, before the Oil begins to insinuate itself through the Paper, which will happen as soon as ever this comes to be dry: And this light, thin Oil may be poured out of the Bag into a Vessel by itself. Then take the last Oil with its very acid, fetid, pinguious Liquor, and pour it into the Bag whilst it continues wet with the former, and there will run through a red, acid, limpid Liquor, a thick, black, pitchy, heavy Oil remaining in the Paper, which, as the former, may be then poured out, and kept by itself.

4. If these acid, aqueous Liquors are put into clean glass Vessels, they generate an oily Crust on the bottom and sides of the Vessels, which gradually increases, whilst the acid Liquor at the same time grows by degrees less and less oily. Hence then it appears, that this distill'd Vinegar is composed of Water, an Acid, and an Oil, and consequently, that this Liquor with the greatest justness shou'd be call'd an oily, saponaceous, volatile, acid Salt. If this acid Liquor, when it is exceeding limpid, nor discovers the least visible Oil, is poured upon pure Chalk, it produces an effervescence, deposits its Acid in the Chalk, becomes Water, and at the same time discovers an Oil, before latent, which it casts up to the top. And if you take the same Liquor, and distill it afresh with a gentle Fire, there then too is separated an Oil, which did not appear before, and you have a pure, acid, limpid Liquor remaining.

5. If a Person has a mind to carry these Oils to greater perfection, after he has collected a proper quantity, he must distill them with boiling Water, by which means the purer part will ascend, whilst the thicker remains at the bottom. And if this is repeated, they gradually approach nearer and nearer in goodness to the former essential Oils, the inert, terrestrial part, in particular, being separated from them, whilst they themselves become thin, limpid, of a beautiful red colour, exceeding penetrating, pure, and not fetid.

6. When, by the methods above-mentioned, all the volatile parts have been forced out by the extreme and long-continued action of the Fire, there will then always remain in the Retort a very black, light, insipid *Caput Mortuum*, which has very little Smell, and is very brittle. And this is the true Coal of *Van Helmont*, which, urge it ever so long with the intensest Fire in a close Vessel, can never be reduced to white Ashes, but will continue black, and purely on account of this blackness, will always remain inflammable: For
that

that which gives it this blackness is an exceeding fixed Oil, which very tenaciously adheres to an Earth, and is spread very finely over its Surface, and hence is properly disposed to receive and support Fire, 'till it is consumed. To demonstrate now this before you, in this earthen Dish I spread this black Mass just as it comes out of the Retort, and in the middle of it lay a live Coal, and you see it is raised into a bright Fire, which, spontaneously spreading itself on all sides, converts all the black parts into pure Fire, and then into Ashes, so that the whole Rasplings, by the propagation only of one small spark, are gradually consumed into Ashes. Nor perhaps can this easy accension of Wood by so small a Fire be easily brought about in any other manner than by first reducing it to a Coal, and then breaking this to Powder. These white Ashes now, thus prepared from *Guaiacum*, are inodorous and almost insipid; but from the green Wood treated in this manner they considerably abound with an alkaline Salt.

U S E.

IN this Operation we learn a good many very remarkable things, which instruct not the Chemist only, but the Physician, and natural Philosopher likewise.

1. For Instance, we hence discover the nature of that smoky Vapour, which first exhales from green Wood, when it is laid on the Fire, before it grows black, flames, or is red hot: For in this case there exhales an acid Water, considerably acrid, which makes the Eyes smart, and penetrates any animal substances that are hung in the Chimney, and so preserves them from putrefaction. A Liquor very much like this too is collected from green Wood, when you lay a long Stick on the Fire in such a manner that both ends shall be out of it; for then the Fire fusing the Juices in the middle, drives out a large quantity of an acidish Water at the ends, greatly resembling that which first rises in Distillation.

2. Hence appears likewise the Nature of that smoky Vapour which rises from dry Wood, when that is laid upon the Fire, and which comes from green Wood, when the Vapour just described is all gone off, that is to say, before either of them begin to be red hot, or Flame; for this smoke is denser, more acrid, acid, and heavy than the former, contains more acid Salt in it, and begins to grow a little black; and hence it makes the Eyes smart a good deal worse. Flesh and Fish hung up in the Chimney, it penetrates more effectually too, prevents their corrupting, and in some measure tinges them of a red colour; and hence it must carry up some of the first Oil of the Wood along with it.

3. But from the preceding Operation we understand farther, the nature of that thick, black, and very acrid Smoke, which rises from Wood when it is just ready to burst out into Flame; for this contains a large quantity of a very acrid, fixed, acid Salt, together with the first, second, and third pitchy Oil, which being in this Smoke all blended together, give the Eyes an intolerable degree of pain. This likewise penetrates the Bodies that are exposed to it, and by its acid Salt secures them from corruption, but at the same time makes a greater alteration in them by giving them another Smell and Taste.

4. Hence

4. Hence then it is evident, that Vegetables afford a Water, in which there is contained an acid, oily, volatile Salt, which being thus pure, has a very penetrating, aperient, attenuating, antiseptic, detergent, and saponaceous Virtue, on which account it is antiscorbutic, diuretic, diaphoretic, and sudorific, especially when it is properly depurated, and rectified. Externally, it is of service likewise.

5. Who cou'd have believ'd now that simple elementary Water could for Years remain in Wood, united with its other Elements, in a hard dry form? I distilled once some Raspings of *Guaiacum* that had lain some Years in the open Air, and hence were grown as dry as Sand, and the acid, aqueous Liquor, which was sufficiently pure, being collected by itself, easily gave out its Acidity into Chalk, or a fixed Alkali, and setting aside a strongish Smell, which remain'd in it, became a pretty pure Water, of which there was a considerable quantity; which Water therefore was concreted with the *Guaiacum* in *America*, remained united with it so many Years, and actually helped to compose that very heavy, hard, dry Wood, but upon distillation recovered its original form of Water. Hence then we see evidently, that Water may lie wonderfully conceal'd in union with Bodies, where one would not have the least suspicion of it, nay and actually be the cause of their Hardness; for as soon as ever the Water is separated by Fire from the other parts, they immediately grow soft, and brittle, nor cohere with any considerable force, though before, whilst the Water remained among them, they together form'd a Wood almost as hard as Iron.

6. And here we observe, that the mixture of different Elements, in a certain proportion, will produce compound Bodies very unlike those Elements.

7. But hence it appears yet farther, that Water, an acid Salt, a Spirit, Oils, and Earth, are so intimately mixed, and tenaciously united together by Nature in the production of Vegetables, that they will not only remain so for Ages, as we see in Cedar, *Guaiacum*, Juniper, and others, but will in Distillation likewise rise together; for we find that Water is contained in the Oil itself, and Oil in the Water, though without any visible mark of their being there.

8. And lastly, hence we learn likewise, that there is in Vegetables an exceeding fixed Oil, which, when all the volatile parts are intirely expell'd, remains united with an Earth, and that matter, which by an open calcination is converted into a fixed Alkali: That this Oil cannot, in a close Vessel, be separated and forced out by any degree of heat whatever, but continues of an exceeding black colour, nor discovers in the Mass the least sign of oiliness: That this is very finely extended over the Earth, and fixed Salt, and hence will take fire so easily, that if the least Spark falls amongst it in the open Air, it will receive and propagate it to every part: That this Oil yields a Fire that is not very smoky, but that has a balsamic, aromatic Smell; and that this small quantity of Oil, so long as it remains, prevents the Salt's being separated from the black Coal, which Salt, when the Oil is consumed by Fire in the open Air, immediately discovers itself in the Ashes that are left behind. These things then being properly attended to, teach the proper nature of a vegetable Coal; and why the Powder of it by being mixed in Chemical Operations with the Bodies to be operated upon, often produces such unexpected and extraordinary effects, especially upon sulphureous ones. Hence we understand too, that the fixed Alkali of these Coals is generated slowly, nor till all the inflammable parts are consumed by the strongest effect of Fire in the open Air: That the last Oil is so intimately united, and tenaciously retained

retained by the fixed Matter of the Plant, that it cannot be disengaged and separated from it by the sole action of Fire, but only when the Air concurs with it: And that hence, in Distillation perform'd in close Vessels, the volatile parts may be drawn off, viz. the Water, Spirit, acid Salt, and a two-fold Oil, and together with all these, a good deal of Earth, but that there will still remain at the bottom, the fixed Oil of the Coal, that matter which by an open Fire is convertible into a fixed Alkali, and more Earth in a large quantity. Thus then we see the Effect of Air and Fire uniting their influence, and acting together upon Vegetables.

9. This Experiment holds universally in all Trees, Shrubs, and a great many Herbs, which being treated in this manner, yield all these volatile and fix'd parts; for in all these there is a volatile acid Salt, and a Matter, which being burnt in an open Fire, will yield a fixed, alkaline one. The fresh Twigs of the Vine, cut in the beginning of *March*, afford in Distillation a large quantity of an Acid, as the *Caput Mortuum* burnt does of a fixed Alkali.

P R O C E S S XXXIII.

Water, Spirits, an oily, alkaline, volatile Salt, an Oil, and a Coal, procur'd from Mustard-seed by Distillation in a Retort.

A P P A R A T U S.

1. **E**VERY body knows that there are both parts of Plants, and whole ones, which, if they are bruised, or scrap'd, give out a very acrid Vapour, which stings in the Nose, and makes the Eyes smart and water, and at the same time discovers a very pungent Smell. Of this kind are the Bulbs of Garlick, Onions, Hyacinths, Narcissus's, Leeks, and Squills. Some Roots too have this property, as the Garden Radish, especially the thick, round one, both white and black; and some Seeds likewise, as those of the Wild Radish, Scurvy-grass, Rockets, Flix-weed, Radishes, Mustard, and Mithridate Mustard. But there are a great many whole Plants too that are also referr'd hither, the chief of which are Jack by the Hedge, Garlic, Cuckow-Pint, the Asphodil, Cabbage, Briony, Onions, Camomile, Celandine, the Rock-Rose, Scurvy-grass, the Wild Cucumber, Sow-bread, Dutroy, Rochets, Flax-weed, the *Indian* Tithymal, Herb Robert of the Wall, Clary, Hyacinths, Henbane, Orris, Dittander, Lilies, Hops, the Love Apple, the Mad Apple, Cresses, Satyrion, Poppies, Ranunculus's, Cherlock, Water-germander, Mustard, the biting Stone-Crop, Tabacco, the Deadly Carrot, Hedge-Mustard, and Spurge: If you treat any of these now in the same manner, you have pretty nearly the same success, as you have likewise with most virulent, caustic Plants.

2. From among these now, I take the common Mustard-seed thorough ripe, and filling a Retort with it to the bottom of the Neck, lute on a pretty large Receiver, and gradually distill with a Sand Heat. The first Liquor then that comes off, is oily, and of a yellowish Colour, and being collected by itself, is limpid, and acrid. The Fire being then increased, there rises another Spirit like the former, but more yellow, and at the same time a light and a very pinguious Oil. These again being sav'd by themselves, are very acrid. The

Receiver being again luted on as before, I make the Fire stronger underneath, and at the same time lay live Coals upon the Sand above, by which means there ascends from the remaining Mass a large quantity of a light black Oil, and, at the same time you have an oily alkaline volatile Salt all about the sides of the Receiver, collected into little spots, as usually happens in the distillation of Hartshorn. If you then keep up the Fire in this degree for a great length of time, there will always rise something of a Vapour of a whitish Colour; and at last there will be left in the bottom of the Retort, an exceeding black Mass, form'd as it were of the melted Seeds, which will be very light, bitter, and not Salt.

3. If you take the first and second Spirits, and in a clean Retort distill them again with a gentle Fire, they yield a limpid, acrid Spirit, pretty much like that of Hartshorn, and used nearly for the same medicinal purposes; and at the bottom of the Retort there remains an oily, fetid Water.

4. If from the last Liquor and Salt, you separate the Oil, and then wash off the Salt that adheres to the sides of the Receiver with the rectified Spirit just mention'd, you will have a Liquor impregnated with a volatile alkaline Salt, which with Acids will cause a strong Effervescence: And if you then distill this with a gentle Fire in a tall Vessel, it will by this Rectification yield a pure volatile Salt, like that of Hartshorn.

5. All the Oils thus drawn off, have constantly the fetid rancidness of distill'd Oils, but by Rectification become purer, and less disagreeable, being resolved by this means into a great deal of Earth, and an Oil, which upon every Operation grows more and more pure.

6. What remains at last at the bottom of the Retort, appears to be a true Coal. But when you reduce it to a dry Powder, it always continues to be sub-pinguious, nor upon the application of a Spark to it, will it take Fire as the Coal from the *Guaiacum* did, in which property therefore these two differ from one another. If this is burnt in an open Fire, it leaves a little Earth, in which there is hardly any thing of a fix'd Salt, as far as I, upon Examination, have been able to discover. I have been inform'd however, by Persons of undoubted veracity, that a large quantity of this Mustard-seed Coal being reduc'd to Powder, and urged for a great length of time, with an intense Fire, in an earthen coated Retort, has at last, like Urine, yielded a true Phosphorus.

7. If all these Observations, then, which are pretty remarkable, are compar'd with what we shall hereafter demonstrate in the analytical account of Animals, it will plainly appear, that this sort of Plant, and those mention'd in the beginning of this Process, have such an agreement with Animals, with regard to what is produc'd from them by a chemical *Analysis*, that they differ very little, if any thing at all; unless, perhaps, from animal Substances there is drawn a little more Water that has no Oil in it, tho' it is not improbable but this too wou'd be the case in Mustard-seed, was it distill'd green. In the mean time, however, this we are sure of, that if a Mustard-seed is sown in the Ground, from the Juices that it draws out of it, it will produce a Plant, which will so dispose the matter of Vegetation, that by a gentle action of the Fire, it will be converted into a volatile alkaline Salt; and consequently, that this Salt is not so proper to Animals, but that it is found in some Vegetables likewise. Nay, this alkaline Salt appears more openly in Mustard-seed, even without Fire, than

it does in Urine, which of all the animal Liquors is the most alcalescent: For I never yet cou'd procure any fresh human Urine that wou'd cause an Effervescence with Acids, tho' good Mustard-seed will, by only being pounded and mix'd with strong Vinegar. Hence, therefore, it appears, that a true oily, alkaline, volatile Salt, may be extracted from crude fresh Plants, without any previous putrefaction, and that as well from those that are found in the Water, as Scurvy-grass, Water-mint, and Horse-radish, as those that grow in places where there is a great deal of Dung, as Rockets, Flix-weed, and Mustard. Who now cou'd have imagin'd, that a volatile alkaline Salt shou'd be generated in Water?

8. From what has been said then, Physicians may be able to judge with certainty, in what cases these Plants will prove beneficial. In those Distempers where there is too great a quantity of an inert, insipid Water, or a cold insipid *Pituita*; where an Acidity prevails in the Juices of the first Passages; where the Bile don't properly perform its Office; and hence the whole Body is cold, heavy, and inflated; if there is no oily, alkaline, putrid disposition of the Humours at the same time, these things, with prudent use, are of excellent service. But where there is too much Heat; an acrid Bile; a feverish Disposition; putrid Juices; an Inflammation; an Atrophy; or a putrid Scurvy: There on the contrary they do harm. And here it will be of considerable service, to examine the whole Vegetable Kingdom almost, as it is divided into those Plants that yield an acid Salt, and those which yield an alkaline one.

P R O C E S S XXXIV.

The separation of Oils from the other parts united with them in Distillation, on which depends their Rectification, Conservation, and Conversion into a Balsam and Resin.

A P P A R A T U S.

1. **I**T is necessary we shou'd have Oils pure and free from every heterogeneous Matter, in order to examine them in a proper manner, preserve them, and then likewise observe the alterations they undergo. This separation now is usually effected by the following Methods. 1. Of a spongy Paper make a conical Bag, fitted exactly into a glass Funnel, which must be set in the Mouth of a Bottle with some clean warm Water; wet this Bag in such a manner, that it may be penetrated quite through; and then pour in the Liquor in which the Water, Spirits, and Oils are mix'd together: The Water, Spirits, and the Salt dissolved in these then, will soon run through, and the Oil will remain in the Paper. Continue the pouring in of the Mixture till the whole is filter'd: But here you must observe, not to let the Oil be alone in the Paper, but always to pour in some more Liquor before all the Water of the former is gone through. By this means, you will at last have all the Oil alone in the Bag, which you must presently pour out into a proper Bottle, and keep by itself. In this way, however, there is a good deal of Oil hangs about the Paper, and is lost, and therefore for the more valuable, there is contrived another method of separation. 2. Take a glass Vessel with a long cylindrical

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Neck,

Neck, whose Mouth is widened a little into a rim; heat this, and pour into it the Water with the Oil swimming at top, till you have fill'd your Vessel quite full. After then it has stood quiet some time, the Oil will rise into the Neck, and the Water will be underneath. Gently pour off all the Oil, if you can, into another clean Vessel, but if you can't, put in again as much hot Water as you took out Oil, which descending to the bottom, will force up the Oil into the Neck of the Glass, whence you may pour it out again, and so proceed, till you have separated and collected it all. And this, by the heat, shaking the Vessel, and fulness of it, may be easily effected within a few drops. 3. But the same thing is done likewise by a glass Vessel, commonly called a separating Glass, which has at the bottom a long, narrow, cylindrical, open Pipe, which is kept stoppt till the Liquor is put into the Vessel, and all the Oil is risen to the top: This then being opened, the Water which is lowest will run out first, and when this is so far gone that the Oil begins to come into the Pipe, stop it again, pour in more of your Water and Oil, let them stand quiet, and the Oil will be collected at top as before, upon which open the Pipe and let out the Water, and so proceed till all the Oil is collected in the separating Vessel by itself. 4. But if the Oil is so heavy as to sink to the bottom of the Water, then if you put these into the separating Glass, after they have settled some time, the Water will be at top, and the Oil at bottom, which therefore you may let out at the Pipe as you did the Water before, and so separate it from the Water, and collect it together. 5. And lastly, if after these valuable Oils are thus separated, there is any Water still remaining upon them, it is necessary it should be taken off, otherwise it will make them mucilaginous: This then is done by making a kind of Tent with a piece of Cap-paper, wetting it thoroughly with warm Water, and then squeezing it out, and dipping the small end of it into the Water upon the Oil, for by this means it will attract that into it, and leave the Oil pure.

U S E.

1. **T**HE Oils being thus separated and collected together, must be put into clean, small, glass Vials, which must be exactly stoppt with glass Stopples, and then be set in a cold, dry place, and open'd as little as possible, for fear the Spirit, which gives them their vertue, and value, shou'd exhale. And if you mix a little of the perfectest Alcohol with most of these Oils, they become thinner, more ready for use, and keep the better. By this means, too, they are prevented from being afterwards so easily inspissated, that they won't drop conveniently out of their Vessels; as well as from growing mucilaginous. This likewise secures them from contracting any rancidity, which perhaps they might do otherwise; nay, if they are actually begun to be changed, by the affusion of Alcohol, they may be recovered again.

2. These Oils, however, by length of time, will be thickened to the consistence of a Balsam, and at last will harden into the form of a Resin. And this in particular is hastened by the *Spiritus Rectior's* exhaling, which happens chiefly from opening the Vessel too often, stopping it carelessly, or, which has much the quickest effect, by leaving it quite open, especially, if it stands in a warm dry place; for then they will in a shorter time be converted into a Resin. For this

this reason, therefore, I have sometimes been ready to doubt, whether it may not possibly be the Spirits that keep these Oils in a state of fluidity. I once my self put some such very pure, liquid, distill'd Oil into a Vial, and when about a year afterwards I had occasion to make use of it, I was surpriz'd to see how thick it was grown, for which reason, I set it by again, and made use of some other, and within three or four years, it acquired the consistence of a thick Turpentine, as you may here observe. Hence, therefore, if Bodies are dipp'd into distill'd Oil of Turpentine, and are then hung up in a place where there is but very little Dust, they will be cover'd over with a pellucid, resinous Crust, within which they will be so excellently preserved, that they will continue for a vast length of time uncorrupted.

3. By the method describ'd then, the proper Spirits of Vegetables being freed from all the other parts, but retained by the tenacity of the vegetable Sulphur, may be kept a long time for valuable purposes, and in a small compass be carried into other Countries with their Vertues intire. Thus, for instance, in a small Bottle that will hold all the Oil of a hundred pounds of Cinnamon, we can collect and preserve all its Vertues; so far, that is to say, as they depend upon its proper Spirit. And this seems to be the most natural method of collecting together the peculiar medicinal properties of Vegetables, in which they are very little altered or lost, and by which, in particular, they may be secured for a great length of time. By this instance, therefore, considered in its proper extent, was there no other, the chemical Art wou'd sufficiently recommend itself to the Physician.

4. As a great many of the essential Oils now are very valuable, there are not wanting Methods discover'd by the avaritious for their adulteration. In order to this, some Persons mix pounded Almonds with the aromatic Substances to be distill'd, the Oil of which uniting with their essential Oil, increases the quantity: The same thing too others do with beaten Poppy-seeds. But others who are appriz'd that the choicest of these Oils may be perfectly diluted with Alcohol of Wine, and that they will by this means become stronger, mix this with them, and thus make a base profit by increasing the quantity with something of vastly less value; tho' it's true, it does not lessen their vertues, but exalt them. The first of these cheats is discovered by mixing the Oil with hot Water, by which means the lighter Oil will be separated from the heavy aromatic one, this sinking to the bottom, whilst that rises to the top; as likewise by the admixture of the purest Alcohol, which will unite with the aromatic Oil, but reject the other insipid one: The second is found out by mixing cold Water with the Oil, for the Mixture will grow white, and the Oil and Alcohol be separated, and discover nearly the quantity of Alcohol made use of in the adulteration.

P R O C E S S XXXV.

Vinegar, Spirits, a twofold Oil, a Resin, and Colophony, procur'd from Turpentine by distillation in a Retort.

A P P A R A T U S.

1. **T**HAT the native Oils of Vegetables are neither simple, nor of a durable Nature, has appeared already; nay, from some Experiments we before explained to you the various Elements of which they consist, or those which by a Transmutation are produced from. We must now, therefore, take under Examination that Oil which spontaneously discharges itself, and is collected on the external parts of Vegetables under the name of a Balsam, or Turpentine. For this purpose, then, I take this clean new glass Retort, with a pretty large Neck, which I cut off in such a manner, as to have the Mouth of it pretty wide, which is altogether necessary for this Operation; and into an earthen Pipkin that has a spout below the Rim of it, I put some very pure, native Turpentine, set it in Water that is almost boiling hot, and let it stand there till it is melted, and runs like Water, upon which I immediately pour it into the Retort, which must be made very hot likewise, that it may not fly with the heat of the Turpentine. In this manner I fill the Belly of the Retort two thirds full, and then, if in pouring it in, any of the Turpentine has lodged upon the sides of the Neck, I hold the Retort with the Mouth upwards till it has all run down into the Belly, for otherwise this thick Turpentine in distillation would run into the Receiver, and mix itself with the Liquor that first rises, and by this means prevent a nice examination of it. I then put the Retort into a Sand Furnace, and lute on a clean Receiver.

2. This being done, I raise such a Fire as will give the Sand about 100 degrees of Heat, a little more or less, and this I carefully keep up as equably as possible, so long as any thing liquid continues to come over into the Receiver. By this means then I have a limpid, thin Liquor, like Water, which subsides to the bottom, and at the top of this another, which is subtiler, thin, limpid, and oily. When nothing more comes off with this degree of Heat, I change the Receiver, and upon examination find the lower Liquor to be gratefully acid, saline, watery, miscible with Water, spirituous, comforting to the Stomach, and a noble diuretic, and of such a nature as to cause an effervescence with Chalk, at the same time depositing its acid part there, and then distilling into pure Water. Hence therefore an acid Salt and Water rise first in this Distillation, together with the other Liquor that swims at top, which is a pure, light, thin, and almost spirituous inflammable Oil, called for this reason *Ætherial Oil of Turpentine*. And this is of so penetrating a nature, that if it is rubbed upon the external parts of the human Body, it will soon disappear, insinuate itself into the Blood, and in a short time give the Urine a violet Smell, and thus sufficiently evince its subtilty, and penetrability.

3. Luting on then a proper Receiver, let your Heat be increased to that of boiling Water, which is easily effected by pouring Water upon the Sand, and making such a Fire underneath, as to give it and keep it in 212 degrees of Heat,

Heat, observing to put on continually so much boiling Water, as exhales in Vapour. The matter, by this means, that remain'd at the bottom of the Retort after the former distillation, and was so thick, that in the cold it would acquire a solid consistence, will be melted again with a crackling singing noise, and will give out another acid Water, very much like the former, which will settle at the bottom, and another Oil that will swim upon it, exactly resembling the preceding, except that it is a little thicker, and inclining to the yellow. With regard to their Vertues likewise, they are both very much of the same nature with the other.

4. If you then change the Receiver again, and give the *Residuum* a pretty strong sand Heat, increasing it however very gradually, you will again have an acid Water at the bottom of the Receiver, which will be red, and heavier than the two former, and at top of this a thicker red Oil, still considerably penetrating, tho' in some measure, however, tenacious. And here it is pretty remarkable, that this acid Water continues to come over as long as any of this Oil does, the Water not rising first by itself, and the Oil afterwards. What remains, then, after the Distillation is over, is exceeding red, hard, and perfectly brittle.

5. This last *Residuum*, increasing the Fire very gradually, and adding at the same time a suppressing Fire at top, I urg'd with the strongest sand Heat, and there was forced out an Oil as thick and tenacious as Turpentine itself, but of a red Colour, and with this somewhat still of an acid, red, heavy Water. When this was done, there remain'd scarcely any thing in the bottom of the Retort.

6. And here give me leave to caution you, that the greatest care is necessary in this Distillation that the Glass don't crack, for if this happens, there immediately exhales a thick oily Vapour, which easily takes fire, and then can scarcely be extinguish'd, but rushes into the Retort, and with a violent Flame and Explosion bursts all to pieces, not without imminent danger to the Operator.

7. There is another method, likewise, which is commonly used for distilling Turpentine into an acid Water, an ætherial Oil, and a Spirit, as it is call'd, of Turpentine, and is as follows. The distilling Vessel of the Furnace, describ'd p. 512. Vol. I. is fill'd one third full of clean rain Water, into which is put half as much of the best Turpentine, and then the other part of the Still is fitted on with the Alembic, and you distill with a Worm and Refrigeratory, making no more Fire than what is just sufficient to make the Water boil gently: By this means then, there will ascend an acid Water, together with a light, pure Oil, and so long as any of this comes off, you must continue the Operation, which being compleated, you will have a kind of Colophony remaining in the Water in the Still. If during the Distillation you throw in some Roses, Flowers of Lavender, or other Plants, you will by this means procure a fragrant Oil. In this Operation, therefore, the Turpentine is resolv'd into a saline acid Spirit, a volatile Oil, and a more fix'd Colophony.

8. And here it is particularly remarkable, that the *Residuum* is always so much thicker, redder, harder, and more brittle, as there is more Water, Acid, and volatile Oil drawn from it; tho' even this last fix'd part, if it is urg'd with an intense Fire, will melt, and become volatile. This acid Water, now,

if it is perfectly freed from its Oil, and rectified, is perhaps one of the best vegetable Acids we are acquainted with.

U S E.

1. **H**ENCE we learn in what form native Oils are contained in Vegetables: For in the first place, the nutritious Juice, when it is first taken into the Plant from the Earth, appears to be nearly acidish and watery; which after it has entered its Vessels in certain parts of the Plant, gradually deposite its most pinguious Particles, which by a union with more of the same kind, heat, maturation, and the effect of the vertue of the whole Plant upon it, appear there in a pinguious-oily Form: And this very same Liquid being afterwards prope'll'd outwards, and being farther acted upon by the same causes, acquires the name of a Balsam, consisting of Water, a saline, subpinguious, acid Spirit, and various Oils, considerably blended together, but still capable of separation; and when any one particular part is by any means separated from the rest, the Balsam is always changed to something of a different nature from what it was of before. Hence then we see, what a vast difference there is in making use of a native Balsam in chirurgical and other medicinal Uses, whilst it is intire, and acts by all its Principles united together, and applying any of these by themselves, after they are separated from it. Certainly a native Balsam, dissolved a little with some Yolk of Egg, is one of the noblest external Medicines the Surgeons are masters of; as it is an excellent internal one too, for many Diseases sufficiently taken notice of by the Physicians. Nay, if it was only by the violet Smell which it gives to the Urine, it would sufficiently discover its wonderful penetrating quality. The Balsams we have now-a-days, are scarcely so much different in their Vertues as they are in their price, and the places where they grow. The principal are, the *Balsamum Asiaticum*, *Ægyptiacum*, *Feruchuntanum*, *Judaicum*, *Memphiticum*, *Opobalsamum*, which are all names for the same thing, and signify a Balsam of a white Colour, in a liquid form like Turpentine, and having a Smell resembling that of a Citron: The *American*, which is of various sorts and from different Trees; as the Balsam *Copaii*, *Capayaba*, *Capivi*, call'd *Moran*, of incomparable Vertues; Liquid-Amber; Balsam of Peru; Balsam of Tolu; *Mechaninn*: The true Turpentine of the *Cbian* Turpentine Tree; the *Strasburg* from the Fir; the *Venetian* from the Larch-tree, and the Common from the Pine: All which by Heat, Distillation, and Time, are pretty nearly resolved into the same Principles, undergo the same Alteration, and have the same Effects.

2. But hence we learn farther, likewise, that in all the Balsams hitherto known, there is an eager, acid, antiseptic, penetrating Water, or Spirit, which is very fragrant, and endued with considerable medicinal Vertues, but easily exhales, and thus quitting the Balsam, leaves it in this respect less efficacious: Hence these are not the better for keeping.

3. The Oils that rise first, which are light, limpid, totally inflammable, volatile, very penetrating, and bitter, are of excellent service in Surgery; for these being pour'd warm, upon torn, prick'd, divided, or half divided Membranes, Nerves, or Tendons, are found incomparable Anodynes, Antispastics, and Consolidants. In larger Hæmorrhages from wounded Arteries or Veins, they prove

prove the readiest, and safest Styptic, having this particular excellence, that they at the same time guard the Nerves, prevent Putrefaction, and consolidate the part. They must then be applied very hot, and be secured with a proper Bandage. Upon this head, you may consult that *English* Author *Jacob Young*, who wrote a whole Treatise about it, called *Currus Triumphalis, e Teribintbo*, printed at *London* in Octavo, 1679. And, indeed, the antiseptic Vertue of this Oil is very remarkable; for if you let any animal Substances lie in it for some time, and then take them out and hang them a little in the Air, and repeat this several times, they at last will acquire a Crust, under which they may be kept a vast while, being intirely secured from Putrefaction. And those Bodies, likewise, that are put into Vessels, and covered with this Oil, become quite incorruptible. This one inconvenience, however, attends it, that it grows gradually opaque, and thick. This warm Oil being rubb'd upon cold, mucous, viscid Humours, often discusses them: It defends the parts too against Cold, and relaxes and softens them. Internally it opens, warms, provokes Sweat and Urine, and gives this a violet Smell: Hence in the cold Fit of Intermittents it is a serviceable Medicine; nay, and by being rubbed upon the spine of the Back just before the Fit comes on, it does so much good, that even Quartans have been cur'd by it in this manner. It must be used internally, however, with moderation; for if it is taken in too great quantity, it affects the Head, causes Drought, and Pain, and urges the urinary parts so violently, that it raises a Diabetes, and provokes a discharge of the Liquor of the prostate Glands, and the Seed; and hence if used moderately, it generally incites to Venery. On this account, it has got a name for curing virulent Gonorrhœas, in which certainly it often proves of dangerous consequence, as the liberal use of it is apt to fire the genital Parts, and so increase the evil.

The Oils that are drawn off in this Distillation of a thicker Consistence, are less penetrating than the former, but more balsamic, and consolidating, sooth the Nerves more when they are in pain, and are more emollient: Hence in Persons of a warm disposition, and prone to inflammations, instead of the thinner Oil these are made use of as Styptics; in other respects their vertues are the same. But the last thick, tenacious Oil, is the most beautiful consolidant of all, incarning almost without suppuration, and being a most excellent Anodyne. This Oil will often cause such an Effervescence with *Glauber's* Spirit of Nitre, as to excite a Flame.

5. The *Residuum* of the Turpentine, after the Distillation with Water, or that which remains when you have drawn off the first Spirit and Oil in a Retort, is red, and in the cold will grow hard, pellucid, and brittle. If when this is melted, you carefully immerge an Insect into it, and take it out again, it will have a clear Crust all over it, like Amber, within which it will be preserv'd from corruption a vast while, and through which it will appear very elegantly, if the beauty of the polish is not injured, which will very easily happen, indeed, from the exceeding tenderness of this resinous Crust. But if you take the Colophony that remains after the second Distillation, this is still harder, and redder, and will easily suffer itself to be reduc'd to a Powder, which has neither much Smell or Taste. This is that noble Powder of so much service when apply'd to Bones that are laid bare, or the *Periosteum*, Tendons, and Muscles, when they are burnt, corroded, bruised, prick'd, torn, or half

cut asunder. This is an excellent Remedy likewise for serous Defluxions of the Joints, and most efficaciously helps to form a Citatrix; nor is it of less use in keeping down the fungous excrescences of Ulcers. Hence, then, it appears, how very serviceable Turpentine is to the Surgeons. But in this whole affair, there is nothing more remarkable, than the successive and spontaneous inspissation of the first thin Oil again into the former consistence of the Turpentine, then to that of a thicker Balsam, and at last to the solid one of a Resin, with this circumstance, however, always attending it, that there is less Acid in these regenerated Bodies, than there was in the native ones.

6. Is this native, volatile Acid, therefore, that resides in this pinguious, oily Liquor, and Water, of the same nature with the aromatic Spirit of other essential Oils? Certainly, in these native pinguious Substances, it is contained and mix'd in such a manner, that with the Water it lies conceal'd under one uniform Appearance: And hence native Balsams are converted into a true Oil, when this Water and Acid are separated from them. And again, when the Water, Acid, and Oil are drawn off, a Balsam is turn'd into a Resin. And this happens even in the external warm Air, for whilst the Action of the Sun dissipates the Acid, Water, and thin Oil, it is gradually inspissated, till it at last puts on the form of a Resin. Hence the same Bodies that are Oils in the Spring, in Winter become true Resins, and in Autumn prove a proper pinguious Tegument for the Trees, to prevent their growing dry, and to secure them from the injuries of cold and frost.

7. From this Operation, then, it evidently appears, 1. That the greatest Heat of the Sun, apply'd for a considerable time, is capable of inspissating liquid Oils through various degrees, till at last they are reduc'd to the solid form of a Resin or Colophony. 2. That the heat of boiling Water acting upon these Oils, is able to effect the same thing in a short time, forming a Colophony in the Still, within the space of four or five hours, the Vapours that rise in the mean time being an acid Water, a Spirit, and an Oil in great quantity. 3. That this Colophony being exposed to a Heat of 280 degrees, is resolv'd likewise into an acid Water, and a red, tenacious, heavy Oil, there then remaining a very hard Colophony, that is pellucid, of a blackish red Colour, and exceeding durable. And lastly, that if even this is strongly urged by the help of a suppressing Fire, kept up till the Glass is ready to melt, it will solely by the action of the Fire be totally converted into a liquid oily Matter, tenacious indeed, but truly liquid, and that, without any hard Colophony remaining behind. 5. Hence then we learn the transmutable Disposition of the Oils of Vegetables, and the various effect of Fire acting upon them: For if it is applied to thin Oils in a certain degree, it inspissates them into a hard, durable Mass, which will always remain so; and yet if it acts upon this very Mass in a greater degree, it will reduce it again to a liquid Oil, which likewise will always continue in that form, or at least for a great length of time, and which by a repeated Distillation with a strong Fire, will become perfectly liquid, and considerably thin: Hence then we see, that some Bodies owe their hardness to Fire, whilst others are indebted to it for their fluidity.

PROCESS XXXVI.

Water, Vinegar, a fetid Spirit, and a Butter, drawn from that Balsam collected by the Bees, call'd Wax, by distilling it in a Retort.

APPARATUS.

1. **S**OME sorts of Balsams being concocted and inspissated by the Heat of the Sun, appear in very small quantities on the Leaves of some Plants, as is evidently seen on those of Rosemary: And there are others likewise which issue in exceeding fine Globules from the open seminal *Apices* of the male part of the Flower. These it is scarce possible for us to collect by any Art whatever. But I remember once, when I was cohobating some Rosemary Leaves with Alcohol, I found, that the Spirits which were good before, had acquired a disagreeable Smell and Taste of Wax. I examined therefore the Leaves with a Microscope, and I thought I evidently saw some little lumps of Wax upon their surface, and upon handling them a good deal, I found plainly that the Wax gradually gathered upon my Fingers. Wax therefore seems to be a *Species* of Turpentine, which the pinguious Juices of Plants when they are heated by the Sun discharge upon the surface, or which is generated in the *Capfulæ* of the *Apices* of the Flowers: This the Bees collect together, roll up into little Balls, dispose upon their hind Legs, carry to their Hives, and form their Combs with, and this being afterwards separated from the Honey, and freed from its impurities, serves for a great many uses in human life. For the most part, it is of a yellow colour, and of a Smell and Taste not disagreeable: In extreme Cold it grows hard, and almost brittle; in Heat it grows soft and melts.

2. Take some of the best of this sort of Wax, and cutting it so small that it will easily go into the mouth of the Retort, fill it half full, and then fill up the remaining half with very pure Sand. Heat the Retort gradually, 'till the Wax is dissolv'd, and has sufficiently imbib'd the Sand, and then place it in a Sand Furnace, and lute on a Receiver.

2. Distill with a Fire gradually increased, and then there generally in the first place rises a small quantity of an acidish Water, that has a very disagreeable, fetid Smell; and together with this, a Spirit.

3. When with a Heat of 214 degrees nothing more will come off, change your Receiver, increase your Fire, and there will gradually ascend a thin Oil, which in the Receiver will harden like Butter, and be of a whitish colour. When this ceases to rise, apply the strongest suppressing Fire, and then the whole substance of the Wax will come over into the Receiver, where it will acquire the solid form of Butter, having changed the hard brittle disposition of Wax for a soft pinguious one. The Sand is here added in so great a quantity in order to prevent the flatulent rarefaction that wou'd otherwise happen when the Wax came to boil.

U S E.

HENCE then it is evident, that the whole Body of the Wax will become volatile in a certain degree of Heat, as appeared before in Turpentine, so that in this particular these both agree with Camphire, tho' this indeed is much more volatile than either of them. Wax now tho' it is totally inflammable, exists in a hard, and almost friable form. Nay when it is melted in hot Water, press'd through a Cloth, form'd into thin Cakes, and whiten'd by being exposed to the Air, and Sun, and often sprinkled with Water, even then the white Mass may be intirely consumed into Flame, and yet it is at the same time as brittle almost as Glass, and seems to resemble nothing less than Oil. In what a variety of forms, therefore, do the inflammable Oils of Vegetables exist, viz. that of an Oil, Balsam, Resin, Pitch, dry Tears, Wax and Butter; though here we see indeed that the Fire at last will produce liquid Oils out of what did not appear Oils before: This the preceding Distillation of Colophony, and the present of Wax most evidently evince. The Wax now when it is thus converted into Butter, does not recover again its former hard consistence, for the Butter always remains soft, even in the extremest Cold. This I don't assert without sufficient authority, for I distill'd myself some of this Butter from Wax, and kept it more than twenty Years in a cylindrical wide-mouth'd Glass, which was covered only with a Paper, and yet in all that time it was not returned to Wax, though we see that the exceeding liquid Oil of Turpentine will in a short time be reduced to the thickness of a Turpentine. Don't you admire therefore the various action of Fire upon the oily parts of Vegetables? Certainly there can be no general rule laid down, with regard to its power upon them, that will always hold true. Camphire, we see, which is a perfectly pure inflammable Oil, rises true Camphire in Distillation, and does not become a liquid Oil.

Butter of Wax, prepared in this manner, is an exceeding soft, anodyne, neurotic, emollient and relaxing Ointment, which excellently secures the Skin from being dried and chapp'd in the Winter, and does service if it is rubb'd upon parts that are contracted: Sharp hæmorrhoidal pains too are greatly reliev'd by it.

P R O C E S S XXXVII.

Butter of Wax, by being distill'd again in a Retort, converted into a liquid Oil.

A P P A R A T U S.

MELT Butter of Wax with a gentle Heat 'till it is perfectly dissolved into a liquid Oil. Pour this melted Butter through a hot Funnel into a glass Retort, heated likewise, till you have fill'd it half full, taking all the care possible that none of it hangs to the sides of the Neck of the Retort, for then it wou'd come thick into the Receiver, which we here endeavour to avoid. Place your Retort in a Sand Furnace, lute on a Receiver, and distill

distill very cautiously, regulating your Fire in such a manner, that there may be about the distance of six seconds betwixt the Drops. When you perceive that you have no more Drops with this degree of Heat, increase your Fire, and distill by the same rule; and this must be repeated, always increasing your Fire with the same caution, as long as there remains any of the Butter in the Retort. By this means then the Butter will rise, almost without any *Residuum*, and in the Receiver, instead of the Butter, you will have a thick Oil, very little lessened in quantity. If this Oil of Wax, thus prepared by a second Distillation, is distill'd again in the same manner, it grows liquider, softer, clearer, and thinner, so that at last it resembles a limpid, subtil Oil. And here the oftener the Distillation is repeated, the softer and more mild the Oil grows, and yet at the same time the more penetrating.

U S E.

HENCE then it appears that the action of Fire upon some oily substances of Vegetables, attenuates them continually more and more, nor gives them at the same time any degree of Acrimony, but on the contrary renders them constantly milder, and yet of a more penetrating nature. This last Oil of Wax is an incomparable remedy for any injuries of the *Papillæ Nervosæ* of the external part of the *Cutis*; for in Chaps of the Lips, Nipples, or Hands, if it is gently rubb'd over now and then, there is hardly any thing that equals it. In discussing cold Humours too, that happen in the Face and Fingers in cold Weather, it is used with success. And where the Tendons are contracted, and occasion stiff Joints, this Oil, assisted by Baths, Fomentation, and Motion, proves greatly serviceable in restoring them to their natural Flexibility. If it is rubb'd frequently upon the Belly, it relaxes the Bowels, and disposes them to discharge their contents, and hence is an excellent Remedy in Diseases of Children.

P R O C E S S XXXVIII.

Medicinal Elæosacchara.

A P P A R A T U S.

1. **A**FTER the Physicians had learned from the Chemists that the Spirit which resides in essential Oils truly contains, in a small compass, all the particular Vertues of Vegetables, they thought with a great deal of reason they were masters of a noble Medicine, but which however had this inconvenience, that the natural make of the Oils made the use of 'em a little dangerous, as from their visciditity they would be apt to adhere to particular parts, and being very acrid, would readily inflame them. They began therefore to think of some method by which they might be disposed to be diluted with Water, and thus in a uniform mixture be conveyed without any inconvenience to the places they were designed for; and this they found might be effected by the help of Sugar, in the following manner. Take an ounce of the driest Loaf-Sugar, and in a glass Mortar, with a glass Pestil, reduce it to an exceeding fine Powder,
4 into

into which drop gradually a Drachm of essential Oil, or, if it is very thick, half a Drachm, keeping it continually rubbing after every drop of Oil, till they are perfectly mixed, by which means the Oil will totally disappear, being all absorb'd by the Sugar. And here the Oil, during the Operation, will diffuse a very fragrant Smell, for which reason it is proper to be as expeditious as possible, and keep the Mortar covered as close as you can with a Cloth.

2. If during the rubbing, you add a little Yolk of a new-laid Egg, the Oil will be more easily reduced to a form fit for mixing with aqueous Liquids, but then it won't keep so long without growing rancid.

3. Thus then Sugar, which is a very pure *Sapo*, or a true essential oily Salt, destroys the pinguious tenacity of the Oil, interposes itself betwixt its Elements, and very closely unites them with itself, and thus produces an extemporaneous Soap, which suffers itself to be well enough diluted in Water for medicinal uses. This indeed, it must be confess'd, won't mix so perfectly and intimately with Water as true Soap will, or as what the Chemists call a perfect essential Salt, tho' for common purposes it answers the end very well. Nor is there any ground to fear any inconvenience from the Sugar in this preparation, for though Sugar has got an ill name, as if it was prejudicial to the Health, this has never been sufficiently proved. On the contrary, it is a wonderful Salt that is perfectly soluble in Water, nay and with Water will readily ferment and produce a Wine. In the mean time, however, which is pretty surprizing, if it is melted at the Fire, it discovers an oilyness which is perfectly inflammable, so that hence it appears to consist of an Oil and a Salt.

4. If these *Elæosacchara* are well prepared, and put pretty dry into glass Vials, and stop't nicely with glass Stopples, they may be kept for a long while without alteration. And thus, without any inconvenience of weight, you have a portable Medicine of excellent Vertues in a small compass. And it has this great convenience in it, that you may at once, without any loss of time, procure a noble medicinal Draught from it, by only mixing a little of it thoroughly with a glass of Wine. The same thing may be effected too by well rubbing a fixed alkaline Salt with an essential Oil; for by this means likewise you will have a Soap; but then the Alkali's take away the gratefulness of the essential Oils, by altering their proper Smell and Taste: And then besides, as they immediately dissolve in the Air, they presently change. Hence then the Physicians may compose a very beautiful and efficacious Medicine: For if an *Elæosaccharum* made with Oil of Mint is dissolved in its distill'd Water, and this is quickened with a proper quantity of its Spirit, and sweeten'd with some of its Syrrup, in this Mixture, it is my opinion, you will have the proper Vertue of Mint.

U S E.

HENCE then we see the saponaceous quality of Sugar, by which it is capable of breaking and dividing Oils in the same manner almost as if they were fermented with it; and yet at the same time, it does by no means diminish their particular Vertues, but rather improves and exalts them: The Ancients, who knew nothing of Sugar, mixed Honey with these Oils for the same purposes. But hence we see likewise the power of Sugar in the human Body;

Body; for being diluted by the aqueous Juices it meets with there, it produces a saponaceous *Lixivium*, which being assisted by the vital Powers, is capable of dissolving viscid, oily concretions; and hence it never generates any pituitous Matter, but actually divides and resolves it when it is formed. Nor does it ever increase the quantity of Bile, or is converted into it, but it divides, attenuates and opens. In the mean time however, by too much dissolving the Oils, it may make a person lean, as by attenuating too much it may bring on a weak, lax habit of Body; and hence to Ricketty Children, and Persons troubled with the Scurvy, it has often been observed to do harm. This singular production now of Nature and Art, if we examine it, is of a pretty wonderful Nature, as I just now hinted; for it totally dissolves in Water; it melts on the Fire; it shoots into perfect Crystals like the purest Salt; it is evidently oily; if it is distilled in a close Vessel, it yields an acid, penetrating Spirit; in an open Fire it is intirely inflammable; it will ferment, and is then converted into a very strong Wine that will cause Drunkenness, and yield an Alcohol; and it will produce the sharpest Vinegar. These things considered then, is it a Salt? How comes it then to take fire and flame? Is it an Oil? How then can it crystallize? Is it an essential Salt? Why then will it ferment? Examine carefully, Gentlemen, the whole compass of Nature that we are at present acquainted with, and I am of opinion, you'll hardly find any other Body in which all these three circumstances meet together.

P R O C E S S XXXIX.

Medicated Potions from Pr. 9, 10, 15-18, 23-31.

A P P A R A T U S.

1. **T**HIS Process, as the preceding, is chiefly for the use of Physicians, and teaches how to apply the known Vertues of Plants to the human Body. Take then of any *Elæosaccharum* one drachm, of *Tachenius's* Salt carefully prepared two drachms, nor does it much signify from what Plant it is made, as there is so very small a difference betwixt them. Rub these together for a good while in a glass Mortar, till they are accurately mixed, and then add six ounces of the cohobated distill'd Water of the same Plant the *Elæosaccharum* was prepared from, and if the Syrup of the same is to be had in the Shops, it may be sweetned with that likewise. By this means then you will have the Vertue of that Plant collected in a small compass, which will act medicinally in the human Body, according to its proper nature. Nor is there any reason at all to be afraid, that the Salt will give it any other quality, for in our account of *Tachenius's* Salt it appeared, that the particular quality of any Vegetable, with regard to its Salt, does not reside in this Salt, but its proper essential Oil, whilst the Salt is contained rather in a Matter common to others. If a Person therefore, in order to make such a mixture from Cinnamon, shou'd take the pains to burn the Cinnamon, on purpose to mix the Salt with the Oil, he would certainly be at more trouble and charge than the goodness of the production would compensate.

2. Thus then you have the concentrated Vertues of any particular Plant: For the elementary Water, which is contain'd in Plants, is intirely the same in all, and therefore makes no alteration in the Effect; and the Salt by being burnt loses its proper quality, and acquires one nearly common to all, and consequently from every Plant has much the same Operation: To the *Spiritus Rectior*, which resides in the Oil, and which you possess in this Mixture, are owing all the proper and peculiar Vertues. This therefore is a very convenient, useful, and efficacious preparation, if one first rightly knows the properties of any Plant, with respect to the human Body: For here you have a *Species*, tho' a less perfect one, of a saponaceous, oily, essential Salt of Plants, in which the famous *Helmont* placed almost all the efficacy of Medicines. If these Oils, according to that Author, are, by an occult Circulation, intimately united with their Salts into a compound form, you will then have a *Liquor* which is a *succedaneum* to the *Alcabeft*: But in these Mixtures you have a *succedaneum* to this *Liquor* of *Helmont*.

U S E.

THE Dose of such Medicines is determined particularly from the strength of the Oil made use of. They are generally best taken upon an empty Stomach, respect, with regard to time, being had to the nature of the Distemper they are prescrib'd for. Thus, for instance, if I would cure a simple Tertian that's very cold in the beginning of it, about two hours before the Fit is expected, I order the Patient to set his Legs and Thighs in hot Water, till he is moderately warm; then I give him half an ounce of a Mixture of the Water, Oil, and Salt of Wormwood every quarter of an hour, and take care he has his Legs and Thighs well rubb'd. This must be continued for the space of two hours, and by this method almost all these Intermittents, even in old Persons, are cur'd safely and conveniently, except there happens to be any thing schirrous in the case, or suppurated Matter. The same Mixture from Tansy, taken upon an empty Stomach, is good against Worms; but here, instead of Salt of Tansy, which is not so easy to be had, we substitute that of Wormwood. And thus in many other Distempers.

P R O C E S S XL.

Sweet-scented artificial Balsams, made with distill'd Oils (23---29) Wax and Pomatum.

A P P A R A T U S.

1. OF the best Pomatum I take one Ounce, and in a *China* Cup melt it over a gentle clear Fire, and then gradually add a drachm of white Wax seraped very fine: When these are accurately mix'd together, I leave them till they begin to come to a consistence, and then drop in one drop of an essential Oil, keeping them constantly stirring, that they may be thoroughly mix'd together. As soon as ever this is effected, I set the Cup in cold Water, that the Balsam by cooling presently, may the better retain the Oil and Spirit. When the

the Mixture is cold, it may be put up into tin or leaden Boxes that shut very close, and so may be kept for years without spoiling. If instead of Oil and Wax, you take the express'd Oil of Nutmegs, that is wash'd till it is white, and has lost all its Smell and Taste, it will answer the same end; and this is the way indeed it is commonly made.

2. If a Person has a mind to make these Balsams of various and beautiful Colours, he may easily do it by mixing some pigment with them. Thus, for instance, if with an ounce of such Balsam you mix a scruple of very fine powder'd Cochineal, it will be of an agreeable purple: If you add a little of the inspissated Juice of Buckthorn-berries, your Balsam will be green: A little fine native Cinnabar will make it of a beautiful red; as Powder of Turmeric will give it a yellow Colour; and Smalt a blue one. Every Person, therefore, may make use of what pleases him best, so he don't add any thing that has a disagreeable Smell, or will help to corrupt these pinguious substances.

U S E.

AS these things are in great esteem on account of the fragrance of their Smell, and are of service to quicken and raise the Spirits when they are languid, it is proper to make them of the choicer sorts of Oils, either alone, or artfully compounded together. Of this sort particularly, are the Oils of the Peel of Sevil, and China Oranges, Cinnamon, Citron-peel, Cloves, Cedar, Jessamy, Lavender, Rose-wood, yellow Sanders, white Lilies, Marjoram, Baum, Mace, Nutmegs, Origany, Roses, the *Syringa*, Balsam of Peru, and Opobalsam, the two last of which are fragrant without Distillation. Other Oils too, that are easily to be had, are fit for making extemporaneous Balsams.

P R O C E S S XLI.

Any Meal, even that of corrupted Corn, call'd Malt, being distill'd with Water, yields an inert Water.

A P P A R A T U S.

TAKE the Meal of any Corn whatever, and reduce it with clean Water to a thin Pap, and then in glass Vessels distill it with a gentle Fire, taking care it contracts no *Empyreuma*, and there will come off an insipid Water, which will contain nothing at all of inflammable Spirits. Or take the Meal of corrupted Corn, as *Tacitus* called it, or Malt, which we shall presently describe, and treat it in the same manner, and you will have a malkish Water as before, in which there will not be the least appearance of any thing Acid, Alkaline, Oily, or Spirituous. And if you mix crude Meal and Malt together, the Event will be perfectly the same.

U S E.

HENCE then it appears, that volatile inflammable Spirits do not actually exist in mealy Vegetables before they have undergone a fermentation,
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nor yet in that Matter, which has been prepared by that sort of dry Fermentation by which Corn is made into Malt. Neither does the Nutritious part rise in Distillation with the Water from fresh mealy substances; for if you examine the Vapour of this Water in the Alembic, you find it forms itself into a kind of dewey Drops, and does not run down in streaks: If it is thrown upon Flame, it does not increase it, but extinguishes it: If it is drank, it is far from heating, or making a Person fuddled: And lastly, it is neither capable of affording any refreshment or nourishment. This Demonstration now holds universally true in all sorts of Corn and Pulse whatever.

PROCESS XLII.

Honey diluted with Water into a Malsa, and then distill'd in the same manner, yields a Water that has nothing but the Smell of the Honey.

APPARATUS.

Take of the best native Honey 1 part, of pure Rain Water 6 parts, mix them well together, and distill them in Glafs with a moderate Fire, and there rises a Vapour, which fixes upon the Head in watery drops, and don't run down in *Striæ*, tho' you draw off two thirds of the Water you made use of. Nor has this Water the least vinous Smell, but only the proper one of Honey, in which there is frequently the fragrant Smell of the Flowers from which the Bees collected it. If any of this Water is thrown upon Flame, it does not support it, but puts it out; and if you drink it, it has a malkish Taste, nor heats or causes drunkenness.

USE.

HENCE then we see, that in this very concocted Liquor of Plants, which is generated and brought to perfection in their Flowers, and is afterwards collected by the Bees, there is not the least appearance of any such Spirit, as is afterwards produced by Fermentation. Whence it evidently follows, that the action of the Sun upon vegetable Juices, whilst they remain in their proper Plants, is not able to affect them in such a manner, as to excite in them a true Fermentation. Pure Honey, therefore, has no heating, drying, constringing quality, but on the contrary, an attenuating, deterging, relaxing, stimulating, saponaceous one. Hence for chirurgical and internal uses, it is of excellent service. And indeed among the ancient Physicians, you scarcely find any thing more recommended than this *Malsa*, as they called it, of Honey and Water, inasmuch as it attenuates, opens, stimulates, and purges, without exciting any heat. But this Water prepar'd from Honey with boiling Water, receives likewise some vertue from the Spirits of the Flowers from which the Honey was collected, which still remain in it. And hence it makes admirable *Collyriums* and Fomentations for Eyes that are inflamed, or disordered with Obstructions; for it is in reality a kind of a Water of those Flowers. What we have demonstrated now of Honey, is equally true of any thick vegetable Juices that are fresh pro-
cured

cured from them, as Manna, Cassia Pulp, Sugar, and Tamarinds, which being diluted with Water, and distilled in the same manner, yield no vinous Spirits. Nor do the thinner Juices of Berries, ripe Fruits, the Wood of the Birch, Vine, or the like, give out such Spirits, if they are treated in the same manner when they are fresh ; so that the Demonstration is universal.

Of F E R M E N T A T I O N.

THERE is hardly any thing mention'd in Natural History, which is of greater antiquity than Fermentation, nothing is commoner in Civil Life, nor does there occur any thing more frequently in the Chemical Art ; so that we may fairly say with the famous *Bellini*, all things are full of Ferments, particularly amongst the Chemists. Nay, if you will believe *Van Helmont*, the proper vertue of Ferments alone, is the cause of all true Transmutations. But dealing too much in Generals, breeds confusion ; for if every Mutation is owing to Fermentation, then the word Fermentation will be as general as the word Mutation, by which means, the Names that belong to particular things are lost. This confusion, therefore, Men of Sense have long complained of, and been desirous that this affair might be set in a true light, which is what I shall now endeavour to do.

1. By the word Fermentation, then, I mean that intestine motion excited in Vegetables, by which they are changed in such a manner, that the first thing that rises from them in Distillation, is acrid, miscible with Water, of a warm aromatic Taste, inflammable like Oil, thin, and volatile ; or else, acrid, acid, that will extinguish Fire and Flame, and is less thin and volatile.

This definition, now, so limits the word Fermentation, that tho' it actually comprehends every thing that occurs in a true Fermentation, yet it won't suffer it to be apply'd to any thing else to which it don't properly belong. I say then, that in every Fermentation, there is an intestine motion of the whole Mass, and all the parts, so long as this physical action continues ; and I call it an intestine one, because it chiefly depends upon the internal principles of the vegetable Substances that are fermenting. I confess, indeed, that some degree of Heat is here necessary ; but still this wou'd not excite a true Fermentation in the Matter, if it was not spontaneously disposed to ferment. Take, for instance, Water, Spirits, Oil, or Salts, and expose them to the very same degree of Heat, and yet you will never bring them to a Fermentation. But I add farther, that this intestine motion can be excited only in vegetable Substances ; for as far as I have been able to inform myself, there never was one instance produced of a true Fermentation in animal ones, except when the Animals had just taken into their Bodies some vegetable Matter, which was not yet thoroughly concocted, and assimilated to the animal Nature ; nor has there ever been observed a proper fermenting motion in Fossils. I know very well, that some famous Authors make no scruple to assert the contrary ; and therefore to distinguish here as nicely as possible, I define a true and perfect Fermentation by its proper effect, and that is, that it always terminates in the production either of the Spirit, or Acid, before describ'd. To put an end therefore to this Dispute, and set the affair at once in a clear light, I would only ask the candid Chemists, whether this action of Vegetables, which I have thus describ'd, ought to be call'd Fer-

mentation? Without dispute they unanimously agree in it. If so, then, I ask farther, whether therefore, for distinction sake, and to prevent any farther confusion upon this head, we should not, according to the Rules of Art, call all those Actions, which do not produce the Effect assign'd, by some other names? I think this evidently must be allowed to be the case. Putrefaction therefore in Vegetables, though it is a true intestine motion excited in them, yet, as for its proper and ultimate effect, it generates putrid Oils, and fetid, alkaline, volatile Salts, I absolutely distinguish from Fermentation. Putrefaction too in the Humours of Animals, is a proper intestine Motion likewise, but then it never produces Acids or inflammable Spirits, but Phosphorus's, and things of that nature, and consequently is quite different from every Fermentation; for I cannot allow any thing to come under this name which don't either generate inflammable Spirits, or an Acid. For the same reason therefore all the various kinds of effervescences, which we shall hereafter explain, must be absolutely excluded likewise, though these properly come under the title of intestine Motions, and are often observed even in pure, vegetable Substances, as we see in very strong Vinegar, and a fixed alkaline Salt.

2. Every fermented vegetable Liquor, now, that in Distillation first gives out a Spirit that will burn, and may be mixed with Water, I shall distinguish by the name of Wine, whatever vegetable matter it is produced from. And this I think the manner of using this word will bear very well; for *Tacitus* uses it not only for what is now commonly call'd Wine, but for Malt Liquor likewise, expressly telling us, that the *Germans* made Wine from corrupted Corn, or what we now-a-days call Malt. All such fermented Liquors therefore, whatever Vegetables they are prepared from, I shall call Wine, without any distinction. And again, every vegetable Liquor, that is fermented in such a manner as in the first Distillation to yield an acid Liquor that will put out Fire, I shall call Vinegar; nor here again does it signify what Vegetable it is made from. The whole Effect therefore of a true Fermentation will be the production either, of Wine, or Vinegar.

3. A fermentable Body I shall call such a one as by the action described, No. 1. may be so changed as to be capable of producing the Wine or Vinegar, describ'd No. 2. As this now has never been observed to be the case in any Bodies but such as are contained in the vegetable Kingdom, hence I must of consequence allow nothing but Vegetables to be fermentable, though indeed it will hereafter appear that they are not all so.

4. By the word Ferment, I shall mean any Substance, that being intimately mixed with the fermentable Vegetables, No. 3. will excite, increase, and carry on the Fermentation describ'd, No. 1. Hence therefore it appears at one view, that such a Ferment must belong to the Class of Vegetables.

5. The fermentable Vegetables now, No. 3. are of very various sorts: These therefore must be divided into as many Classes as they require different methods of Fermentation, nor can we here with any propriety or convenience make more or less. Thus, as we must treat Rye in one manner to produce Wine from it, and the fresh express'd Juice of Grapes in another; so it is absolutely necessary to distinguish these two Vegetables into different Classes: But on the other hand, as Wheat, Barley, and Oats require the very same management as Rye for this purpose, hence, in this respect, there must be no distinction

distinction made betwixt these, but they must be referr'd to the same. In the mean time, however, it is necessary to observe, that all Vegetables are not disposed to ferment; for those which we formerly described, Process 33, as abounding naturally with a considerable quantity of an alkaline Salt, or as easily disposed to yield such a Salt, are unfit for Fermentation, tending on the contrary to Putrefaction. This formerly, whilst I was but a Novice in these things, I experienced in Onions, and Turnips; for whilst I was searching after a fermented Spirit from these, as a remedy for the Stone, I lost my labour, for I obtained an alkaline, fetid, volatile Salt, with a Spirit of the same kind, instead of a true fermented Spirit. Hence therefore, though all fermentable Substances will undergo a Putrefaction, yet the converse is by no means true, that therefore all that will putrify will ferment. In Vegetables therefore in this respect there is a vast difference, as you may see, Process 32, 33.

6. These things then being distinctly considered, to the first Class of Fermentables we shall refer all those Seeds of Vegetables, which, when they are ripe and dry, suffer themselves to be reduc'd to a fine Powder, and not into an oily Paste; which Powder is called Meal. And here likewise I shall include those Seeds, which though they abound with a pinguious Oil, yet may be so chang'd by Art, as to be converted into a Meal that is not so oily. These mealy Fermentables now I am obliged to subdivide again into the three following sorts.

1. The ripe Seeds of Culmiferous, Graminifolious, Spicated Plants, called Corn, as Oats, *Indian* Wheat, Grass, Barley, Job's Tears, Millet, Rice, Canary-Grass, and all sorts of Wheat and Rye. To these likewise, on account of the affinity of their nature, may be added, Buck-Wheat and Flax; as also from their coming near 'em, the Seeds of all the Cucumber kind, as Citruls, Cucumbers, Goards, the Counter-Poison, Musk-Melons, the Male Balsam Apple, Pompions, and the like. Under this head too we may likewise rank the Seeds of Lettice, or any other Plant of the same nature.
2. The Seeds of almost all the Leguminous, Podded Plants, with the Papi-lionaceous, or any other Flower, as Judas his Tree, Broom, *Spanish* Broom, Furz, *Crotolaria*, Dwarf-Broom, Crimson Grass Vetch, Shrub-Trefoil, Stinking-Bean-Trefoil, Kidney Beans, Melilot, Trefoil, Fenu-greek, Rest-harrow, Medick-fodder, *Medicago*, The Nettle-Tree, Bastard Acacia, Bastard Sena, *Coronilla*, *Barba Jovis*, Pease, Everlasting Pease, *Clymenum*, Tares, Lentils, Yellow Vetchlings, Beans, Goats Rue, Bitter Vetch, Liquorice, Saint-foin, Chiches, Ladies-fingers, Lupines, *Emerus*, Birds-foot, *French* Honey-suckle, Hatchet Vetch, Horseshoe Vetch, Scorpion-wort, *Astragalus*, Acacia, Cassia, Sena.
3. Nuts that are not too oily, as all kinds of Almonds, Chesnuts, Hasel-Nuts, Horse Chesnuts, Walnuts, Cocoa-nuts, and Pistach Nuts; which, when they abound with too great a quantity of Oil, must by some method or other be deprived of it, which is best done by letting them begin to shoot, and then drying them.
7. The second Class of Fermentables comprehends all the pulpous Fruits, as they are call'd, in which when they are ripe there is a large quantity of an acidish sweet Juice. Of this kind are all Cherries, both sorts of Gooseberries, Mulberries, Raspberries, Elderberries of all kinds, all acidish Apples,

all

all Pears, Oranges, *Sevil* and *China*, Citrons, Lemons, Apricocks, Peaches, Plumbs, Medlars, and the like, provided they don't naturally tend to an alkaline fetid Putrefaction.

8. In the third Class are contained particularly, all succulent Herbs, and all their parts, as Flowers, Leaves, Roots and Stalks, if so be they are disposed to grow acid, rather than putrid: These therefore again may be collected from Process 33.

9. The fourth Class contains the fresh, native Juices express'd from Vegetables, their Fruits in particular, No. 7, 8. And hither we must refer likewise that thin Liquor that runs from Incisions made in some Trees, as the Birch, Walnut, and Vine, particularly in the Spring season: For almost all these Juices will spontaneously ferment, and then have their natural disposition intirely altered from an acidish, stimulating, refrigerating one, to a heating, inebriating, vinous one. *Helmont*, the Father, recommended the Water that thus distills from the Birch, in the Month of *March*, as a secret for the Stone, that is to say, when it was fresh, or carefully kept without changing: And Mr. *Boyle*, from his own and other Persons Experience, asserts its Vertues in this case still more strenuously; but he found, that though the fresh was of service, yet it was quite of another nature when it had been fermented.

10. To the fifth Class again, belong those vegetable Juices, which are generated, and thicken'd by nature into a saponaceous Substance of a saline and pinguious nature together. Of this sort are Manna, Honey, Cassia Pulp, Sugar, and all other things of this kind, that are not Balsamic, Gummy, Resinous, or Oily.

11. Whether now to a sixth Class we shou'd refer the Waters of Rivers, I am somewhat at a loss. These certainly seem to be common *Lixiviums*, impregnated with all kinds of Vegetables that fall into them, and are at last resolved and intimately blended with them. And then those that run through populous Cities have not only the fresh Liquors of Vegetables, but their fermented ones mix'd with them likewise. If these therefore are put up in Casks, which were used for Malt Liquor, Wine, or Vinegar before, there may lie concealed in them a great quantity of Spirits, which may afterwards discover themselves. And hence when they come under the *Æquator*, and into the torrid Zones, by being exposed to so great a degree of Heat, they may be work'd up into a kind of Fermentation, Vol. I. p. 353, 354. To these six Classes then I think may be reduced all Bodies that are susceptible of Fermentation, when they are manag'd after various manners according to their peculiar dispositions.

12. In the Bodies now contain'd in the first five Classes, there are required some physical conditions to render them fitter for Fermentation, as

1. The most perfect maturity of them all in their kind: For all Seeds and Fruits, which are brought by Nature to such Perfection, that if they are sown in a good and proper Soil, and at the right Season, they will produce a Plant fit for this Operation; whereas when they are crude, rough and watery, they are not so well disposed for it. The rough Juice of unripe Grapes, or Crabs, is but little fit for Fermentation, though the express'd Juice of them, when they are ripe, ferments spontaneously; and the case is nearly the same in others.

2. Some

2. Some degree of Oiliness is necessary likewise, but not too great a one; for very oily Substances grow rancid, rather than ferment, though at the same time those will not ferment that have none. Hence very fat Almonds when they are pounded are less liable to be affected in this manner; and yet, if by the assistance of Water, they are properly reduced to a Milk, they are then disposed to ferment; but most of all so when they are macerated in Water, and are just brought to shoot; for then their Oil being greatly lessened renders them fit for this Operation.
 3. But farther, they must not be too rough, and astringent; for such Substances ferment with a great deal more difficulty: thus the Juice of Bistort, Tormentils, and the like, can scarcely be raised to a Fermentation.
 4. And lastly, it is particularly requisite in fermentable Substances, that they shou'd be capable of being dissolv'd in Water: Hence Barks, Woods, and Roots, so long as they exist in these forms, will not be changed in this manner, though their express'd Juice, being then miscible with Water, will ferment very readily.
13. Ferments, now, or Bodies proper for promoting a Fermentation in others, are principally,
1. All such Substances as are spontaneously very prone to Fermentation themselves, and hence will soon ferment without the addition of any thing else. Of this kind in particular are the Juices of ripe Summer Fruits, which are so much disposed to Fermentation, that they can scarcely be kept from it, except by adding something to them of a contrary nature. Thus too Dough, made of Flower, work'd with Water, if it lies in a warm place, cannot be prevented from fermenting. Hence therefore we need not be solicitous about this first sort of Ferment, as Nature every where supplies us with it abundantly.
 2. The Yeast, or fresh Flowers of Malt Liquor, or Wine, which are thrown up to the top whilst they are in the action of Fermentation; for if this light, frothy Matter is mix'd with other fermentable Substances it wonderfully promotes their Fermentation, provided these Flowers are fresh, and not fallen.
 3. The same Matter, afterwards grown heavier, and subsided to the bottom, if it is not too old; for this likewise still retains its former Vertue, tho' in a less degree than before: Thus we see, if the Lees, or Settling is shook up with its own Liquor, it often occasions a new Fermentation, as it will with others likewise.
 4. Cassia, Manna, Honey, Sugar, and the like inspissated Juices.
 5. The acid, mealy, fermented Dough or Leaven of the Bakers. For if fresh, sweet, wheaten Flower is kept in a dry place, and secured from Insects, it may be preserved for years without Corruption; but if this is kneaded with Water into a soft, stiff, sweet Dough, and this is lightly cover'd in a warm place, it begins within the space of an Hour to grow lighter, puff up, and be full of Bladders, and lose its Smell, Taste, and Tenacity, and afterwards acquires both a sour Smell and Taste, which was then called *ζύμη*, *Fermentum*, a Ferment, and gave the first name to the whole Operation; for if this Leaven is mixed with fresh Dough not yet fermented, it will make it ferment much sooner, and more efficaciously than it wou'd do otherwise

otherwise. Hence then we see, that a Ferment may be soon prepared from a Body in which no Ferment actually existed before.

6. The *Residuum* of former fermented Liquors, with which wooden Casks are sometimes impregnated; for if these are thoroughly penetrated with the Wines that were in them before, they are disposed to excite a much speedier and brisker Fermentation in any fresh Liquors that are put into them.
7. Hither likewise is referr'd the beaten White of Eggs, which, though it does not so properly belong to the Class of Ferments, yet in some cases may be admitted well enough. Thus, for instance, when the fermentable Liquors are so dilute and thin that they too easily discharge the Air and Spirits, which both excite and keep up the Fermentation, and consequently don't retain them 'till they have chang'd the disposition of the fermentable Matter, into that of a fermented one; then the Whites of Eggs being mix'd with them, by their tenacity, render them sufficiently thick to inviscate and secure the active Spirits for a convenient time. These do not here therefore act properly as a Ferment, tending naturally themselves to Putrefaction, but only assist the causes of Fermentation, by preventing their too speedy Exhalation. The same thing therefore may be easily effected by other viscid Substances likewise.
8. Some persons too have added Salts, as well acid and austere, as alkaline. But this again is only in particular cases, as the former. Thus, for example, when Substances to be fermented have so great a quantity of Acid in them as to impede their Fermentation, it is observed, that a prudent addition of a small quantity of an alkaline Salt will render them more dispos'd to it. And again, when there happens to be generated any thing subputrid in the fermentable Matter, then a proper addition of a little Acid will often restore again an aptitude in them for this Operation. Hence therefore it appears that though these are not Ferments themselves, nay, not so much as Fermentables, yet, in some certain circumstances, by removing the impediments to it, they become promoters of Fermentation. Tartar however, if it is good, may in some measure be rank'd amongst Ferments.
9. And lastly, it is observ'd, that the roughest Substances, by being mixed with Fermentables, will in some cases too assist their Fermentation, though they very much hinder it in others. Hence Quinces, unripe Medlars, rough Cherries, and the like, have been referr'd too to the Class of Ferments. This however is only true when the fermentable Liquor is of itself too thin, and therefore wants an addition of somewhat rough, the better to keep in its volatile Spirits.
14. Having thus then dispatch'd Ferments, let us now proceed to examine into the preparations which fermentable substances require to make them ferment more successfully. Those then that are comprehended under the first Class, require for this purpose a very particular management, for
 1. Those mealy Seeds, when they are thorough ripe and dry, are thrown, in warm weather, into Rain-Water that is caught in the Spring, in particular, and are there suffered to lie till they are swelled, and have taken in as much Water as they can: And this is called Maceration.

2. The Corn being thus soak'd, is taken out of the Water, and laid in large heaps in an open place where there is a moderate Wind blowing through. And by this means, in a short time, there spontaneously arises in the heaps a pregnant warmth, by the assistance of which, the vital parts of the Seed are quickened and rendered active, and begin to shoot, by putting forth their seminal Leaves, and the rudiments of Roots. As soon as ever this is the case, there is a great deal of caution necessary, that the Corn by growing too hot, don't begin to putrify, and that by germinating too long, it don't consume its mealy substance in shooting out into Leaves and Root; for the Fermentation that follows afterwards, is always so much the better, as this Germination is more nicely hit, a certain degree being necessary, but no more.

3. As soon as ever the Germination is sufficiently advanced through the whole heap, the Corn must be immediately spread abroad, that by lying too thick, it mayn't acquire too great a degree of Heat, but may be cool'd and dry'd by the Wind's blowing through, a north Wind in particular. By this means, then, its shooting any farther is put a stop to, the mealy part being attenuated by the former Operation, but not consumed. The Corn being thus prepared, it is gently thrown down a Pipe that is made very hot, which expeditiously dries it, and almost, but very slightly, torrifies it. This then is what *Tacitus* call'd corrupted Corn, and what now-a-days goes by the name of Malt. The principle alteration now that is induced upon the Corn by this management, is that its tenacity is so far hereby destroy'd, that tho' native Corn will not dissolve in hot Water, yet this will easily suffer the greatest part of its substance to be resolved by it: For whereas crude Wheat, by being chewed, will be reduced to a tenacious substance, which can scarcely be attenuated by the most patient Manducation, yet this, when it is made into Malt, if you chew it, will be easily divided, and intirely dissolv'd in the *Saliva*. But besides, the Malt in making acquires a soft, sweet Taste, which was not in the Wheat before. When this Malt, now, is just going to be used, it is ground with a Mill into a Meal, which is then call'd ground Malt. And what I have here observ'd in this instance of Wheat, is found to be true of all the Seeds in the first Class of Fermentables. Thus if Beans are macerated till they are grown turgid, and are then thrown into a heap, and suffered to shoot, and afterwards dried expeditiously with a pretty strong Heat, and then ground, they will yield the same *Phænomena*. *Phil. Transf.* No. 142. p. 1069. *Le Febre. Cap. de Ferm.*

15. The preparation of the second Class of Fermentables, consists, in the soft pulpos Fruits, in treading, pressing, and pounding them, by which means their Juice is separated from them with a considerable Froth. But if their substance is of a harder kind, they may then be boiled in Water, and afterwards reduced to a soft Pulp, as is often done with Apples and Pears. If they are pretty dry, they may be rasped with a proper instrument, and then be pounded with Water till they are brought to a Pulp, as in the Bulbs of *Jerusalem* Artichokes, *Virginia* Potatoes, and the like, in which there is not much tendency to Putrefaction; for if that is the case, then instead of fermenting, they will putrify.

16. Those that belong to the third Class, are beat into a Pulp whilst they are fresh and juicy, adding only a small quantity of Water to make it of a thinner consistence, and then they are sufficiently prepared.

17. And as for the Bodies of the fourth and fifth Class, if they are of themselves too thick, they must be diluted with such a quantity of Water as will produce a Liquor that is capable of keeping up a new-laid Egg to its surface: But if on the other hand they are naturally too thin, then you must take them whilst they are fresh, and before they have undergone the least Fermentation, and by boiling them with a gentle Fire in a low broad Vessel, inspissate them till you have reduced them to a proper thickness; for otherwise they will scarcely ferment, or generate any good Spirits. Nor will the thick ones, without being diluted in the manner just mentioned, easily yield any fermented Spirits, but will readily degenerate into an Acid. Sugar that is dry, will keep in a very great Heat, without undergoing any alteration; but if it is reduced to the consistence of Cream, it ferments violently, and is converted into a Liquor that plentifully abounds with Spirits. And the same thing is true in Honey, &c.

18. The next thing then to be considered, is the quantity of the Ferment that is necessary to be mixed with fermentable Substances, after they are properly prepared, that the Fermentation may proceed most successfully. Here therefore we observe, that

The Preparations of the first Class reduced to Malt, in the Summer, scarcely require the assistance of any Ferment, but are of themselves sufficiently, nay often, too much disposed to Fermentation. In Winter, however, the addition of some Ferment is necessary, as well as some artificial Heat, without which they would not be put into motion. And here the hotter you keep them, even in the Winter, the less quantity of Ferment there will be occasion for. A little Yeast, about an ounce, for instance, to twenty pound, is sufficient; or Honey or Sugar in the same proportion; or Baker's Leaven in double the quantity.

The second Class of Fermentables scarce ever want the assistance of a Ferment, unless the Weather happens to be too cold, on which account, if the Fermentation proceeds too slow, you may add here too a little Yeast.

The third Class in Summer time, especially if it is pretty warm, ferment of themselves sufficiently: In Winter, if the Fermentation is check'd, it may be promoted by the addition of Sugar, or Honey, as we explained before Paragraph 17.

Nor in the fourth Class are Ferments often necessary, for these Bodies too, if the weather is favourable, ferment so violently, that they can scarcely be kept within bounds; especially if it is very hot, and the Fruits have had a fine Season for ripening.

The fifth Class, likewise, does generally too without Ferments, they rather acting the part of Ferments themselves. There is here therefore nothing more necessary, than to give them a proper degree of Heat, and keep it up equably. Hence, therefore, we see, that upon the whole, Ferments are not so necessary as is generally imagined.

19. Any fermentable substances whatever then, being thus prepared, and diluted with a sufficient quantity of Water in the manner we have explained, let them be poured into an oaken Cask, in which a Liquor of the same kind

was

was fermented before, and which still remains well soaked with it. Set the Vessel by in a place where it shall be exposed to betwixt 60 and 70 degrees of Heat, and let the Bung-hole be left open, that the Air may pass freely in and out, or let it be gently covered with a bit of Flannel to prevent any Insects falling into it.

20. I took here before you a glass Cucurbit, the biggest I could get, and placed it upright in a wooden Chest in such a manner, that by putting a small quantity of Fire at the bottom, I could keep it in an equable Heat. I then fill'd it with a crude fermentable Matter properly prepared for Fermentation, covering the Orifice slightly with a Flannel, and exciting a Heat but of betwixt 60 and 70 degrees, even in the Winter season; and it was pleasant to observe the *Phænomena* that followed, which in this way lie open to observation, always happen in the same manner, and make up the whole History of Fermentation.

1. The Mass then, which at first is at rest, and is contained within a certain part of the Vessel, begins to rarefy, swell, rise up, and conceive an intestine motion through the whole, discovering itself by the various agitations of the Liquor, upwards, downwards, and in short, in all directions, nor ceasing, tho' the *Impetus* changes every moment. In the mean time there appear Bubbles generated in every part of the Mass, which with a strong tendency endeavour to ascend, sometimes bursting as they rise, or else at the surface, with a hissing noise. Hence the whole Matter grows frothy, but the surface in particular, and with a noise, like that of Ebullition, there is discharged a sharp Spirit, that stings the Nose, is acidish, wonderfully elastic, nay incoercible, bursting asunder almost all Vessels in which it is contained, nor in these respects to be equalled by any thing else that I am acquainted with: Hence the great *Helmont* thought this ought to be distinguished by a particular name, and therefore called it *Gas Sylvestre*.

2. Whilst these things proceed in this manner, the thicker part of the fermentable Mass begins to be separated from the thinner, and is thrown up to the top, where it is collected in a thick, spongy crust, which accurately covers the Liquid underneath, and confines and repels its more active parts, lest they should too easily exhale before they have performed their proper Office. And then it is very entertaining to see how great and constant an agitation there is through every the least Particle of the liquider part that lies covered with this tenacious Crust. Certainly, we can scarcely conceive of a greater attrition than arises from the rapid agitation of these Corpuscles among one another. And hence it comes to pass, that the Crust being elevated and separated by the explosions that are continually happening, there frequently bursts out a Vapour through the Clefts with a considerable noise; upon which the Crust presently closing again, confines, as before, the active principles, that they may not be too readily dissipated. And indeed, the Formation, and Continuance of this Crust, tends above all things, to bring about a perfect Fermentation.

3. And whilst these things happen, it farther appears, that whereas all the thick part of the fermentable Matter was at first carried up, and collected at the top, there are now some parts at the bottom of the Crust, which growing less rare, and being no longer kept up by those Bubbles that rendered them light, begin to descend through the Liquid part, are agitated

upwards and downwards, form Bubbles about them, and by this means rise, and then discharge them again and sink, and when this has happened alternately in this manner for a good while, at last fall to the bottom, and remain at rest. But at the same time, new little Masses of the same kind separate from the Crust, and excite the same *Phænomena*; and when this has proceeded for some time, it often happens, that the whole upper Crust, now grown heavier, and less rare, on account of the Spirits it has discharged, sinks down at once, and in a little while rises up almost intire again, and that with such an *Impetus*, as a Person can scarcely believe, that has not seen it. When the whole Crust now is perfectly consumed and sunk to the bottom, then the Fermentation ceases, tho' the same degree of Heat is still continued; and then a clear, thin, light Liquor swims at top, and the *Fæces*, Lees, or Grounds lie at the bottom.

4. Hence in every true Fermentation, the fermentable Matter is first equally mixed together, and then is separated into two parts, a Liquider underneath, and a thicker Crust at top. This Crust, so long as it continues there, is called the Flowers of the fermentable Liquor, or Yeast, and of all Ferments, is the most convenient, and quick in its effect. But again, in the second stage of Fermentation, it is separated into three parts, *viz.* the Flowers at top, the Liquor underneath, and a third part, which begins to fall and be collected at the bottom, under the title of the *Fæces*, which are thicker and heavier, and are then quite exhausted of that principle which causes the Fermentation. And lastly, in the third stage, it is again divided into two parts, the upper of which is clear, fine, and thin, and is then called Wine, whilst the other which is thick, and lies at the bottom, is called the Lees or Mother of the Wine.

5. But there is nothing more surprizing here, and that better deserves taking notice of in this affair of Fermentation, than that prodigious *Spiritus Sylvestris*, which rushes out with such an *Impetus*, when the Fermentation is at the height; nor is there any Poison that I am acquainted with, that is so subtle, swift, and fatal: For if a very large Vessel full of Must, in the very act of Fermentation, should discharge this Spirit through a small vent-hole in the upper part of it, and the stoutest Man should apply his Nose to this Hole, and at once draw in this Vapour, he would drop down dead in an instant, without any apparent cause of it. If a Person only takes in a little, he falls into an Apoplexy; if still less, he is either deprived of his Understanding, and the remaining part of his Life is a perfect Changeling, or else becomes Paralytic. And hence the same things happen to those Persons who are a great deal in Wine-vaults, where the Wines are fermenting in the time of Vintage, especially when they are very close. For this reason, therefore, these places ought to be purified by Fires, and setting the Windows open, that the Air may draw through. From Sugar dissolved in Water, and then fermented with its Spume, we have an account of a Spirit produced, which being drawn into the Lungs, only in a small quantity, in an instant stopp'd all Respiration, exciting an intolerable Asthma. *Phil. Transf. Ab. Vol. II. p. 635.* Hence, therefore, Physicians may learn, what a powerful effect Liquor may have that is drank in the very act of Fermentation; and how violent that Spirit may be which is gene-

rated in hot weather in the human Body, from large quantities of very ripe Fruits, especially if by a convulsive constriction of the Stomach they are prevented from passing any farther, and hence, by being kept warm there, acquire a prodigious elasticity, and acrimony. In Alcohol now, there still remains a good deal of this Poison, and hence if the Vapour of it is taken into the Nose in a great quantity, and for a long time, it causes the greatest degree of Drunkenness, or a slight Apoplexy: If it is used too freely internally, it affects the Brain and Nerves, particularly, and their functions. In Chemistry, however, we are still at a loss from whence arises this Spirit. We know, indeed, it is the production of an actual vigorous Fermentation; nor do we know that such a one is generated in any other way: But still we cannot by any means conceive how it can in an instant cause death, without any intervening disorder of the *Cerebrum*, *Cerebellum*, or Nerves, almost without any matter, or without any visible alteration, either in the Solids or Fluids. But to return, as soon as ever the Fermentation is over, it is proper to close the Vessel, and let the fermented Liquor stand for some time upon its *Fæces*, or Mother, for this Liquor will still consume a good deal of them, and assimilate them to itself, and by this means becomes stronger, and more spirituous, and so more fit for Distillation.

21. The time necessary for completing a perfect Fermentation, can't possibly be determined exactly, as this depends upon the place where the Vessel stands, the Season of the year, the Heat, and Wind it is exposed to, and the nature of the fermentable Matter itself. In *Africa*, the Liquor of the Palm-tree finishes this Operation in the space of a few hours. In *Asia* too it is very soon over: But in the northern countries it proceeds more slowly. Hot weather forwards it, and shortens the time of its duration; Cold checks it, and protracts it. With a South Wind too it goes on more successfully than with a North Wind, which is some impediment to it. The express'd Juice of Grapes and Sugar ferment in a short time, and very violently; other fermentables work more slowly. But tho' it is impossible to ascertain any time for this Operation, yet it is easy to know when a perfect Fermentation is at an end, *viz.* when all the *Phænomena* mentioned have appeared in the order described, and at last cease spontaneously: And then the Vessel must be immediately stopp'd, and the fermented Liquor must be kept upon its Lees; for otherwise the Spirit generated by the Fermentation, would in a short time exhale, and leave the fermented Liquor vapid, and good for nothing; whereas if the Liquor is kept quiet in a Vessel well stopp'd, it grows gradually finer, more subtil, and fuller of Spirits. Thus the fresh express'd Juice of Grapes, may, by boiling, be inspissated without losing any of its vertue, and yet when it is fermented, if it is exposed to but a cold Air, it is soon exhausted of all its Spirits.

23. The Liquor that is thus prepared by a compleat Fermentation, has in all Ages, amongst all Nations, and in every Language been called by the same name, Wine; the proper nature of which is distinguished by the following marks which are common to every sort of it.

1. In the first place, it is capable of producing a disorder in the function of the animal Spirits and Powers. And this it generally brings about in the following manner: First, it refreshes, exhilarates, raises the Spirits,

Spirits, makes a Man merry, and disposes him for the gayer Diversions of Singing, Dancing, and the like; it then affects his proper and prevailing Passions, discovers them particularly, and makes him speak his mind freely; afterwards it disorders both his internal and external Senses, and disturbs, weakens, and at last takes away voluntary Motion, so that neither the Foot, Hand, nor Tongue, can perform their Office; and then follow Sleep, Palsies, Apoplexies, and often Death itself. This now is the peculiar Property of Wine, nor is there any thing like it in any other Body that I am acquainted with: Henbane, Tobacco, Opium, and the Thorn-Apple, whilst they affect the Brain act in quite a different manner. And this Vertue is nearly the same in every sort of Wine; for Malt Liquor, Mead, Cyder, Perry, and Wine made with Gooseberries, Grapes, or any sort of Berries, has always the same effect: So that this surprizing Power is solely the effect of Fermentation.

2. But Fermentation likewise changes vegetable Juices from their relaxing, resolving, saponaceous, refrigerating, and, for the most part, purging quality, into one that corroborates, thickens the Humour, dries, and heats. Examine, for example, any mealy Substances reduc'd with Water to a crude Pap, the inspissated fresh infusion of Malt, before it is fermented into Beer, a *Mulsa* of Honey and Water, Syrups made with Sugar, Manna, or Cassia Pulp, diluted with Water, the fresh exprels'd Juices of very ripe Fruits, and fresh fermentable Herbs when they are at their maturity, I say, consider all these, and don't they, if they are taken in too great quantities, produce windy disorders in the Bowels, excite a *Diarrhœa*, and make a Person chill? And yet when they are properly fermented, and rightly made into Malt Liquor, Mead, and Wine, how very different are their powers and effects? Certainly they retain nothing of their former disposition. The rich Juice of very ripe Grapes is perhaps the most powerful Dissolvent of the Humours we are acquainted with, and if us'd immoderately, often bring on a fatal Dysentery; and an infusion of Malt inspissated by boiling, drank plentifully, has the same effect; and yet strong old Wine from the former, or generous old Malt Liquor from the latter, or the distill'd Spirit from either of them, but particularly Alcohol, is a good Antidote against 'em.
3. But another perfectly singular Property of Fermentation is this, that from the fermented Matter it generates a Liquor, call'd a fermented Spirit, which has this particular quality, that it is convertible into a lucid Flame, and at the same time will bear to be mix'd with Water, and which is quite of a different nature from the *Spiritus Sylvestris* before describ'd, which seems to be produc'd in the very act of Fermentation, and is then too dissipated into the Air. This Liquor now seems not to have any thing like it in all Nature: For the volatile, inflammable Spirit, which I once saw in a very dangerous manner burst out of the Retort in the distillation of Phosphorus, wou'd not be diluted, and extinguished with Water: And as for the Vapour which arises from large quantities of human Excrements thoroughly putrified in a close place, and takes fire, and bursts into a violent Flame upon the application of a Candle, that seems to be of the same nature, but horribly fetid: Oily Substances too, when they are

urged with the last degree of Fire in distillation, send forth bluish white Fumes, which upon holding a lighted Match to them will take Fire, but then these are reducible to Oils, or a Phosphorus, that won't mix with Water. Upon a careful Examination, therefore, I have not been able to discover any Liquor, which wou'd absolutely, and spontaneously, as it were, mix with Water, and yet at the same time might be converted into a pure Flame, except that which is produc'd by the Fermentation we have been describing.

4. Another proper effect of Fermentation is the generation of the Wine Stone, call'd Tartar, as was explained before, Process 8. I confess indeed, that this is not produc'd from all *Species* of Wine; for it is neither found in the best Malt Liquor, Mead, nor many other sorts. From some Vegetables, however, this is form'd good and pure, but then only when they have been made into a Wine by a proper Fermentation, and are grown very fine. Hence, therefore, I always look upon Tartar as a peculiar production of Fermentation, and think it shou'd be call'd the Essential Oily Salt of the Wine, and be absolutely distinguished from the Mother or Lees.
5. But Fermentation, farther, always produces a surprizing alteration in the Smell, Taste, Nature, Qualities, and medicinal Vertues of Vegetables. By comparing the sixteenth and seventeenth Processes together, this has already appear'd very evidently; for the cohobated Water of fresh Rosemary differ'd intirely in every property from that which was drawn from it after it had been first fermented with Honey. The Must just press'd from the ripe *Rbenish* Grapes that lie exposed to the Sun upon the sides of Mountains, is of an exceeding sweet Taste, and yet when the Fermentation of it is compleated, and it is grown fine in its Cask, it is gratefully acid. Other Wines that are not thoroughly fermented, but have their Fermentation stopp'd before it is perfectly finish'd, remain sweet indeed, but then they very easily fall into a Fermentation again, and when it is over become acidish. And that Aloes and Colocynth, by Fermentation, lose their Bitterness, we have an account by *Wedelius, Act. Lips.* 1686. p. 366. I have here too set before you very pure Spirits prepared from Malt Liquor, Mead, Cyder, Wheat, and Grapes, nor do I imagine you will discover any difference betwixt 'em.
6. Again, Fermentation produces that new Smell, Taste, and Vertue, which is properly called Vinous. And here there is somewhat nearly acidish, warm, and oily, even from Meal, Sugar, and Honey.
7. And Fermentation only generates the Spirits abovemention'd, either from a Matter that was before absolutely of another nature, or from the Oil of the Plant. This last opinion indeed I think seems very probable. But then from which of the Oils have they their Origin? Almost all the Chemists say from their Essential Oil. But by what Experiment they are able to determine this I own I cannot comprehend; for the *Spiritus Rectior* which forms the Essential Oil is lost by Fermentation. In a fermented Liquor too, depriv'd of its Spirit by Fermentation, there remains a good deal of Oil; and yet I cou'd never excite a new Fermentation in this *Residuum*, nor by any art extract any more such Spirits from it. In every fermentable Substance
therefore

therefore there is naturally only a certain part which is dispos'd for the generation of Spirits, nor can more than one determin'd quantity be procur'd from them by Fermentation, let it be assist'd by any contrivance whatsoever. But there is yet another thing too which deserves consideration, and that is, that the finest, and most thoroughly fermented Wine generates white Tartar, which is full of a perfectly inflammable and exceeding penetrating Oil, and yet you can by no Chemical Operation produce inflammable Spirits from this, though you can from the Wine in such great abundance. Hence then you see, Gentlemen, that the Matter which is convertible into these Spirits by Fermentation is of a perfectly singular nature. But as Fermentations of one kind or another, which properly generate these Spirits, are always going on in all parts of the World, there must of consequence be a vast quantity of these Spirits produc'd, which are either consum'd by Animals, or dissipated into the Air. The *Saliva*, Blood, and Urine, however, of those persons who constantly drink freely of these Spirits every Day scarcely afford any Spirits in Distillation; but then, it's true, there is never wanting in Nature proper Matter for producing more, let but Fermentation come in to its assistance. Think of these things, Gentlemen, and you will find here a new subject to examine into, worthy your penetration. But Fermentation generates something saline likewise; for the Acid produc'd here is considerably volatile, though less so indeed than the Spirit. Thus from Vinegar there rises a volatile, acid, subpinguious Salt, which the Substance did not afford before it was fermented. Nay even the Spirits themselves that are generated by Fermentation, have somewhat in 'em of this volatile Acid. Hence the Oils and acid Salts of fermentable Bodies seem to be attenuated, render'd volatile, and united together by Fermentation, and to be consum'd in a certain quantity. Thus if I distill unfermented Rosemary with Water, I have an Oil which has the true Smell and Taste of the Rosemary, and a milky Water impregnated with the same Qualities: If I ferment it with Honey too, and then distill it before the Fermentation is quite compleat, I procure likewise a white, thick, opake, distill'd Water, which possesses abundantly the Vertues of the Rosemary, together with some Oil swimming at top, though in a smaller quantity than before: But if I suffer it to be absolutely fermented, and then commit it to Distillation, I draw off a pellucid Spirit of Rosemary, that will mix with Water, and is endued with excellent medicinal Vertues; but the former Essential Oil appears no longer.

8. This Spirit produc'd by Fermentation, which partakes of the Oil, becomes by this Operation more volatile than Water; whereas the Essential Oil, before the Operation, was not so volatile, as the Vegetable might, by a gentle Heat, be depriv'd of all its Water, without any Oil's ascending with it.
23. The circumstances now necessary to a successful Fermentation are principally these:
 1. It is requisite that the fermenting Liquor should stand quiet, that the Crust which forms itself at top may remain intire; for whoever is continually breaking

breaking this, and mixing it with the Liquor underneath, will be disappointed if he expects a perfect Fermentation.

2. There must be a free admission of the common Air, which must be intimately mixed too with the fermentable Matter, by treading, kneading, or pressing: If this is kept out, the Fermentation will not proceed.
3. Such a degree of Heat too is necessary as was before described, viz. betwixt perhaps 40 and 80 degrees the outside.
4. And lastly it is observed, that the Spring and Autumn in particular, favour this Operation, when those Vegetables are in Flower, from which the Wine was made: Hence the Wine of Grapes is said to grow foul, and easily ferment again, when the Vine is in Blossom.
24. The checks to Fermentation, by which it is either impeded after it is begun, or quite put a stop to, are chiefly as follow.
 1. The acid Vapour of burning Sulphur included in a considerable quantity, with that Air which is in the Cask above the fermenting Liquor: For if you take a Cask, and thoroughly penetrate and fill it with this Vapour, and then putting your fermenting Liquor into it, fill the upper empty part as full as you can of this Vapour likewise, and carefully stop it in, you will prevent any farther Fermentation; which, however, after being at rest some time, may be reviv'd again by its proper causes, and restrained by the same Fumes. The same thing too is effected by mixing a large quantity of a strong Acid with the fermenting Matter: The Acids of Alum, Nitre, Salt, Sulphur, and Vitriol, have this property, but at the same time they spoil the Liquors.
 2. Alkaline Salts too, if they are mixed in great quantity with fermenting Liquors, excite for the present a very considerable Effervescence, but that soon ceasing, the Liquor is presently at rest, its proper nature being so destroyed, that it can scarcely be afterwards raised to a Fermentation, but will rather be disposed to putrify. Hence it appears, that alkaline Substances are a greater obstacle to Fermentation than Acid ones, the former destroying or suffocating all the Acid. And for this reason,
 3. All those Bodies which will intirely absorb acids, if they are mix'd with fermenting Liquors in a proper quantity, after a short struggle and effervescence, put a stop to this Operation: Chalk, Crabs-eyes, Corals, Pearls, Oyster-shells, Iron, Lead, and Tin, have this effect.
 4. The stopping up the Vessel so closely, that nothing can possibly pass in and out, provided the Vessel is so strong that it won't be burst by the force of the included Liquor. This is evident in new Ale put into very strong Bottles, which afterwards, when it comes to have Air let in upon it, converts the Fermentation, so long suffocated, and prevented, into the most violent Effervescence, and discovers a prodigious collected Power. The same thing is found true in Casks likewise; for there is always a constant action and re-action betwixt the containing Vessel, and the contained Liquor.
 5. A great degree of Cold too, puts an end to Fermentation intirely; for under 36 degrees of Heat it will scarcely ever be carried on.
 6. Nor is too much Heat a less obstacle to it, which if it exceeds 90 degrees, dissipates rather the active principles of Fermentables, than assists and

quicken them. Hence an exhalation performed with a greater degree of Heat than this, inspissates Fluids to such a degree, as renders them absolutely unfit for Fermentation. And boiling has the same effect a great deal sooner, so that the richest Juice of Grapes, which can scarcely be kept from fermenting, will, by being briskly boiled, lose all its disposition to ferment, and be converted into a Mass that will afterwards remain quiet for years without alteration.

7. The separation of the elastic Air by means of *Boyle's* Air-pump, during the absence of which, this fermentative motion intirely ceases.
8. And lastly, a very great condensation of the same Air with the fermentable Matter, absolutely prevents both the Beginning and Progress of Fermentation.

25. After Liquors thoroughly fermented, have been kept some time in a cool place together with their Flowers, and *Fæces*, and in Vessels well stoppt, and pretty full, and by this means have got more Spirits, if you have a mind to distill them, it is proper to stir them about and mix them with their Lees, for they will then give out their Spirits in greater abundance. But then, however, it is necessary to take care that the Grounds don't fall to the bottom of the Still, and by being burnt there, give the whole Liquor an empyreumatical Smell and Taste: For this reason, therefore, the Liquor must be kept stirring with a Stick till it is ready to boil, by which means the thicker parts being kept constantly mixed with the thinner, they will afterwards by the motion of this great Heat be easily kept so. In this manner then you will be able to procure the Spirits, as well from the *Fæces* as the Liquor itself, and will in the best manner provide against an *Empyreuma*. And here I may add, that if the Fermentation has been over some time before the Distillation, there is less danger of the Liquor's rarefying and rising out of the Still; whereas if you distill when they are just fermented, the *Impetus* of Fermentation that still remains, will often carry up the Liquor when it comes to boil violently, and so disturb the whole Operation. At the beginning, therefore, it is necessary to proceed with caution. But

26. An *Empyreuma* is particularly prevented,

1. By rubbing the bottom and sides of the Still with some pinguious oily Matter, before the Liquor to be distill'd is poured in.
2. By keeping it constantly stirring till the thick part begins to be mixed by the Heat, and so is prevented from collecting and sticking to the bottom.
3. By first boiling some Water briskly in the Still, and whilst it continues in that condition, at once flinging in your Liquor; for then the hot Vapour filling the cavity of the Still, will hinder the fermented Liquor's fixing to the sides.

27. If now, as I hinted before, the whole fermented Matter, *viz.* the top or head, middle Liquor, and bottom or mother, are accurately mix'd together before they are distill'd, you will have a larger quantity of good Spirits.

28. When your Liquor then is heated to such a degree, as to be just ready to boil, you must beware of the first *Impetus*: This is best guarded against, by leaving the Still one third empty, and covering the Aperture of the Still with a thin Cloth, before you fix on the Head, and then managing the Fire in such a manner, that the Drops shall only fall presently after one another. In this

manner

manner then, your Distillation may be performed safely, and after it is thus continued for some time, it may be cautiously increased, by which means it will most successfully separate all the Spirits. The thinner, clearer Liquors, however, as Mead, Wine, and old malt Liquor, don't require so much caution; but in mealy Substances, distill'd after a perfect Fermentation, you can't be too careful. The former, therefore, you may at once venture to distill in such a manner, that the Spirits shall almost run through the Worm in a full Stream.

29. The Distillation of fermented Bodies then being managed in the manner described, there first comes off a Liquor, which is acrid, heating, and pungent, and has a very particular penetrating Taste, called a spirituous one: In its nature too, it is exceedingly active and volatile, so that there are but very few Bodies that are more so: A pure alkaline Spirit, the Spirit fuming from Tin, *Glauber's* Spirit of Nitre, and Sea-Salt, and a pure volatile alkaline Salt, indeed, have a greater degree of volatility; but this is more volatile than almost any thing else. This Liquor, when it is very much heated, readily takes fire upon the application of Flame to it, and will almost totally consume. Taken internally, it causes Drunkenness and stupefaction of the Senses, and then an Apoplexy. In a moderate Dose it wonderfully raises the Spirits. It very soon heals the Nerves when they are prick'd, half torn asunder, and in great pain. All animal and vegetable Substances put into it, it intirely preserves from Putrefaction, only making some alteration in their Colour. If you dissolve a little of the finest Sugar in this, when it is not perfectly free from Water, the pellucid Liquor you will then have, will preserve the most tender Bodies. If it is diluted with Water, and then used warm as a Fomentation, with *Sal-Ammoniac*, and Vinegar, there is nothing perhaps that more happily resolves *Coagulum*s, discusses inspissated Humours, prevents the spreading of a Gangrene, and causes a separation of the unsound parts, or dries up any discharge of thin Humours more effectually. This Liquor is called Spirit of Wine, and that part of it that comes off first of all, is called the Precursor.

30. If, when this Spirit is all drawn off, you urge the *Residuum* with the same Fire, in the same Vessels, you will then have a Liquor less volatile, acetose, acid, astringent, cooling, nauseous and putrid; and at the bottom there will remain some thick *Fæces*, which, treat them in whatever manner you will, can never be brought to ferment again, and yield new Spirits, tho' from the Consistence of them, one would be very ready to expect it. If you expose this *Residuum* however, to a very strong Fire, you may draw from it a fetid, empyreumatical Oil.

31. If the *Residuum* of any fermented Substance after Distillation, is dried and burnt in an open Fire, it is converted into salt Ashes, from which may be procured a sub-alkaline, or alkaline Salt, exactly in the same manner as in Process 5, 6, 9, 10, 12, 19. Hence, therefore, it evidently appears, that the most perfect Fermentation is not able to render volatile that Matter of Vegetables, which is fixed by being burnt, and which by the 7th and 8th Process, is convertible into an essential Salt.

32. Thus then, Gentlemen, I have given you a short, but true chemical History of Fermentation: And I have in such a manner explained to you, the Objects, Helps, Impediments, Causes, Manner, Action, and Effects of it, that

perhaps there is not any one Physical Operation more clearly defin'd, and more nicely distinguish'd from all others, than this. You will be very careful therefore, for the future, not to confound this Action of Nature with any other that is different from it, if you wou'd keep free from uncertainty and error. By this means Physick will be purged from those idle notions of Ferments, which to the great detriment of the Art have been introduc'd into it by some Dablers in Chemistry. Thus too the Natural History of Animals and Fossils will be freed from many insignificant *Hypotheses* of Ferments, which really never happen among them: In the first chylopoietic Organs of Animals, that live upon fermentable Meat and Drink, Fermentation seems indeed just to begin, but then to be soon put an end to; though perhaps in some few Diseases it may reach farther, and be carried on through the Intestines. In Alchemy too the greatest Masters have taken an unwarrantable liberty, when from some resemblance of the Operations, they have asserted, that Metals likewise ferment. In all Arts we should strictly distinguish every Operation by those individual Properties which constitute the particular nature of that Action, and then as soon as ever the Word that signifies it is heard, the Mind immediately conceives what must certainly happen there. Let us therefore be exceeding cautious not to confound Fermentation with Effervescences, Ebullition by Fire, or Putrefaction of Animals, or Vegetables, concerning which we shall treat hereafter.

P R O C E S S LXIII.

Meal and Malt, work'd together with a proper quantity of Water, ferment.

A P P A R A T U S.

1. **H**AVING thus laid down the general Doctrine of Fermentation, it will be proper to give some Examples of it, that you may perceive yourselves the manner in which both Art and Nature proceed. And here I must observe to you, that there are two different Operations, by the first of which Malt Liquor, or Wine of Corn is prepar'd, and from this, Spirit of Wine; by the second a Spirit is drawn at once from fermented Corn, in the same manner as it is from Malt Liquor. In the first method, upon Ground Malt you pour Water almost scalding hot, mix them well together, and let them infuse for three or four hours, by which Infusion alone the Malt will impregnate the Water with its flowery part, which wou'd not have been effected by crude Meal. The Liquor then being drawn off from the Malt, must be boil'd 'till it is reduced to a proper thickness; and this Decoction, in this state, is emollient, loosens the Belly, purges, cools, and resists Inflammation. If when this Liquor is cool you mix with it some strong Ale Yeast, or Grounds, and let it stand in a warm place in a Vessel with the bung hole open, there will arise a violent Fermentation, which being quite compleated, the Liquor is immediately strain'd cold through a Cloth, and stopp'd up very close in its Cask, and becomes excellent Drink. But in order to keep it a good while, and prevent its growing sour, you must add some very bitter Herbs to it whilst it is boiling. If this Decoction of Malt then is made sufficiently bitter, boil'd to a proper thickness, perfectly fermented, stopp'd up
very

very close, and put into a Cellar, and after it has been kept a great while, is distill'd with a Worm, it will the first time yield as fine a Spirit of Wine as you can procure from Wine, by any Art whatever, which will be exceeding fragrant, nor have any the least disagreeable Smell. Having experienc'd this therefore my self, I learn'd, that there is not so much difference betwixt such Malt Liquor and the most generous Wine, and cou'd not help wondering, that this Art shou'd be known and practis'd in all Ages that we have any History of. Thus *Diodorus Siculus* tells us, L. I. *That in those Countries, where there were no Vines, King Osiris taught the Inhabitants to make a Liquor from Barley, which in the Fragrance of its Smell, and Sweetness of its Taste was not much inferior to Wine.* *Herodotus* too in *Euterpe* mentions an Ale, or Wine, made from Barley. And *Tacitus de Mor. Germ.* says, *they had a Liquor prepar'd from corrupted Barley, or Wheat, which resembled Wine.* And according to *Aëtius*, βάρη signifies Barley wetted till it begins to germinate, and then dried.

2. But the same thing is done in another, and more common way as follows. I here take of ground Malt 24 pounds, of Rye Meal 7, which I order to be mix'd and work'd well together with hot Rain-water, 'till they are reduc'd to a Liquid of a middling thinness; I then put this into an oaken Cask, which I set in this wooden Chest, that I may keep it in a moderate Summer's Heat. By this means then it of itself ferments sufficiently, so that I leave it till the Crust, which during the Fermentation is form'd at top, disappears, and subsides to the bottom. I then stop the Cask, and let it stand some time, and the Liquor at top becomes clear, and acidish, and at the bottom there is collected a large quantity of a mealy Matter, that is not glutinous, but is fit for Distillation.

PROCESS XLIV.

Honey diluted with Water ferments.

APPARATUS.

1. **I** HERE, as you see, take some Honey, and dilute it with Rain-water, till it will bear up a new-laid Egg at its surface. This is call'd a *Mulsa*. with this I fill a Cask set upright, that the Hole through which the Liquor is drawn may be at top, in order to be left open; and I put the Cask into a wooden Chest, and keep it constantly in a Heat of 70 degrees. In a little time then the Liquor begins to work with all the *Phænomena* of a true Fermentation. I leave it in this manner, 'till it has quite done fermenting, and have then a Liquor of a sweet spirituous Taste, which I stop up close. This is call'd (*Hydromel*) Mead.

PROCESS

P R O C E S S XLV.

The Malt and Meal fermented (Process 43.) distill'd into inflammable Spirits and Vinegar.

A P P A R A T U S.

1. **I** N T O this Still I throw a Pint of boiling Water, and make Fire enough to keep it boiling, and then pour in the Malt and Meal, fermented according to Process 43, taking care first to shake and mix the whole well together: with this I fill the Still two thirds full. I then raise my Fire, and at the same time keep the Liquor continually stirring with a Stick, that the thicker part may not subside to the bottom, but that the whole may continue as thoroughly mixed as possible. When it is grown so hot as to be just ready to boil, I fix on the Head, and manage the Fire in such a manner that the Head may be very hot, and the Spirit may distill pretty fast through the Worm. By this means then I have a clear, thin Liquor. This must be watch'd carefully, to observe how long it continues to come off, and must be kept by itself, under the Title of a fermented Spirit.

2. This being quite drawn off, there rises an acidish, disagreeable, nauseous, white Liquor, in which there is nothing of the warm, spirituous Taste of the former, and which, if you draw it any farther, begins to grow fetid.

U S E.

T H I S first Liquor is that which in our History of Fermentation we describ'd under the character of a Spirit produc'd by Fermentation.

P R O C E S S XLVI.

If Mead, prepar'd by Fermentation, according to Process 44, is distill'd, it yields a Spirit that will burn, and a Vinegar.

A P P A R A T U S.

1. **H** Y D R O M E L, or Mead, made in a proper manner, and kept a good while close stopt, I commit to distillation; and as this is not of so flatulent a nature, there is less caution necessary in this Process than there was in the preceding. In the first place then there comes off an excellent Spirit, no ways to be distinguish'd from Spirit of Wine, which must be narrowly watch'd, and kept by itself.

2. After this is intirely drawn off, change the Receiver, and then you will have an acidish, watery, white, disagreeable Liquor.

U S E.

U S E.

Both these Processes are Examples of the Distillation of Spirits from fermented Substances, together with the Cautions that are necessary to be observ'd in the Operation. The thick Matter, both of the fermented, mealy Bodies, and the Mead, that remains at the bottom of the Still, after the Spirits are drawn off, contains somewhat nutritious in it, as the *Residuum* likewise of Malt Liquor does that is treated in the same manner; but yet if you manage it according to the Laws of Fermentation, you can never bring it to ferment again, but it grows sour and vapid, by no means yielding a Wine from which a Spirit may be prepared, but corrupting gradually more and more.

P R O C E S S XLVII.

The Depuration of the spirituous Liquors produc'd by Fermentation.

A P P A R A T U S.

1. **T**AKE any fermented Spirits that have been once distill'd, fill a Still two thirds full with them, and distill them again with such a Fire, as to make them come off in a constant little Stream, or just to make the Liquor boil. In the first place then you will have a very clear, thin, fragrant, sapid, spirituous Liquor, during which time you must often remove your Receiver, to taste whether the same Liquor still continues to rise. When this ceases, change your Receiver, and keep this Spirit by itself in a Vessel very nicely stoppt, which is call'd by the Chemists, rectified Spirit of Wine. And here it is certain, that those Spirits which come over first are always the best.

2. If you continue your Distillation, you will have Liquors that are acidish, white, and more watery, which you must take great care are not mix'd with the former. These come off in considerable quantity, and go by the name of a Phlegm, containing but very little Spirit.

3. There remains then, in the bottom of the Still, a Liquor that is somewhat thick, opaque, pinguious, acid, of a disagreeable Smell, and, with regard to Spirits, perfectly aqueous. When pure Brandy is distill'd in this manner, the *Residuum* is always red, and of a roughish Taste, which Colour and Taste arise chiefly from the wooden Casks in which such sorts of Liquors are kept, from which they extract the oily and resinous part; for when they are first distill'd they have neither that Colour nor Taste, but acquire them by standing in these Vessels, and get rid of them again by Rectification.

U S E.

1. **H**ENCE then we see the method by which these Spirits may be so depurated as to be obtain'd at last almost pure and alone; for the oftener they are rectified in this manner, the more simple they constantly are, depositing in every distillation a watery, acidish Phlegm: By this means, however, tho' you have them gradually purer and purer, yet they will always retain some Water.

2. We

2. We hence too learn, that the Spirit of Wine, sold commonly in the Shops, under the name of Brandy, consists of four parts, intirely distinct from one another: For it contains, first, the pure fermented Spirits, which we shall exhibit to you by themselves in the following Process; secondly, a pure Water, which may be separated from it by the two next Processes; thirdly, a certain acetose, fermented Acid, which rises in the first Distillation of Spirit of Wine, and pretty tenaciously remains united with it, but which however may be accurately disengag'd from it by Process 49; and lastly, a small quantity of a fetidish Oil, which always discovers itself upon mixing Spirit of Wine, even tho' it is rectify'd, with a dry, fixed Alkali, or upon drawing it from the same by Distillation. And hence it has happen'd, that the Chemists, not attending to this in their use of common Spirit of Wine, have been surpriz'd with *Phænomena* which they did not expect, and which were not so properly owing to the pure Spirit of Wine, as to those other Bodies that were mix'd with it. But these may be produc'd by other causes, whereas this Spirit is the effect of Fermentation alone.

3. There have been Authors of note among the Chemists, who observing an Acid almost always intermix'd with these Spirits, have hence asserted, that these Spirits are acid, and are generated from an Acid. But if we will examine this affair with proper attention, I am apt to think, the case will appear otherwise. For if you take the purest Spirits, and distill them from off a fixed, alkaline Salt, they will by this means be freed from every Acid that we are acquainted with, and yet they will then be genuine, and in their greatest perfection. I allow therefore, that these Spirits are not produc'd, except from Vegetables, nay, and from these only grown acidish by Fermentation, but yet I must deny that these Spirits, though generated from an acescent Matter, are acid themselves. We cannot therefore with justice assert, that these Spirits are acid or alkaline, but must acknowledge, that they are somewhat of a particular nature.

4. This Spirit, reduc'd to its greatest purity, by this method of rectification, will still always continue compounded.

P R O C E S S XLVIII.

Alcohol prepar'd from the fermented Spirits of Process 45, 46, 47, without the addition of any thing else.

A P P A R A T U S.

1. **T**AKE any fermented Spirit, particularly one that is rectified, and with a gentle Heat, not exceeding a 100 Degrees, draw it half off in a tall, narrow Cucurbit, and with the Furnace, describ'd Vol. I. p. 510. The half that thus rises first, treat again in the same manner with very clean Glasses, and repeat this till the *Residuum* that is left in the Cucurbit appears as strong as that which is drawn off. This Spirit then is what goes commonly by the name of Alcohol of Wine, and is look'd upon as a pure simple Spirit that has nothing heterogeneous, no not so much as any watery Phlegm mixed with it. This was the method made use of by the ancient Chemists, only with other Furnaces. See the *Collector of Chemical Menstruums*, concerning the methods of preparing the
Spiritus

Spiritus Vini Philosophicus. The more exact scrutiny, however, of later Waters has discovered, that there still lies some Water concealed in these Spirits, and that hence, Experiments made with these, where Alcohol without any Water mixed with it is necessary, prove unsuccessful. And besides, this tedious Operation takes up a great deal of time, for which reason the industrious Chemists were not at rest till they had discovered some more expeditious method of preparing pure Alcohol, which they found might be done in the following manner.

2. They contrived a Furnace in such a manner, that a pretty large Still might be set in Water in a *Balneum Mariæ*, and consequently, when the Water boiled, could be affected only with a heat of 214 degrees. In this is put as much common Spirit of Wine, as will fill the Still two thirds full. An Alembic Pl. xv. is then fitted on, which runs out into a tall, upright, narrow Tube, and is then turned down again, and has its extremity inserted into the Mouth of a Worm. You then raise your Fire till you make the Water in the Bath boil, and consequently the Spirit in the Still boil more briskly, by which means, the Spirit alone being able to rise to such a height, and through so narrow a Tube, will distill by itself so long as there remains any of it in the Liquor. As soon as ever, therefore, the pure Spirit ceases to come over, the watery Phlegm not being able to ascend, the Distillation will be finished: And thus you will have, the first time, and within three or four hours, as much Alcohol as you could well procure by the preceding method in the space of a month. No body, therefore, should by any means be without this *Apparatus*, who has occasion for a pretty deal of Alcohol in his chemical Operations. Upon a nice examination, however, I found, that even in this way, there was still somewhat, tho' a very small quantity indeed, of Water, intermixed with the Alcohol, which in Distillation, perhaps, might be carried up by the Spirits. For this reason, therefore, I repeated the Distillation with the Alcohol thus prepared, in the same Furnace, and I had then an Alcohol, which in almost every mark appeared pure, and simple, tho' yet, thus pure as it appear'd, it was found not to be intirely free from Water. Hence, therefore, I am induced to believe, that the Spirit can never, by this method, be absolutely separated from the Water, tho' at the same time I must acknowledge, that the quantity of Water that remains after this Operation is but exceeding small.

3. On this account, therefore, I afterwards performed the Distillation in the following manner. I take the Alcohol that rises the first time in the method described, with this I fill a Still half full, add half a pound of hot, decrepitated, pure Sea-Salt, and then putting on the Alembic, and making all very close, let them continue thus for the space of twelve hours, in a Heat so small, as by no means to make the Alcohol boil. I then begin the Distillation, and the two first ounces of Alcohol that come off, I keep by themselves, for fear there should be any watery Vapour in the Tube of the Alembic, or the Worm, which by these first two ounces will be sufficiently brought away. Of the remaining Alcohol, then, the first two thirds I receive into a very clean, dry, glass Vessel, and keep by itself in a Bottle as nicely stoppt as possible; and afterwards I draw off the other third, and keep that by itself likewise. The Salt then will remain in the Still wetted with the Water, which it attracted out of the Alcohol, and retained so tenaciously, that tho' it was acted upon by the Heat of boiling Water, it would not part with it, and suffer it to rise with the Al-

cohol. Nor does the Salt, prepared in this manner, make any alteration in the Alcohol, by mixing itself with it; for it is decrepitated, and put in hot. By this method, then, I have been able in a very short time, to prepare the purest Alcohol for any chemical purposes.

U S E.

1. **A**LCOHOL brought to this degree of perfection, is the next lightest Fluid to Air; perfectly transparent; very thin; exceeding simple; totally inflammable, without producing any Smoke, leaving any *Fæces*, or diffusing any disagreeable Smell whilst it is burning; exceeding volatile, without any *Residuum* left behind; absolutely immutable in Distillation; greatly expansible by Heat; very easily disposed to Ebullition, if exposed to the Fire; of a very pleasant Smell; and of a particular grateful Taste. All the Humours of the human Body, that we are acquainted with, it coagulates in an instant, except only the pure Water, and Urine, whilst it hardens all the firmer parts, and thus preserves both from putrefaction, or spontaneous dissolution: Bodies of Insects, Fish, Birds, and other Animals that are put into it, it secures from corruption, or alteration, for ages, if it is closely stopt up: With Water, Vinegar, any Acid Liquors, Oils, and pure alkaline Salts, both fix'd and volatile, it suffers itself to be mix'd, and that nearly with an equable Mixture: And lastly, it dissolves gummy and resinous Substances. Hence, therefore, it appears, that there is no Liquor produced, either by Nature, or the Chemical Art, that is capable of being united with more Bodies than Alcohol is. But in a particular manner it proves an excellent Vehicle for the *Spiritus Rector* of Vegetables, which by a union with it, may be conveniently extracted from its proper Body, and retain'd and applied to medicinal and other uses. Those great Masters of Chemistry, who were distinguished by the Title of Adepts, are supposed, in their description of the preparation of this perfect Alcohol, to have shadowed out the preparation of the Philosopher's Stone: But it is certain, that Alcohol owes its origin to Fermentation alone, nor can be prepared in any other way whatever.

2. In the human Body, by its Smell, Taste, and Vapour, it wonderfully quickens, gratefully affects, and invigorates the animal, natural, and vital Spirits, Nerves and Brain: Hence it exhilarates the Mind and Senses, makes a Person brisk and agile, and proceeding through various degrees, at length causes drunkenness, which as it here comes on very suddenly, so likewise it goes off in the same manner. The Blood, its *Serum*, and other thin Juices it coagulates immediately, and hence being drank imprudently, it is said to have killed Persons in an instant. If it is applied externally, it dries, corroborates the Vessels, and coagulates the Fluids in those Vessels into which it is able to penetrate. The extremities of the Nerves that it comes at, it instantly dries, contracts, and deprives of all Sense and Motion. Hence it appears, how imprudently, nay, and often how unhappily Alcohol, either pure or impregnated with aromatic Spirits, Camphire, or the like, is made use of as a Fomentation in surgical cases, and ordered to be heated and well rubb'd in. I would advise you therefore to be cautious upon this head, for instead of a pretended vivification, calefaction, restoration of agility, resolution, and dissipation, you will obtain

obtain no other effects than what I just now ascrib'd to these Spirits. In Wounds too, Ulcers, and other open Maladies, pure Alcohol performs the very same thing, viz. coagulates, and dries and burns the Nerves. Its true indeed, it eases the Nerves of all sense of pain; but then at the same time it destroys all their use. And it has the same effect when it asswages those that are prick'd, or half torn asunder. It at once stops bleeding by contracting the Vessels, and coagulating the Blood it is apply'd to, but with the concomitant circumstances just mentioned. Hence, therefore, it is often a very speedy and excellent remedy in these cases, tho' always attended with some inconveniences.

3. From what has been said then, we learn what effect pure Alcohol has upon animal or vegetable Substances that are put into it: For if there is any thing oily in these that the Alcohol can get at, it dissolves it, and extracts it out of them, and hence these afterwards become contracted and wrinkled. In this manner, the preparations of the parts of Animals have often been observ'd to be chang'd: And aromatic Flowers, Leaves, and Fruits, are affected in the same manner. If little Birds, or other small Animals covered with hard Scales, are immersed in hot Alcohol, they are beautifully preserved, as this contraction, tho' it does actually happen, yet on account of their Feathers and Scales does not in these appear so evident. And if after these have been macerated for some time in the purest Alcohol, till they are thoroughly penetrated by it, they are then taken out, dried in an Oven not too hot, put into glass Vessels, and intirely kept from any communication with the external Air, they may be kept in their proper form for ages, to the very great advantage both of Natural and Pharmacal History, as by this means they may be transmitted safe to posterity, whereas descriptions are frequently defective.

4. As there are a great number of instances, and those of consequence too, where both the Chemists and other Artificers have occasion for the most pure and perfect Alcohol, the least admixture of any heterogeneous Matter immediately rendering the Operation unsuccessful; hence it is absolutely necessary we should have some marks by which we may be able to distinguish, whether our Alcohol is pure or no: The chief of these then, I shall now lay before you, and they are as follow: 1. If the Alcohol contains any Oil dissolv'd in it, and so equably distributed through it, that it is no ways perceptible, then upon the pouring of Water into it, the Mixture will grow white, and the Oil will separate from the pure Alcohol. 2. If any thing of an Acid lies concealed in Alcohol, a little of it mixed with the alkaline Spirit of *Sal-Ammoniac*, will cause an Effervescence, and thus discover the presence of the Acid; for otherwise there would be only a simple *Coagulum*. 3. If there is an alkaline Salt in it, this will appear too by the Effervescence excited on pouring in an Acid: And as for other Salts, they are seldom found in it. 4. But it is a matter of greater difficulty to find out whether there is any Water intermix'd with it; and therefore the Chemists have contrived certain methods, by which this may be examined likewise. In the first place then, they imagined, that after having gone through the tedious labour of the repeated Distillation above-mentioned, they might be satisfy'd that they were in possession of pure simple Spirits, without the admixture of any watery Phlegm; but as I took notice to you before, I have never been able in this manner to procure pure Alcohol, but it would to the last retain something of Water. Secondly, they put some Alcohol into

a clean, dry Spoon, and heating it, set it on fire in a place where there was not the least Wind, and if after the Alcohol was burnt out, there was no Water at all remaining in the Spoon, they at once pronounced it pure Alcohol. Some Persons however who were more curious by other Experiments, which we shall mention by and by, discovered, that by the action of the Flame, the Water that lay concealed in the Alcohol might be dispersed into the Air, and consequently, that no Water remaining in the Spoon after the consumption of the Alcohol, was no certain proof, that there was none contained in it before it was set on fire. In the third place, therefore, they took some of the best Gun-powder, and drying it very well, put a little of it into a dry Spoon, and pour'd some Alcohol upon it, and then heating the Alcohol, set it on fire, by applying a Flame to its Surface. They then let it burn away in a quiet place, and if the Gun-powder fired when the Flame was just going out, they concluded certainly that the Alcohol was pure: But against this Experiment there lies the very same Objection as against the former. These two last Methods, therefore, when they succeed, demonstrate, that the Alcohol, with respect to Water, is very pure, but not that it is absolutely so. In the fourth and last place, therefore, there has been another way discovered, by which it may be certainly known whether Alcohol contains any Water at all in it, and that is this. Take a chemical Vial, with a long narrow Neck, the Bulb of which will hold four, or six ounces of Alcohol. Fill this two thirds full with the Alcohol you want to examine, into which throw a drachm of pure, dry Salt of Tartar, coming very hot out of the Fire, and then shake them well together, and set them upon the Fire till the Alcohol is almost ready to boil. If then, after they are thus shaken and heated, the Salt of Tartar remains perfectly dry, without the least sign of moisture, we are sure that there is no Water at all in this Alcohol. If any Person will still contend that there is Water in it, upon the foot of that Experiment, that Water may be collected from its Flame whilst it is burning, of this I treated sufficiently, Vol. I. p. 188, 189, which therefore, if you please, you may have recourse to. By this method, now, I have been able to discover Water in Alcohol, that by the others appeared perfectly free from it: For I took some Alcohol, which burnt intirely away, and set fire to Gun-powder, and upon putting such an alkaline Salt into it, I perceived by the Moisture it acquir'd, that there was still some Water in it: And again, I took some Alcohol in which there was a fixed Alkali that had remained dry for a long time, and was so when I made the Experiment, and gently mixed a few drops of Water with it, and tho' the Salt had continued dry so long, it soon after grew moist from this small quantity of Water, and appeared in oily streaks running down the Sides of the Glass. Thus, therefore, the true nature of Alcohol is sufficiently determined by its individual Properties; especially if to what has been, you add this Observation, that such an Alcohol does not appear whilst it distills through the Alembic: For it neither forms dewy drops like Water, nor runs down in *Striae* like strong Spirit of Wine, but is quite invisible; which property of it, as evidently appears by their Writings, was known to the ancient Chemists. This then is the ultimate effect of Fermentation, as it is scarce possible to carry this Alcohol to any greater perfection, or indeed, to induce upon it any alteration.

PROCESS

I

PROCESS XLIX.

A Preparation of Alcohol with Alkali's.

APPARATUS.

1. **A**S one often wants a large quantity of pure Alcohol out of hand, and perhaps ha'n't by one a chemical *Apparatus* ready for preparing it, the following method which I am going to propose to you, will answer the purpose very well, provided it would be no ways inconsistent with the use you want it for, that there should be a small matter of a fixed Alkali mixed with it. In this clean glass Cucurbit, then, I have some common Spirit of Wine, into which I pour a third part of its weight, of pure dry Pot-ashes, which presently fall to the bottom. I shake the Vessel then, and you perceive the Salt immediately grows moist, and begins to dissolve at the bottom, whilst a thin red Liquor swims at top. And the more I shake them, the more the lower part melts, and the upper separates from it; nor is it ever possible to make them mix thoroughly together, but as soon as ever they come to stand still, they immediately collect themselves into two perfectly distinct *Strata*. And here the stronger the Spirit of Wine is, the greater will be the quantity of the upper Liquor; and the contrary.

2. Let the Vessel stand quiet for some time, that the Liquors may become intirely separated, and then by a gentle inclination of the Glass, pour off the upper Liquor into another dry Cucurbit, taking as much care as you can, that none of the lower goes in along with it. At the same time let there be ready in the Fire a very dry, fix'd, alkaline Salt, which must be put hot into the Spirit thus deprived of some of its Water, and then the Glass must be stoppt, and shook about for a considerable time; upon which you perceive the dry Salt acquires some farther Moisture. I proceed then to shake them together, till I observe that no more of the Salt will be dissolved, but that there swims at top a red limpid Liquor which will be so much the purer, as the alkaline Salt was drier and hotter, and was longer shook about with the Liquor. This being done, I pour off the Liquor into a tall dry Bolthead, and throw into it a little more alkaline Salt that is exceeding dry, pure, and hot, and set them in 100 degrees of Heat, shaking them about very frequently; and if the Salt don't then grow at all moist, the Alcohol will be perfectly freed from its Water, but then it will have a red Colour, a Taste not simple, and a somewhat disagreeable Smell, and by its Effervescence with Acids, and its lixivious Taste, will evidently discover the presence of a latent Alkali. And here we take notice, that in this Operation, there always appears a pinguious Oil, which separates itself from the Spirit of Wine, or the Pot-Ashes, or perhaps from both, and has a fetid Smell. The fixed Alkali too, here made use of, by absorbing and uniting with itself the Acid which was in the Spirit of Wine, is altered in its nature, and at last becomes a compound Salt and a pretty volatile one too. And hence I found, that when this Salt had been made use of a good many times, and so was dried after every Operation, it at last was almost of the nature of the *Terra Foliated Tartari*, and intirely unfit for any purpose, where there was required

quired a fixed Alkali. Hence then again is confirmed what was advanced concerning the nature, and different component parts of common Spirit of Wine.

3. If Alcohol, thus prepared, is distill'd once in a Cucurbit, with a gentle Fire, it becomes sufficiently simple, and fit for almost all the uses where you want a pure Alcohol. It's true indeed, there will be somewhat subalcalescent still united with it, though this too may be prevented by cautiously adding a few drops of Oil of Vitriol before the Distillation, and proceeding so long as there is any effervescence excited, and no longer; for if you then distill it, your Alcohol will be pure.

4. Hence then we see, that the preparation of absolutely pure Alcohol is not so easy as some Persons pretend: For in Distillation there is an acidish, and a watery Liquid intimately combined with it, and if you add an Alkali to it, though it frees it from the former, will still continue closely united with it itself. For this reason then we need not be at all surpriz'd, that some very curious Experiments, that require the purest Alcohol, do so seldom succeed. And hence it is plain, that an alkaline Salt will often properly dispose Alcohol for particular Operations, either as it frees it from its Water, Acid, and Oil, or as it impregnates it with an alkaline quality, and thus improves its dissolving power. We must have a proper regard therefore to all these considerations, before we can pretend to pronounce, concerning its ill, or good effect.

5. The Chemist, therefore, when he has once produc'd such Alcohol as we have describ'd, finds he is come to the Limits of his Art, as it cannot be carried to any greater perfection, be resolved into any more simple principles, or indeed be any ways altered. Upon a carefull examination, now, into this affair, I here experienc'd, that the most limpid Spirit of Wine, depurated by one common distillation, or, as it is called, rectified Spirit of Wine, might, by the affusion of the purest dry Salt of Tartar, be divided into two parts, and those sometimes nearly equal, one of which was simple Water, the other the purest Alcohol; and this is a Truth sufficiently known: But, after a great number of Experiments, I cou'd never yet see, that simple Alcohol, by being mixed with a pure fixed Alkali, wou'd unite its oily half with the alkaline Matter into the form of a balsamic Soap, called the *Samech* of *Paracelsus*, the other half at the same time separating itself into mere elementary Water. This, indeed, the great *Helmont* asserts, p. 58. 86: But this separation, as far as I am able to judge, succeeds only with rectified Spirit of Wine, and then indeed not as the followers of *Helmont* maintain, viz. that the Sulphur of the Wine associates with the alkaline Salt; for in my Experiments the Water is attracted into the Salt so long as there is any in Alcohol, and the Alcohol is repell'd, whereas they say, that the Oil of the Alcohol unites with the Salt, and expells the Water. But in the eightieth Process I shall have occasion to lay before you some very laborious Operations upon this head, nor is any thing more necessary to our present purpose.

PROCESS

P R O C E S S L.

The Origin of Vinegar.

A P P A R A T U S.

1. **H**AVING rightly understood the Effect of one Fermentation, *viz.* the generation of Alcohol, we must now take into consideration another production of it, and that is vinegar, which cannot any ways be procur'd but by Fermentation, and that a double one too; for you must first make Wine, before you can make Vinegar, and then indeed any Wine is fit for this purpose. For if you take any sort of Wine, and mix with it a large quantity of its own Lees, and the Flowers that rise to the top during its Fermentation, adding too a good deal of powder'd Tartar, together with the Skins, Stalks, and Twigs of the Vine, and the acid, austere Leaves, that have a saline, tartareous Matter in 'em; then, if you stir these well together, and set them in a warm place, particularly in wooden Casks that are thoroughly penetrated with the Vapour of Vinegar, and in an Air that is full of acetose Vapours likewise, they will by this means undergo a new Fermentation, with a considerable production of Heat. And in this particular, this second acetose Fermentation differs from the former; for if this is protracted too long, the Wine, indeed, grows sourish, but then it grows flat, and never becomes good Vinegar. In order to this, therefore, a particular Management is required, which we shall presently lay before you.

2. The remote Matter, therefore, of an acetose Fermentation are all Vegetables, that are dispos'd to a vinous Fermentation, provided they are first, by this, converted into Wine. The Matter from which Vinegar is immediately prepar'd, is every sort of Wine, with this Circumstance, however, that the stronger the Wines are, the sharper generally are the Vinegars that are made from them, whilst the smaller Wines produce a weaker.

3. The Ferments now by which this acetose Fermentation is most successfully assisted, are particularly these.

1. The acid *Fæces*, or Lees of an acidish Wine.
2. Grounds of Vinegar collected in old casks, especially if they are well saturated with very strong Vinegar.
3. Tartar from an acid Wine, reduc'd to Powder.
4. Vinegar itself, properly prepar'd, and brought to its greatest degree of sharpness.
5. Old wooden Casks, which have laid for a good while full of the strongest Vinegar, and hence are thoroughly penetrated with its sharp Acid.
6. The frequent stirring up of the Lees in its own Wine.
7. The Stalks and Skins of Cherries, Currants, and Grapes, the Tendrels of Wines, and such parts of other acid-austere Vegetables.
8. The acid Rye-Leaven of the Bakers.
9. A Composition of all the preceding mix'd together, especially if there are some very warm Aromatics added to the Acids; for then the Vinegars made with them are strongest.

4. This whole Operation was formerly accurately describ'd by *Glauber* in his Writings against *Barner*, an account of which was afterwards publish'd by the *English* in their *Philosophical Transactions*, and is in short as follows. There are two large oaken Vessels made in the shape of common Casks, in each of which, at the distance of a foot from the bottom, as they stand upright, there is fix'd a wicker Grate. Upon these Grates are laid a *Stratum*, of a moderate thickness, of fresh, green Twigs of Vines, and over these, to chuse, such a quantity of the Stalks of Grape-bunches without any Grapes on 'em, as is sufficient to fill the Vessel to within a foot of the top. These two Vessels then being thus prepar'd, the Wine of which the Vinegar is to be made is pour'd into both of 'em, but with this difference, that one of 'em is fill'd quite full, the other only half full; and then every day that which is half full is fill'd out of the full one, so that each of them are half full one day, and quite full the next. By this means then, the second or third day there arises a fermentative Motion, with a sensible heat, in the Vessel that is half full, which every day increases more and more in the half full one, whilst in that which is quite full the same day the Motion and Heat is almost suffocated, and put a stop to; so that hence the Fermentation and Heat are excited and destroy'd alternately in each of the Vessels. In this manner they continue to fill them one out of t'other, till there appears no more Heat or Motion, even in the half full one, which is then a sign, that this acetose Fermentation is finish'd; for which reason the Vinegar must be then put up in Casks, and stopp'd close. The hotter now the place is where these Vessels stand in which the Vinegar is prepar'd, the sooner will it be made, which in *France* is compleated in Summer in about fifteen days: But in cold weather, and a cold place, the Operation is longer. And here it is necessary to observe, that when either the Weather, or the Workhouse, is very hot, it is often necessary to fill and empty the Vessels, in the manner describ'd, every twelve hours; for otherwise there arises such a Heat and Fermentation in the half full one, that the volatile Spirits of the Wine, not being yet sufficiently secured, are dissipated by the Heat, and fly off before they can be properly intangled and fixed into the acid Spirit of the Vinegar: And hence the Liquor, though it wou'd be sour indeed, would at the same time be flat, and by no means sharp strong Vinegar. For this reason too, the Vessel that is half full is always accurately closed with a Cover made of the same Wood with the Vessels, that the Spume of the fermenting Liquor may be forced down again, and thus the repell'd Spirits may act longer and more powerfully upon the austere Substances underneath, and by the reaction of them be better secur'd from dissipation. But the full Vessel is not cover'd, but left quite open, that the Air may have a free admission to the Liquor to be changed. This then, Gentlemen, is that second Fermentation, that tends to the making of Vinegar, and terminates there. It is wrong, therefore, to look upon this as a Liquor prepar'd after the inflammable Spirits of the first Fermentation are gone off; for this wou'd be flat and dead, and far from Vinegar. On the contrary, the more generous, and the fuller of Spirits the Wine is that is used for this purpose, the better will be the Vinegar; the smaller, or flatter it is, the weaker. For this reason, the strongest Malt Liquor, if it is treated in the same manner, yields an exceeding good Vinegar, as the rich *Spanish* Wines do likewise. In this Operation, now, it is particularly remarkable, that this conversion

version of Wine into Vinegar is not brought about without a considerable Heat's being generated during the Fermentation; whereas Must, whilst it ferments in the time of Vintage, scarcely grows warm; and Malt-Liquor, notwithstanding the violent Motion that is excited during its working, not at all. Is Heat, therefore, always necessary to the generation of an Acid? Certainly frummentations, and other vegetable Substances, and Milk, in order to their growing sour, require warm Weather, artificial Heat, or that of the human Body. And we see, that the extreme force of the Fire converts Salt that is not aced, and Nitre, and Sulphur, which are not acid, into the strongest Acids. Think carefully of these things, Gentlemen, and you'll find, perhaps, that every thing must have its proper degree of Heat. But there is something else here that deserves our consideration, likewise, and that is, that whilst Wine, by the method describ'd, is converted into Vinegar, this clear thin Liquor deposits an incredible quantity of thick, pinguious, oily, and as it were soapy *Fæces*, which hang about the sides of the Vessels, the Vine Twigs, and the Stalks of the Bunches. Whence, now, shou'd this arise? In the Wine, certainly, there is not the least sign of any such thing, and as for the rough Twigs and Stalks, there is nothing one wou'd expect less there, than a pinguious Oil. And yet it is in this manner form'd from the Wine; for if it is wash'd off it will be generated from it again. And here we must observe, that it is necessary once a year to clear away all this thick unctuous Matter, for otherwise, when the Wine was put into the Vessels, it wou'd not be chang'd to a thin sharp Vinegar, but a thick, corrupted, pinguious Liquor good for nothing at all. The Twigs, therefore, which are now very turgid with a Ferment of the sharpest Vinegar, are wash'd from the greasy Matter with which they are loaded, and this is done as expeditiously as possible, that the Water mayn't fetch out any of the Acid with which they are impregnated. The Grates, Sides, and Bottom too, of the Vessels, in which the Vinegar is made, are clean'd with the same caution, and as soon as ever the pinguious Impurities are remov'd, the Grates, Twigs and Stalks are dispos'd as before, and are fit to proceed to work with again. In time, however, the same oily Crust will be form'd again, and thus evidently demonstrate, that the Wine does actually throw out an Oil whilst it is chang'd from its own proper nature, to that of Vinegar. At the same time too, the acetific Ferment remains in the Vessels, Grates, and Stalks; and hence, when these Vessels have been us'd a great while, they acquire this Power very strongly, and with the Grates, &c. become spongy *Reservoirs*, as it were, of Vinegar. And lastly, as the Alcohol, which I mention'd before, prepar'd from very strong old Malt Liquor, can scarcely be distinguish'd from that drawn from the richest Wine; so here the same Malt Liquor, treated in the manner explain'd, may be converted into Vinegar, as good, pure, and fit for any uses, as ever was made from the best Wine; nor is it easy here to find any difference betwixt them, except what is owing to the Bitters put into the Malt Liquor, to make it keep, which give it another Colour and Taste from what it wou'd have had if it had been prepar'd from the pure Corn: In other respects they are intirely alike. This Operation therefore appears sufficiently evident.

5. The effect therefore of this second Fermentation, when it is absolutely finish'd, is the production of good Vinegar. In order now to have a right notion of this affair, let us consider what this Vinegar is. Vinegar then is

an acid, penetrating, subpinguious, volatile, vegetable Liquor, produc'd from Wine in the manner just describ'd, the first part of which that rises in distillation is truly acid, and by no means inflammable, but extinguishes Fire and Flame, in the same manner that Water does. These Properties therefore, which, if rightly attended to, appear pretty extraordinary, accurately distinguish Vinegar from Wine. Wine then, by one Fermentation, is prepar'd directly from Vegetables; Vinegar, by a second Fermentation, from Wine that is already made. The volatile part that first rises from Wine in Distillation, will take fire, and rise into a bright Flame; that from Vinegar, like Water, puts it out. Here, therefore, there is a very extraordinary production of one thing from another of a different nature. Some of the most skilful among the Chemists, indeed, have asserted that Vinegar is a volatile Tartar of Wine; because Tartar is the most acid part of Wine, but not volatile; Vinegar, Wine converted into an Acid, but a volatile one. And this too they thought still farther confirmed by this consideration, that Wine for the most part deposits a Tartar; Vinegar, though it stands by a great while, never any, though as it is deprived of a great part of its Oil in making, and hence is rendered so much the more acid, one wou'd naturally expect it shou'd generate a greater quantity. And it is true, indeed, that what remains at the bottom after the Distillation of Vinegar, seems to come near to the nature of Tartar, but yet, upon a nicer Examination, we find it something very different from it, as we shall see in the following Process. It will be of service to us, now, not only with regard to the Chemical Art, but, with a view to Medicine and Natural Philosophy, to have a clear notion of the nature of this Vinegar, which we shall endeavour therefore to lay before you in the following particulars.

1. Vinegar, then, is a Liquor, distinguish'd by its proper Marks above-mentioned, to which we only now add, that it is a volatile, oily, acid Salt; for its Oil, which lies surprizingly conceal'd under a sharp, thin Acid, most evidently discovers itself by a great many Experiments, which we shall hereafter give you in the 76th and 173d Processes. This Compound, now, is vastly beneficial to the human Body; for at the same time that by its Acidity it resists Putrefaction, which the animal Humours are so incident to, and which is of so dangerous a consequence, it is soften'd by its Oil, and render'd less acrid. This Liquor, too, is of so penetrating a nature, that it soon insinuates itself through very dense Substances, in its full strength, and without any separation of its parts, nay, will make its way through almost all the human Body, and thus being distributed into the chief of its Vessels, well exert its proper Powers there, especially as it is then assisted by the natural Heat, and vital Motion. And then again it very readily suffers itself to be mix'd with any of the animal Fluids that we are acquainted with, the Oil itself not excepted, by which means, and its penetrating power together, it is capable of producing many beautiful effects in our Bodies. In Fevers, arising from a stimulating acrid Bile, an alcalescent Salt, any thing putrid generated in the Body, or the venomous bite of an Animal, it has an excellent cooling Power, and at the same time asswages the Drought that accompanies 'em. And hence, in these cases, we have nothing extoll'd more by *Dioscorides* and *Hippocrates*, than Oxycrate, or Vinegar and Water, especially when render'd milder by

by an addition of Honey. In external Maladies, as Erysipelas's, Phlegmons, and putrid Ulcers, the Surgeons find nothing of greater service. In virulent Bites, there is not any thing more efficacious than Oxycrate, as appeared evidently in the Bite of a mad Dog. And as to making Persons fuddled, it is in its nature so distant from that, that whereas fermented Spirit of Wine is the only thing that promotes it, Spirit of Vinegar proves a remedy for Drunkenness where it is excited, nay, tho' a Man is quite drowned in Sleep from the abuse of spiritous Liquors, he may be roused by giving him Vinegar. Hence, in stimulating the Nerves, and quickening the Spirits, there's scarcely any thing of greater service. In weak, languid, drowsy, and lethargic Persons, and those afflicted with Syncope and Vomitings, after having tried the most artful chemical productions in vain, I have given relief by applying Vinegar to the Nose and Mouth, or administering it inwardly. Nay farther, which hardly any body wou'd be ready to believe, but those that have experienced it, in Convulsive, Hypochondriacal, and Hysterical Cases I have often known it do good likewise. Justly, therefore, did *Hippocrates* and *Galen* recommend its use to Hypochondriacs. In a true Putrefaction too, and deadly Corruption of the Humours, and in preventing the spreading of a Gangrene, I speak experimentally, it has scarce its equal. But what need is there of many Arguments to this purpose? In the extreme Heat of Autumn, when every thing runs presently into a putrid *Sanies*, are not Flesh and Blood kept from Corruption by sprinkling them plentifully with Vinegar? But, with proper respect to those Gentlemen who are of another opinion, I assert farther, that Vinegar has an attenuating Power likewise: For if it is mix'd warm with the Blood, or its *Serum*, it does not coagulate them, nor by its admixture generate any Polypus's, but on the contrary, dilutes them, and kindly resolves them when they are coagulated. In acute Fevers, therefore, in malignant burning Fevers, in the Plague, the Small-pox, Measles, and the like Distempers, Vinegar is an excellent Medicine, where volatile alkaline Salts are used with such unhappy success; for by their stimulating Acrimony they increase the Velocity, and of consequence the Density of the Blood, which depends upon it. Consistent with this, certainly, was the practice of the famous *Franciscus de le Boe Sylvius*, who, if not the Author, was at least a vast admirer of the *Sal Volatile Oleosum*; for by the help of what Prophylactic did he visit his Patients in the Plague, without any inconvenience? Why by only drinking an ounce or two of Vinegar: Nay, he tells us, that happening once to omit it, he presently suffered for his negligence by a Pain in his Head. And lastly, to conclude, a more certain and efficacious Sudorific we are not acquainted with; for Vinegar, either diluted, or alone, will procure a plentiful Sweat, in the Plague, and other malignant Diseases, where other things seldom prove successful.

2. The Generation, now, of this Vinegar seems to depend upon the Combination of the inflammable Spirit, produced by the first Fermentation, with an Acid somewhat more fixed, which lay concealed in the Wine; for that these inflammable Spirits are not lost, or perish, we have made appear already. May therefore these Spirits, by the second Fermentation

be united with the essential Salt of the Wine, or the Tartar? This I leave to your mature examination, only adding, that it does seem here as if the Spirit of Wine was altered in its nature, and so put on that of Vinegar. And if this is the case, this, may be, is the only way commonly known, in which the Matter of Alcohol is actually changed into something else.

3. Perhaps the most beautifully essential Salt of Wine is the Tartar that is generated from it; but this is all consumed in the making of Vinegar, tho' there is nothing at the same time separated from it, but a thick oily Matter: For if you take the finest new Rhenish Wine, and put it into a clean Pipe, it will produce a great quantity of excellent Tartar; but if after it is made into Vinegar, by the Method described, it stands ever so long, it will generate none; and yet, as I took notice before, there is nothing deposited or formed, during the second Fermentation, that at all resembles Tartar, but only a pinguious tenacious Matter, that is as different from it as possible.
4. In the Distillation of Wine, the Spirit produced by one Fermentation, comes off before the Water; but in old Vinegar prepared by two, the watery part rises first, and when this is drawn off, there follows an acid Spirit, which is always the stronger and more acid, the lower you draw it. Hence then we see, that the first Fermentation renders its proper production volatile; the second rather makes what that generates, more fixed. If we attend carefully, therefore, to the Action of Fermentation, it certainly appears very surprising: For from sweet Must it produces an acidish Wine; from a Matter in which there was no Alcohol before, it generates Alcohol; and again, from a sweet Wine forms an Acid; and from the Matter of Alcohol, gives us somewhat as different from Alcohol, as possible.
5. The helps to this second acetose Fermentation, are
 1. A considerable degree of Heat.
 2. The free access and admixture of the Air.
 3. The stirring the Liquors about, and mixing them together in the open Air.
 4. The addition of some very warm Aromatic during the Fermentation.
6. The Impediments to this Fermentation, are every thing that I mentioned to you before, in our account of the first Fermentation, under this Title, except that stirring the Liquor about is here of service, whereas in the other it does harm.

Thus then, Gentlemen, I have laid before you the whole History of Fermentation, both vinous, and acetose.

P R O C E S S L I.

The Distillation of Vinegar, into an acid Water, an acid Spirit, an Extract, a Sapa, Tartar, and Oil.

A P P A R A T U S.

1. **T**AKE some old Vinegar, made from the best Wine, fill a tall glass Cucurbit three quarters full with it, and with a gentle Fire draw off one quarter.

This then will be light, and limpid, will be dispersed all over the Alembic in form of dewy Drops, and will run down like Water, not in *Striæ* like Spirits; the Taste of it too will be acidish; and if it is thrown upon Flame, it will extinguish it in the same manner as Water does. If this Water is distill'd again to one half in a clean Cucurbit, the part that comes off first consists chiefly of Water, and is of excellent service, where one wants a very mild Acid. In this the Writings of all the Chemists have agreed. *Vigani*, however, has taken the liberty to assert, that the Liquor that first rises in the Distillation of Vinegar, is inflammable, and will burn if it is thrown upon Fire. To put an end therefore to this dispute, I'll relate to you, what, upon examination, I have found to be the case. I took twenty Pints of Vinegar, which was made in *France*, and thence brought here immediately, and had not yet acquired a very sour Taste, and putting it as it was into a very large glass Retort, with a great deal of patience, I distill'd it with a gentle Heat, upon which there rose a Vapour into the Receiver, which when it came to be cool, form'd oily streaks upon it, just such as one sees in the Distillation of Wine. I was surpriz'd, I confess, at this, and therefore proceeded in the same gentle manner, till these *Striæ* were succeeded by some dewy Vapours dispersed about in the same manner as happens in the Distillation of Water and Vinegar. I presently then remov'd what came off first, which had a Taste like common Spirit of Wine diluted with a weak Vinegar, and if it was thrown upon a bright Flame, burnt like Spirit of Wine. When the same Vinegar, however, was better than a year old, and had been kept all the time in a Vessel nicely stop'd, upon performing the same Operation the success was different, for then what came off first was not an inflammable Spirit, but a mere watery Vapour of Vinegar. Hence, therefore, I learnt, that the inflammable Spirits are by time intimately fix'd into the Acid of the Vinegar; that hence the Taste of new Vinegar still continues vinous, but gradually grows sharper, and sourer; that then all the first inflammable Spirits are chang'd, and none but Acid ones remain; that somewhat therefore truly inflammable, is by this means converted into Vinegar, which is not inflammable afterwards; and that for these reasons, what the Chemists have asserted is true, tho' *Vigani's* Opinion must be allow'd so likewise, if you understand it of new Vinegar.

2. I then increased my Fire a little, in order to distill the remainder of the old Vinegar, which was three quarters of the whole, and kept it up in this degree, till I had drawn off two thirds of this *Residuum*, so that now there was only one pint left in the Retort, of four I made use of at first. This Liquor then appeared in drops like Dew, was of a much acider Taste than the former, nor of a disagreeable Smell, but somewhat sub-empyreumatical. It was heavier too than the former, for being mixed with it, it subsided to the bottom. This may properly be called distill'd Vinegar.

3. If the remaining quarter is distill'd with a still stronger Fire out of a glass Retort into a Receiver not too cold, there will come over a very limpid Liquor, exceeding acid, and so penetrating, that it will insinuate itself through the Lute. This will scarcely rise, except it is urged with a great degree of Fire, and then will heat the Receiver so much, as to make it easily fly. Even here, however, there is no appearance of Streaks, and if this Liquor is thrown upon Fire, it puts it out. Proceed then till there remains only a twentieth part,

or less of the Vinegar first made use of. This last Liquor will have an empyreumatical Smell.

4. This being done, there will be left at the bottom of the Retort, a black, thick, acid, oily Liquor, smelling very strong of an *Empyreuma*, which being urged with the last degree of Fire, will yield an exceeding acid, heavy, empyreumatical, fetid Liquor, and an Oil of a surprisingly fetid Smell, whilst there remains a black, acid *caput mortuum* in the Retort. This being burnt in an open Fire, yields a bright Flame, and produces some brown *Fæces*, in which there is a large quantity of an acrid alkaliescent Salt.

5. Hence then it appears, that there does not remain the least appearance of Alcohol in so large a quantity of Vinegar; that there is nothing here of the nature of Tartar, but that the whole rather, a very small part only excepted, is become volatile; and that Vinegar is absolutely of a different nature from any other Acids that we are at present acquainted with.

These things, Gentlemen, I have gone through, before you in this manner, that you might get an insight into the nature of Vinegar from its Composition and Resolution. This Operation, however, would be both too tedious, and chargeable for preparing distill'd Vinegar for common chemical uses. For this purpose, therefore, we take a copper Still, well tinn'd within, and fill it three parts full of Vinegar, and then fixing on a glass Head, proper for this use, we distill with a Worm, raising such a Fire as to make the Vinegar boil. The first quarter part then that comes off we collect by itself, and afterwards draw off two quarters more, which we keep under the Title of distilled Vinegar for Chemical Operations. The other quarter that remains in the Still may be saved too, till by repeated Distillations you have got a sufficient quantity of it, and then will serve for preparing the strongest distill'd Vinegar for some particular uses. I have always however found it tainted by corroding the Copper, for which reason it is dangerous to prescribe it internally.

U S E.

THIS distill'd Vinegar, is a saline, oily Acid, possessing the same virtues which we in the preceding Process ascribed to Vinegar; but as it is freed from its terrestrial impurities, it is more penetrating, active, and volatile. The *Sapa* that remains in the Retort after $\frac{2}{3}$ ths is drawn off by Distillation, is a most noble antiseptic Medicine, used either internally or externally, but on account of its horrible Taste, must be mix'd with a good deal of Sugar or Honey, as *Angelus Sala* observ'd in his *Oxyfaccharum*: For this *Sapa* is a true detergent acid Soap, which becomes continually more efficacious, in proportion, as it grows thicker, for by this means, it gradually grows of a more oily nature. By this Experiment, now, we learn, how wonderfully the distinct Elements of Bodies may lie concealed among one another; for who could believe, that after Wine was grown fine, it could contain so much of an oily Matter, as we see it deposits in the making of Vinegar? Who, from Vinegar so thin and sharp, could expect a black, oily, thick, inflammable *Sapa*? Or who could possibly imagine, that in the most limpid distilled Vinegar, which in thinness vies with Water, there should be an invisible pinguious Oil, and that too in great quantity? In the mean time, some of the nicest Artists have observed, that if the acid

acid of distill'd Vinegar is combined with Powder of Lead in such a manner, as to produce the Sugar of Lead, it then coalesces with that into a pinguious, tenacious kind of sweet Sugar; and that if this is then gently dried, and distill'd in a Retort, it yields an oily Liquor that burns like Spirit of Wine. So that hence it seems as if the latent sulphureous part, which was concealed in the thin Vinegar, discovers itself by this Operation, and is, as it were, regenerated. Unless you would rather imagine, that a combustible Oil is separated from the soft metalline Body of the Lead by the Acid of the Vinegar, and consequently that the inflammable Liquor drawn off, owes its origin intirely to the Metal. This however, I confess, does not seem probable to me, insomuch as Lead, when it is corroded by the acid Spirit of Nitre, tho' it produces a rough sweetish Vitriol in Distillation, yet as far as I know, does not yield such inflammable Liquids, as it does when it is corroded by Vinegar. And then besides upon the Mixture of the purest Spirit of Wine, with the most thoroughly calcined Salt of Tartar, there is regenerated an inflammable Liquid, as will evidently appear by another Experiment in the 66th Process. Nothing, however, here, is more surprising, than that the exceeding acid *Fæces* of Vinegar should afford an Alkali.

P R O C E S S LII.

The Rectification of distill'd Vinegar, per se.

A P P A R A T U S.

TAKE any quantity of the distill'd Vinegar of the preceding Process, No. 2. and with a gentle Fire, in a tall Cucurbit, draw off half the quantity. The half that comes off keep by itself, as do likewise that which remains in the Cucurbit. That which rises will be light, limpid, watery, and less acid; whilst that which remains after distillation, will be an exceeding strong, sharp, distill'd Vinegar, and heavier than the former.

U S E.

THE Rectification, therefore, of Wine, and Vinegar, are effected in a quite different manner: In the former, the first volatile part is the best; in the latter, that which is more fix'd, and is left behind. Hence Vinegar, by boiling, is rendered stronger, and more sharp; Wine by being boiled, becomes weak, thick, turbid, disagreeable, and vapid. And for this reason, if Flesh, Cartilages, Bones, and Skins, are boiled a great while in Vinegar, they are, by the action of the acid of the Vinegar, which is agitated, and grows stronger during the boiling, reduced at last to a thick liquid Matter. This strong distill'd Vinegar is useful, in particular, in all Solutions of Metals; for these require a pretty strong acid.

P R O C E S S

P R O C E S S LIII.

The Rectification of distill'd Vinegar by the help of Verdegrease

A P P A R A T U S.

1. **I**F Plates of the best red Copper are corroded by the Spirit that exhales from press'd Grapes, after the Must is separated, and they are grown warm, and emit a spirituous Vapour, there will be a Mould generated upon their surfaces of a bluish green Colour. This is scraped off, and sav'd, and then the Plates are again treated in the same manner, by which means they afford more of the same Mould. This then being collected together, is called Verdegrease, which therefore is Copper corroded by this Spirit, and combined with it. And this cannot be successfully prepared in any places, where there are not these *Fæces* of Must possessing such a sharp and penetrating Power. This Spirit, therefore, is not properly an acetose Spirit, but one rather of a middle nature, betwixt a true Acid, and a fermented vinous one. Take some of this Verdegrease then, that has an agreeable Colour quite through its whole Mass, pound it, put it into a clean glass Cucurbit, and pour upon it such a quantity of rectified distill'd Vinegar, as is sufficient to cover it to the height of 10 inches. Set the Cucurbit in a pretty great Heat, *viz.* one about 150 degrees, and with a Stick keep the Mixture frequently stirring, and in a short time the Spirit of Vinegar will be ting'd of a beautiful deep green Colour. Let it stand to settle, and then decant the clear Liquor very gently, without pouring off any of the bottom, and upon the *Residuum*, pour some more distill'd Vinegar, and digest it, stir it, and let it stand quiet, and decant as before. Repeat this Operation as long as the Vinegar continues to be ting'd, and then all these colour'd Liquors, mix'd together, are call'd a Tincture of Copper. When the Verdegrease will give out a Tincture no longer, there will be a great quantity of it still left undissolv'd.

2. Let the tinctur'd Liquors be filter'd through Paper, and then be distill'd in a clean Cucurbit, with a Heat of 200 degrees, till a Pellicle begins to be formed on the very green Liquor that remains. The Fluid then that comes off will be limpid like Water, aqueous, and but little acid. Let the inspissated Liquor be set by in a Cellar, and it will in a short time shoot into most beautiful, green, pellucid Crystals, which will fasten particularly to the sides of the Glass, and incrustate it over. Pour off the remaining Liquor as nicely as you can from the crystalline Crust, which must be dried as gently as possible in a hot Air, and carefully separated from the Glass, and so kept, that it may not be affected with too great a degree of Heat, for fear of its becoming opake. Let the decanted Liquor be again inspissated to a Pellicle, and then formed into the same Crystals, which must be treated with the same caution as the former. And thus you must proceed, till by this means all the true Copper that was contained in the Verdegrease is reduced to these pure Crystals of Verdegrease, which in the Shops go commonly by the name of distill'd Verdegrease. If this is reduced to Powder, it gives a most beautiful green Pigment. If it is sprinkled upon a foul Ulcer, it excites Pain, forms an Eschar, and thus dries up

up the Mouth of the Ulcer, whilst at the same time an Inflammation is excited underneath, which separates the Crust, by which means the worst kind of Ulcers are sometimes happily cured: For it is of the same nature as the Caustics, made with Mercury and Silver.

3. When you have got a sufficient quantity of such Crystals, put them into a glass Retort, and distill them with a Fire gradually increased, and you will have first a small quantity of a watery Liquor, which must be kept by itself, or thrown away. When this is drawn off, there will succeed an acid, pinguious Liquor, which will run down in streaks, is considerably heavy, and is the most saturated with an Acid, of all the Liquors that can by any Art whatever be prepared from Vinegar. *Basil Valentine*, therefore, recommends this for the Solution of Pearls in his *Manuductio Medicinæ*; and *Zwelfer* being acquainted with this, boasted of his *Acetum Esurinum*, pretending to be master of the *Alcabeft*, for which he was sharply handled by *Tachenius*. When the Operation is over, there remains the Powder of the corroded Copper, which may be again dissolved in distill'd Vinegar, and be form'd into green Crystals as before.

U S E.

THIS fermented Acid is the strongest that can be procured from Vegetables, and consequently possesses the most excellent Vertues, both Chemical and Medicinal that can be expected from such an Acid. As it is efficacious, therefore, in restoring an appetite where it is destroy'd by a Putrefaction of the Bile, or other Humours, hence it has obtained the name of *Acetum Esurinum*, Hungry Vinegar. But in those cases, where the appetite is pall'd by a predominant acid, which the Physicians are sensible is often the case, there this only increases the cause, and so proves prejudicial. This Acid, however, by being mix'd with absorbent, or alcalious Substances, will lose its acid Vertues in the same manner as all others do, and therefore *Zwelfer*, who asserts the contrary, in this case must not be regarded. In order now to understand the proper effect of this Operation, we must observe, that distill'd Vinegar consists of Water and an Acid: This Acid is attracted out of the Vinegar by the Copper, whilst the Water is unaffected by it, and left by itself: The Acid then adheres to the Copper, and subsists with it in the form of a solid Body, and scarcely at all alter'd, till by the force of the Fire it is separated from it in its former nature, and then it leaves the Copper reduced to Powder, but without any other alteration. This, now, as far as I have been able to inform myself, cannot be effected by any other Body but Copper; for Gold, Silver, Mercury, and Tin, are not dissolved by it; and tho' Iron and Lead are, yet they change it in such a manner, that a pure acetose Acid cannot be procur'd from them again, but something of a very different nature. Hence then we see what a prodigious difference there is in Solutions; the Acid of Vinegar is attracted into Copper, and is thence procured again by Distillation, very little altered, being only freed from its watery part; Lead attracts the same Acid into it, and rejects the Water; and yet if you endeavour to separate it by Distillation, you have an oily pinguious Liquor, of a quite different nature from that of Vinegar; and if Iron is dissolv'd by the same Acid, it yields nothing again but Water, and surprisngly al-

tered. And as for other Absorbents, or fixed or volatile Alkali's, if it is combin'd with any of them, it never returns back again a pure Acid: so that perhaps Copper alone, or Verdegrease made from it, is the only Body we are acquainted with, that is disposed to sharpen and exalt the pure Acid of Vinegar.

P R O C E S S L I V .

The Generation of Tartar from Wine.

A P P A R A T U S .

1. **W**INES, made from Grapes in particular, especially those which have an acid, or rough Taste, generally generate a pretty deal of Tartar. This however they produce good only, when their Fermentation is perfectly over, and they come to grow fine. And the purest of all is formed by them, when they are drawn off fine into another Cask. It is procured in greatest quantity from Wines that have stood quiet for some time upon their own Lees, and have in some measure gently consumed them. The limpid white Wines yield the white Tartar, the best of which comes from the Rhenish Wines, and is very white, and in large lumps, and is made use of for medicinal purposes: And here the whiter, heavier, more shining, and thicker, with respect to its Substance, it is, it is so much the better; See Process 8. That from the red Wines is not so pure, is generally formed in Masses not so solid, and is of a more oily nature. Concerning all these sorts, consult again Process 8.

2. This stony Salt of Wine, which is not in the least disposed to be dissolved either in Water or pure Wine, but like a Stone remains without alteration, if it is boiled in a good deal of Water, will in some measure melt, and render the Water turbid, and in it you will perceive little shining Corpuscles suspended and swimming about. And thus even whilst it is boiling, it casts up continually a kind of Pellicle to the top, which being taken off with a wooden Spoon full of little Holes, and spread in a clean hot broad Vessel, and there dried, forms a white fine Powder, which goes by the name of Cream of Tartar. And if you continue to take this off, as it is thrown up in boiling, the whole Body of the Tartar, except a few *Fæces* at the bottom, will be converted into this white acid Powder, or Cream of Tartar.

3. If you boil white Tartar in a very clean Vessel with twenty times its weight of Water, or more, till it is thoroughly resolved, and whilst it continues boiling hot, pour it into a pure wooden Vessel without any of its *Fæces*, then a Crust will immediately begin to form itself upon all the parts of the Vessel where the Liquor can reach to, which will continually increase more and more, and thus in a short time the whole Body of the Tartar which was dissolved in the Water, will be form'd into regular shining Globules, call'd Crystals of Tartar, which must be collected, gently dried, and kept for use; so that the Water that remains when it comes to be cold, will retain but very little of it.

4. Hence, therefore, we see, that this Salt, produced by a vinous Fermentation, is in these Properties intirely different from every other Salt in nature that we are acquainted with. This Cream now, or these Crystals, may, by being boiled in fresh Water, be again converted into Cream and Crystals; and by this

means your Powder will be always of a whiter Colour. Neither the Cream, however, nor the Cryftals are more valuable for any chemical or medicinal uses than the Tartar itself.

U S E.

THE right understanding this and the eighth Process gives us a good insight into the nature of Fermentation, and this production of it, Tartar. It is this that affords that wonderful Salt, which in many cases is of such excellent service. The Dyers, Silver-smiths, Chemists, and Physicians, make great use of it. The Chemists have a great many Preparations from it, and some of their most valuable too. In Medicine, it is of admirable service in purging the first Passages, gently, if it is given in a small Dose, but very powerfully, if administered in a large one. But here you may consult that very candid Chemist *Angelus Sala*, who has wrote exceeding well upon this head.

P R O C E S S LV.

The Resolution of Tartar, by Distillation, into an acidish Water, a Spirit, an Oil, and a fix'd alkaline Salt.

A P P A R A T U S.

1. TAKE a glass Retort, fill it two thirds full of the purest pieces of the best white Tartar, and place it in a Sand Furnace. Fix on a large glass Receiver, nay, if you are not afraid of fouling it in such a manner that it will scarcely afterwards come clean, the very biggest you can get. Lute the Joint with a common Lute of Linseed, and then give a gentle Fire, scarcely exceeding a 100 degrees, which must be continued for a considerable time. By this means then you will have a moderate quantity of a thin, limpid Water, which is acidish, somewhat spirituous, bitterish, a little odorous, and very penetrating, insomuch that it will very easily perspire through the Pores of the Lute: Let this be removed and kept by itself.

2. Your Fire being then increased to the Heat of boiling Water, there will rise a whitish Vapour, and in that an exceeding penetrating Spirit, which is surprizingly flatulent, and is so vastly subtil, that it can scarcely be confined, but insinuates itself through almost all sorts of Lutes; and if we endeavour to keep it in with that very strong one, called the *Lutum Sapientiæ*, by its elasticity it bursts the Vessels to pieces. And here it is remarkable, that this Spirit seems to act with a kind of *Impetus*, and remission, and thus to perspire, by blowing as it were through the Lute. But with this flatulent, sylvestrian Spirit too there immediately comes over a prodigious subtil thin Oil, which is of a yellowish Colour, has a kind of aromatic Smell that is not disagreeable, and a bitterish Taste, and is of a heating Quality. Nay, in this wonderful Oil I found such an incredible penetrability, that though the Neck of the Retort went five inches into the Mouth of the Receiver, and the Joint was luted as close as possible, yet this volatile Oil had returned back again betwixt the Retort and Receiver, and had so insinuated itself through the Body of the Lute, that some of it dropp'd

down into the Plate underneath, whilst some more of it ran down the outside of the Receiver. Nor have I by any Art been hitherto able to prevent it; for if you make use of an impenetrable Lute, then the Vessels burst asunder. I don't wonder, therefore, that *Paracelsus* and *Van-Helmont* shou'd so highly extol this Oil in Diseases of the Ligaments, Membranes, and Tendons, which, upon experience they asserted they cou'd cure, even though they were come to be contracted.

3. These Liquors being separated and put by themselves, urge the *Residuum* with a Sand-heat gradually increas'd to the greatest, and you will still have such a Spirit and Oil as before, but at the same time, there will come over too, a thick, black, fetid, heavy, very tenacious, and bitter Oil. The Tartar then that remains in the Retort is black, acrid, and alkaline in every Quality.

4. If the remaining Mass is then farther urg'd with the most violent suppressing Fire, there will still rise something of a very thick, black, pitchy Oil, together with a Fume; and these will never cease, increase your Fire to ever so great a degree, or protract your Operation ever so long. The *Caput Mortuum* then that is left in the Retort will be very black, vastly acrid, alkaline, and dry, and when upon breaking the Vessel it is exposed to the open Air, it immediately grows warm, and runs *per Deliquium*, nor can be kept dry without a great deal of Caution, though the Tartar from which it is produced will scarce suffer itself to be dissolv'd in Water.

5. If this black dry Mass is exposed to the Fire in the open Air, it flames, and when it is burnt out, leaves a white, alkaline Salt, which is exceeding strong, caustic, pure, and in the greatest quantity that it can ever be procured. This affords but very little Earth, dissolves spontaneously, and very readily, and if it is kept for a considerable time in a strong Fire, it grows bluish, of a marble colour, and sometimes brown, and by this means becomes always so much the more acrid, as we took notice before, when we were treating of Alkali's Process 12.

U S E.

IF there is any thing to be learn'd any where, there is certainly here. How wonderful is the Action of Fermentation? It first separates all the thicker parts and leaves a liquid, subtil, limpid Wine. From this there is afterwards generated a Substance that is almost like Stone, and will not dissolve in Water, whose Elements, therefore, must have lain concealed in this fine Liquor. And from this stony Concretion again are procured a Water, a Spirit, and an Oil, of such various sorts, so thick, and in so great quantity. In what part of the Wine now was this Oil contain'd, or where did it lie concealed? There was an Alcohol there, indeed, but nothing like such an Oil. But there is something in this Affair still more surprizing, and that is, that though native Tartar is, both in its external and internal parts, merely acid, and causes an effervescence with Alkali's, as will evidently appear, Process 75, yet purely by the Action of the Fire upon it, and that not a great one, and in a close Vessel too, the greatest part of its Substance is converted from an acid disposition to a true, simple, alkaline one, even without any considerable separation of an Acid from it. And this, perhaps, is the only instance where a fixed alkaline Salt is generated by a

moderate Fire, in a Vessel into which there is no admission of the Air; for in other cases there is produced only a black, insipid Coal: Who then cou'd have suspected, that so plain an Acid cou'd by this means have been changed to an Alkali? If you take now the acid Water, the Spirit, and the Oils, and pour them back upon the remaining alkaline Mass from which they were distill'd, and then distill them in the same manner as before, you will have scarcely any Acid, and but a little Oil, but almost all the Substance of the Tartar will be converted into an Alkali. Hence then we see, that a very acid Body of a considerable bulk may be easily changed into an alkaline one; whereas the conversion of a strong Alkali into an Acid, has not, as far as I am acquainted with these things, yet appeared so evident. Hence, therefore, I cannot help being considerably surpriz'd, when I reflect on the very singular nature of this Tartar, which, to the best of my knowledge, in the whole compass of things, has nothing like it. As for the uses of these various parts, the first distill'd Oil is wonderfully penetrating, and is commended for discussing cold Tumours, and for restoring Flexibility to the dry, tendinous parts of contracted Limbs, if at the same time they are properly assisted by Baths, Fomentations and Friction. If these Oils are rectified, they become still more subtil and penetrating, and are then extoll'd by the Chemists for resolving even gouty Concretions. Many People say, that your rich perfum'd Balsams may be exalted by this Oil; but they say likewise, that the Smell of Musk and Civet, when it is grown flat, may be quickened by the Fumes that rise from a Privy. Salt of Tartar, now, is procured by this method in greater plenty, from the same quantity of Tartar, than by any other whatever, and always in a greater, as the Distillation is carried on more gently. And of all fixed Alkali's this is the most excellent, the acridest, the most penetrating, and the purest, nor is there any known Body in Nature which yields a greater quantity of this saline, alkaline Matter, than Tartar does. If the black Alkali, that thus remains from this vinous Substance after the last Distillation, is set by in the Retort, only slightly stopp'd with Paper, it will be intirely dissolv'd into a Liquor, which being filter'd through *Hippocrates's* Sleeve, makes an excellent Oil of Tartar *per Deliquium*, that is exceeding fit for an infinite number of chemical Uses, and serves admirably for some particular Operations. If the same Salt is burnt in an open Fire, and then strongly calcined, and suffered to run in the Air, you have then too an Oil of Tartar *per Deliquium*, but a great deal more acrid and alkaline than the former.

PROCESS LVI.

Tincture of Gum Lac by the help of the Processes 12, 55, 47, 48, 49.

APPARATUS.

1. **T**HE Chemists have observed, that some Vegetable Substances are with difficulty dissolved in Alcohol, and yet, when they are dissolved in it, give evident proofs of their excellent medicinal Vertues. Of this kind are Dragon's Blood, Gum Juniper, Lac, Myrrh, and others, in which there is such a wonderful tenacious Hardness, that they won't easily suffer a dissolution. After

ter various methods, therefore, tried to incide and prepare these Bodies for a more speedy and perfect solution, the following is found to be the most convenient. And here we shall give you an instance of it in Gum Lac, which comes from *Asia*, and is a kind of Resin which the Ants scrape off of the Trees, and by building their Nests with it, collect it in great quantities, particularly in the Island *Ceylon*, from whence we have the best sort. Take then some of the choicest and purest of this Gum, reduce it to a fine Powder, and sprinkle it well with the alkaline Oil of Process 12, or 55, so as to reduce it to a kind of Pap in a Urinal with a round bottom. Set the Glass in our Furnace, describ'd Vol. I. p. 510, and apply such a Heat to it as just to dry the included Matter. When it is dry take the Urinal out, and let it stand exposed to the open Air, and you will have an alkaline Oil *per Deliquium*, which must be then dried again in the Furnace, as before. After the Solution and Exsiccation has by this means been repeated some number of times, the vitreous tenacity of the Gum is at last resolv'd, and it is reduc'd to a Liquid of a most beautiful purple colour. This then must be gently dried again, and what remains must be taken out of the Glass, and will then be properly disposed for the Extraction of a Tincture with Alcohol.

2. The Gum then being thus prepar'd, put it into a tall Bolthead, pour as much pure Alcohol upon it as will cover it to the height of three or four inches, and closing the Mouth slightly with a Paper Stopper, put it into the same Furnace, that it may be kept just ready to boil, for the space of two or three hours. Nor need you be at all afraid of any inconvenience from the Vessel's not being close stoppt, for the height and narrowness of the Neck will prevent any of the Alcohol's evaporating. Then let the whole grow cold, and by a gentle inclination pour off the pure ting'd Liquor from the subsiding Matter, and put it into a clean Glass, which must be well stoppt. Upon the *Residuum*, then, you may repeat the same Operation in the same manner, and mix the second colour'd Liquor with the former, and so proceed till the Gum won't give a Tincture to the Alcohol any longer, which will be then quite exhausted, and good for nothing.

3. These Tinctures being all put together, and depurated from their subsiding *Fæces* by standing quiet, must be inspissated to one half by evaporating the Alcohol with a gentle Fire in a glass Cucurbit, and are then admirably prepar'd for their proper uses.

U S E.

HERE then we see, that an Alkali, the Air, and a digesting Fire opens a compact Body in such a manner, that it afterwards suffers its Vertues to be extracted by Alcohol; that the reciprocal Action of humectation and exsiccation penetrates at last to the very inmost parts of it; but that still there is some Matter in it, which is able to resist even the efficacious Power of this alternate Operation, nor will be resolv'd, but remains at last in the form of *Fæces*; and that these Tinctures therefore possess the active Vertues of such Bodies, which are now freed from any impediment from the grosser terrestrial parts. This method therefore is efficacious, speedy, convenient, and of very extensive use in making the most beautiful Preparations. And here the general Vertues of the

the Tincture will depend, first, upon the *Spiritus Rector* of the Bodies from which they are extracted, which lies concealed in them, and often is endued with a surprizing efficacy; secondly, upon their balsamic pinguious part; thirdly, upon the corroborating resinous part, which generally enters into their Composition; and fourthly, upon the dissolving Alcohol, which we have particularly examined already. Hence, therefore, we may venture to pronounce of these in general, that they are heating, stimulate the Nerves, raise the Spirits, are drying, resist Putrefaction, increase particular Powers, and constringe the Vessels. As for this noble Tincture of Gum Lac, it is of excellent service in Disorders of the Mouth, Gums, and Teeth, in the Scurvy, if they are prudently rubb'd with it. If it is taken internally, too, it is a very good and safe Medicine in the same Distemper, as it don't excite too great a degree of Heat. In the Gout, the colder kinds of Rheumatism and Scurvy, leucophlegmatic, and dropical habits of Body, and the like, it is used with great success. And here it is best to clear the Stomach first, and then give it three times a day in *Spanish* or *Canary* Wine, when the Stomach is most empty. It has an agreeable Smell, and a bitter Taste that is not unpleasant, with an Astringency which sufficiently indicates its corroborating Power. Hence where a mucous Humour is predominant, particularly in the uterine Vessels, as in the Whites, it is extoll'd as an excellent Medicine.

P R O C E S S LVII.

Tincture of Myrrh by the help of the Processes 12, 55, 47, 48, 49.

A P P A R A T U S.

TAKE some choice Myrrh, and proceed exactly as in the preceding Processes, and you will have a truly valuable Tincture, which the Artists were long in search of, but had always the mortification to see that this noble Gum would not remain dissolved. A great many methods therefore have been tried of dissolving it with various *Menstruums*; but this succeeds the best.

U S E.

HERE we have an instance of a Chemical Solution, in particular for Medicinal Purposes. *Van Helmont* formerly asserted in his Writings, that if Myrrh cou'd but insinuate itself into the most intimate vital parts, it wou'd have a great tendency to lengthen out Life, so far as this cou'd be expected from the incorruptibility of the vital Balsam. If foul Ulcers of the Mouth, Nose, Gums, and other parts of the Body are washed with this Tincture, by its detergent and antiseptic Vertue, it proves of excellent service in healing them. If the Bodies of dead Animals are thoroughly penetrated with it, first made hot, they are preserved from Putrefaction. Internally it is of admirable use in *Languors* from a simple *Inertia*. To the Fair Sex in particular it is greatly serviceable in those Distempers which are owing to a watery, mucous sluggishness of the Fluids, and a too great laxity and weakness of the Solids, which they are naturally disposed to from the soft loose make of their Bodies, especially

especially in the *Uterus*, which is the most dilatable part of all: In that mucous uterine discharge, therefore, called the *Fluor Albus*, it has an excellent effect, and hence cures all those Disorders that depend upon it.

P R O C E S S LVIII.

Tincture of Amber by the help of the Processes 12, 55, 47, 48, 49.

A P P A R A T U S.

TAKE some choice pieces of the clearest, purest, yellow Amber, and reduce them to a very fine, mealy Powder. Rub this well with the alkaline Oil of Process 12, or 55, the longer the better, till it is brought to the consistence of a very uniform Pap. Put this liquid Matter into a clean Urinal, and dry it gently in the same Furnace, and then let it run in the Air, and dry it again as in the two preceding Processes, and repeat this a pretty many times, for it is penetrated with a great deal of difficulty. The Matter being at last well dried, put it into a Matrafs, with a very long slender Neck, and pour as much pure Alcohol upon it as will cover it to the height of three inches. Shake them well together, and then let them boil gently in the Furnace, for the space of some hours, which here may be done without any inconvenience. By this means then you will have a red Tincture. When this is grown cold and clear by standing, pour it off gently into a clean Vessel, and stop it very close. Then proceed in the same manner as before, till the whole substance of the Amber is almost consumed into such a Tincture. A Tincture may be prepared by the same method with Alcohol alone, without any Alkali; but this with an Alkali is better.

U S E.

HERE then we see the efficacious Power of an Alkali, which thus procures an entrance for the Alcohol into a Body that is brittle like Glass, and whose singular and surprizing resinous Nature no body has hitherto clearly explained. A fossil Acid, indeed, and *Petroleum*, or something of the like nature seem to enter into its Composition, which is not resolved without a great deal of difficulty. This Tincture, however, is neither acid, alkaline, nor oily, but contains the whole Substance of the Amber dissolved, with a refreshing, aromatic, bitterish Taste, some astringency, and a fragrance that is wonderfully reviving. If it is well made it grows turbid in the Winter, and deposits a mealy and kind of resinous Matter, and thus evidently demonstrates how pregnant it is with the dissolved Amber: As the warm Weather, however, comes on, it grows pellucid again, and takes up what was separated from it before. If from this Tincture you draw off half the Alcohol, the remaining thick Matter will let fall a kind of mealy Powder of Amber, which is of an exceeding aromatic Smell and Taste. It is surprizing here, now, that this Body shou'd almost all of it be so equably dissolved in the Alcohol without any considerable separation of its Elements, and yet shou'd acquire such noble Medicinal Virtues, which did not discover themselves before in the Amber itself, especially

as by distillation it is divided into such various parts, of such different Qualities and Vertues, as will appear in Process 86. Hence then we have another evident proof that there is an incredible diversity in chemical productions, as they are prepared with different *Menstruums*, and by different Methods. Hence we see farther too, that the most different Elements may lie intirely concealed in a compound Body, without the least discovery of their nature or presence, and that, though they are very subtilly divided by rubbing, or by a *Menstruum*. And hence, lastly, it appears, how the sole division of a Body brought about by a *Menstruum* may produce new Vertues in it without any separation of its Elements. This Tincture now is of admirable service in all those disorders which arise from too great a mobility of the (*instrumentum proximum*) most immediate Instrument of the human Affections, viz. the Spirits, and nervous System, to the production of which, a weak habit of Body has a particular tendency. Hence in hypochondriacal, hysterical, languid, cold, watery, pituitous, leucophlegmatic Cases, Catarrhs, and Convulsions that are often caused by these Disorders, it is an excellent Medicine. And for this reason both *Helmont* and *Boyle* rank'd it amongst the most efficacious Antispasmodics, and Antileptics, where they were owing to this Cause. These three instances then are sufficient to let you into the true method of extracting Tinctures from those Substances which give them out with the greatest difficulty. The Dose, now, and Method of using this Tincture are the same we gave you Process 56.

P R O C E S S LIX.

Tincture of Benjamin by the help of the Processes 47, 48, 49.

A P P A R A T U S.

IF this noble resinous Body, which spontaneously distills from its Tree in great abundance, is reduced to Powder, and without any preparation boil'd in a Bolthead with Spirit of Wine once rectified, it will be presently dissolv'd into a red sweet-scented Liquor. If the pure solution is then poured off, and the *Residuum* is treated again in the same manner, and so on, almost all the Benjamin will be dissolved, a few *Fæces* only being left at the bottom. If you boil Alcohol with it in the same manner, the Tincture becomes still stronger. Both of them have a sweet Smell, and a warm, bitterish, balsamic Taste.

U S E.

HENCE it appears, that a resinous, pinguious Body may be intirely dissolved in Alcohol, and make with it a Liquor that is pretty thin, and homogeneous. If a little of this Liquor is poured into a good deal of Water, the Mixture grows white, opaque, and milky, and is called *Lac Virginis*, because, if it is used as a Wash, it softens the Face, and if it is suffered to dry on, it covers it with a very fine, beautiful Pellicle. Hence it is reckoned amongst the innocent Cosmetics, and is sometimes on account of its grateful Smell used by the Barbers in shaving. This Resin of Benjamin, and Camphire, are wonderfully volatile, and, without the assistance of an Alkali, spontaneously dissoluble in Alcohol, in a gentle degree of Heat.

PROCESS LX.

Tincture of Guaiacum-wood by the help of the Processes 47, 48, 49.

APPARATUS.

1. TAKE some very fine Rasplings of the choicest, heavy, fresh, green Guaiacum-wood, or rather the Powder of its Bark, put it into a tall Bolthead, and pour upon it enough rectified Spirit of Wine to cover it to the height of four inches, without the addition of any thing else. Boil them together, in the manner already explained, for the space of four Hours, frequently shaking the Glass. By this means then there will a red Liquor swim at top, which, after it has stood and settled, strain carefully through a Cloth, and keep by itself. Pour some fresh Spirit on the *Residuum*, and treat it in the same manner, and so proceed, and when all the Tinctures are properly depurated, mix them together, and you will have a Liquor of a very penetrating, warm, aromatic Taste and Smell. If you make use of Alcohol for this purpose, instead of rectified Spirit of Wine, the Tincture will be so much the better.

2. When this Tincture is prepared with pure Alcohol, draw off the Spirit with a gentle Fire, in a tall Cucurbit, till there remains but one quarter, which will be a very rich Tincture, strongly impregnated with the Vertues of the Guaiacum. If there is a watery Phlegm in the Spirit made use of, then, if you inspissate it so far, the Resin will begin to precipitate, but if you draw the Tincture with the purest Alcohol, it will bear this inspissation without any separation of its parts, and at the same time will increase in its Strength.

USE.

IN this Operation then you see the method by which the oily, resinous, balsamic part may be extracted from sweet Woods, which may then be preserv'd for medicinal purposes. The Liquor thus produced, too, is valuable on account of the Resin that may afterwards be procured from it. The Vertues of these Tinctures depend upon the proper Qualities of the Woods they are extracted from, so far as they reside in their aromatic, balsamic, oily, resinous part. Hence, from Aloes-wood, *Calambac*, Snake-wood, Rose-wood, Saunders, and the like, by this method, and with this solvent, are prepared Tinctures of excellent Vertues. This Tincture of Guaiacum, externally applied, is of wonderful service, where there is any thing fungous, mucous, or virulent, in venereal and other malignant Ulcers, whether their seat is in the Skin, and *Membrana Adiposa*, or in the Mouth, palate, *Fauces*, or Throat.

PROCESS LXI.

Tincture of Scammony by the help of the Processes, 47, 48, 49.

APPARATUS.

THE thick, pinguious, milky Juices which spontaneously distill in great plenty from some Plants when they are wounded, after they come to be inspissated

inspissated by the Heat of the Air, or Sun, generally discover somewhat of Refin in 'em. Of this kind are Lettice, Gum-succory, Sow-thistle, Hawk-weed, Dandelion, Vipers-grass, Goats-beard, Succory, Spurge, the Euphorbium, *Convolvuli*, Poppies, and the like. These Juices then being dried and reduced to Powder, must be boil'd in the same manner in a Bolthead with Spirit of Wine, either once or twice rectified, by which means they will be almost all dissolved, leaving but a little terrestrial *Fæces* behind. And thus we draw a Tincture from the Scammony of Syria, which is the inspissated Juice of a *Convolvulus*.

U S E.

Tincture of Scammony prepared in this manner will purge in a small Dose, viz. two drachms mixed with three or four times as much Syrup of Damask Roses; and from this is generally prepared the Refin of Scammony. The instances now we have given in these three last Processes discover to us particularly the Action of pure Spirits of Wine upon compound vegetable Substances, which proceeds according to the Law observed by the ancient Chemists, viz. that Spirits dissolve that which is like them; for Alcohol that is absolutely pure extracts from dry vegetable Bodies, Spirits, Balsams, Oils, Colophonies, Refins, Gum Refins, and perfect saponaceous Substances, leaving a pure, dry Salt, and an Earth behind. When the Operator, therefore, knows that all the particular Vertues which he wants to extract from these Bodies, reside in these parts, then the Tincture shou'd be made with the purest, and most perfect Alcohol, as we observed in the Tincture of Guaiacum: But on the other hand, when these Vertues are lodg'd in the oily, resinous, saline, and saponaceous parts together, it is better to make use of common rectified Spirit of Wine, than Alcohol, for that acts by its watery part upon the saponaceous saline Matter, and by its spiritous, upon the balsamic, oily, and resinous, and consequently in such a Tincture you have their Vertues united together. This is evident in the Root of Hellebore, Hermodactils, Jalap, Mechoachan, and Turbith; for the Tinctures extracted from these with Spirit of Wine once rectified, purge much better than those made with simple Alcohol. Thus if you draw a resinous Tincture from Jalap with Alcohol, it is less efficacious, and there will still remain a purging Quality in it, which may be got out of it by boiling it in Water; if you extract one with common Spirit of Wine, it purges more, and the *Residuum* is hardly good for any thing. From what has been observed then we infer, that a fixed alkaline Salt is not necessary in many Tinctures, nay, that it wou'd destroy or alter their Vertues; and that they are not always to be extracted with Alcohol: In these cases, therefore, we must always first carefully consider what sort of Spirit is to be made use of. All these Tinctures, now, that are made with pure Alcohol, generally burn away intirely like simple Alcohol, and thus evidently demonstrate, that the inflammable part only is here extracted from the Compound, all the rest being left behind. When the peculiar Vertue of a Vegetable, therefore, resides in the saline, saponaceous part alone, then a Decoction of it in Water is better than in Alcohol. Opium is best of all dissolved in Water, then in Wine, and next in Spirit of Wine, and is always so much the worse, as the Spirit is stronger.

PROCESS LXII.

A Purging Potion from Process 61, and a Sudorific one from 60.

APPARATUS.

IF, as I observed before, you take two drachms of Tincture of Scammony well prepared with rectified Spirit of Wine, and mix it with three times as much of any purging chologogue Syrup, as *Syrupus de Rhabarbaro*, *Cichorei cum Rheo*, *Rosaceus solutivus simplex*, or with Sena, and give it upon an empty Stomach to a pretty strong Person, who wants this particular sort of purging, it generally answers the end very well, by clearing away the Bile. Or if you take four drachms of such a Tincture drawn from the choicest Jalap with common Spirit of Wine gently rectified, and add to it half an ounce of *Syrupus de Spina Cervina*, you will have a Potion, which will purge off a vast quantity of thin Water, without any considerable ruffle or inconvenience. In those disorders therefore where this kind of purging is necessary, it proves an excellent Hydrogogue. These Tinctures therefore are generally kept in the Apothecaries Shops for any extemporaneous prescriptions. But again, if you take four drachms of Tincture of Guaiacum prepared with pure Alcohol, and then inspissated to one half, and mix with it four times as much *Syrupus quinque radicum aperientium*, de *Artemesia Fernelii*, or the like, and give it to a patient fasting, and in bed; it commonly soon disperses itself all over the Body, heats it, puts it in motion, and disposes it to sweat pretty plentifully. And hence it is commended in venereal disorders, that spread themselves through the subcutaneous parts of the Body. And lastly, such a Potion prepar'd with Tincture of Snake-wood, and given in the same manner a little before the cold fit of an intermittent, has often an excellent effect, by promoting Sweat, heating the Body, and dissipating the Cause before it has formed the Fit. The effects of other Tinctures may hence be easily understood.

USE.

THE Vertues of a great number of Vegetables reside in their Resins. And these are generally tenacious, and by this property are ready to fix and adhere to particular parts of the Body: At the same time too by their tenacity they are either rendered slow in their Action, or prevented from exerting it efficaciously; but when they are dispersed through the vegetable, spiritous *Menstruum* describ'd, they act quicker, pass sooner, and operate in a great deal less Dose. These Resins, however, when they are dissolved in Spirits, are so acrid, that they can't be drank alone, and yet if you offer to dilute them with Water, there is immediately a tenacious Matter precipitated to the bottom. Nothing, therefore, is better to mix them with, than a thick Syrup, in which they will not precipitate; nor will they, on account of its wonderful simplicity, be at all altered, or lose any of their proper Vertues by this Mixture, though at the same time they will by the thickness and sweetness of the Syrup be rendered much milder.

PROCESS

PROCESS LXIII.

A Lac Virginis from Process 59.

APPARATUS.

IF the very red Tincture of Benjamin, rightly prepared according to Process 59, is examined, even with a Microscope, it appears uniformly pellucid; but if you let fall a drop of it into Water, it immediately grows white, and opaque, and produces some Films, that are discernible by the naked Eye, but more so if looked at with a Glass. If any quantity of this Tincture therefore is mixed with ten times as much Water, it grows presently milky, turbid and full of Flakes, and almost all the Benjamin is precipitated to the bottom, in form of a fine mealy powder, so that there remains very little either of its Taste or Smell.

USE.

THIS Experiment then serves to discover to us the nature of Resins, with regard to Alcohol and Water; that of the white precipitation of an oily Body in Water (Process 15, 16, 17, 21, 26, 27, 28, 29;) the production of a Resin, by an Extract made with Spirits; and the separation of this Resin again from the Spirits, by the help of Water. This resinous Matter now that subsides in the Water, presents to the view some very subtil, smooth Pellicles, which, being rubb'd upon the Skin, render it sleek and soft, and at the same time make it look beautifully. Hence it is made use of to wash the Face with, where there are Pustules, little Ulcers, Freckles, or the like Blemishes.

PROCESS LXIV.

Resins procur'd from Process 60, 61.

APPARATUS.

I. **T**AKE a Tincture drawn from an oily resinous Vegetable with Alcohol of Wine, according to Process 60, 61, and when it is grown very fine by standing quiet, let it be inspissated with a gentle Fire in a Cucurbit, till there is only one fourth part remaining; and here the Alcohol that is drawn off, if it is sav'd, will serve again for the same use. Pour the inspissated Tincture into twelve times as much clean Water, contain'd in a low Vessel, that has a Mouth big enough to admit one's Hand. The Mixture, then, in an instant will grow turbid, and white, and will presently discover some yellow Corpuscles, which being collected at the bottom form a thick, tenacious, pinguious Matter, which is sub-pellucid. Put the whole into a Cucurbit, and with a very gentle sand heat draw off the remaining Alcohol with an Alembic, and proceed in this Operation as long as the Streaks in the Head make it appear, that the inflammable Spirits still ascend. The Spirit that comes off mix with that which you drew off.

off before, and there will then remain only the Water, and at the bottom of it the Matter just described, which will melt with the heat of the Water, and afterwards grow hard.

2. Throw away the Water, in which, tho' there will be some Smell and Taste, yet there will be but very little Vertue. At the bottom, let the resinous Matter collect itself into one Mass, which you'll easily unite together, and which at first will be soft and flexible, and will stick to your Fingers, so as to be troublesome. When you have wash'd it, however, some number of times with fresh cold Water, it gradually grows stiff as it cools, and being dry'd, forms a hard, brittle, pellucid Body, which softens and runs with Heat, will not dissolve in Water, but may be diluted with Oil, or Alcohol, and burns like Oil in the Fire. This is what goes by the name of a Resin, and must be kept in a cold dry place, and in a clean, dry, close Vessel. This may be procured, by this means, from almost any vegetable Substance that is oily, heavy, dry, and resinous. Nature often spontaneously produces the same thing from Vegetables, but never more perfectly than in the Camphire-tree, which furnishes us with a pure, white, clear, fragrant, volatile Resin, but which is with difficulty reduced to Powder. From the Benjamin-tree too there oozes out a pure volatile Resin, in pretty considerable quantity. But when pure Alcohol, now, is made use of to extract Tinctures from Vegetables, that are resinous indeed, but at the same time juicy and green, then the Water that abounds in these Juices mixes itself with the Alcohol, so that hence it becomes diluted, and of consequence acts like common or rectified Spirit of Wine, according to the greater or less quantity of Water that is supplied by the Plant. In this case, therefore, its Operation will be different from what it is, when the Body is dry.

U S E.

1. **T**HIS Experiment, then, which is a pretty general one, teaches us the nature of Resin, which seems once to have been a pure thin Oil, in the Vegetable, according to Proceſs 34, 35, and what we there took notice of concerning the origin of inspissated Oils. Hence the Chemist learns the various appearances under which Oil is capable of subsisting, as it is affected by different degrees of Heat or Cold: In a certain degree of Cold, it is a hard, brittle Resin; when it comes to be exposed again to Heat, it dissolves into a pure fluid Oil. Some Chemists, indeed, have asserted, that Resins are produced by the combination of a strong Acid with a limpid Oil, as they observed that the very strong caustic Spirit, both of Nitre and Vitriol, upon being mixed with such an Oil, forms a pitchy tenacious Mass, which by the help of the Fire, may be farther perfected into a Resin: And hence they said, that Sulphur itself, being generated in this manner, is a true Resin of the Earth. There is a great deal of reason, however, to doubt, whether the Resins we are speaking of are formed by a coagulation of an Oil with an Acid, inasmuch as in the natural Alteration of Balsams into Resins, the Acid is more and more separated from the Balsam, as that from its liquid State grows gradually thicker, and harder, and at last, when it comes to be hardened into a Resin, there is still less Acid in it, than when the Mass continued somewhat liquid. Nay farther, too, the Resins that are thus produced by the mixture of an Oil with an Acid, are always

ways different both from those which nature spontaneously furnishes us with, and those which are procured from Vegetables by the help of Alcohol; for these last will dissolve in Alcohol, whereas Sulphur is not affected by it.

2. In the Resins thus prepared, which by the inflammability of their whole Substances, discover their perfectly oily Nature, there seems to reside the original *Spiritus Rector*; for the Smell, Taste, and particular Vertues are found still to remain in this resinous Substance, that is to say, those which are lodg'd in the oily part of the Vegetable. And hence, these being entangled in the tenacity of the Resin, may be secured for years, whereas they would be dissipated sooner from the Vegetable itself. But from the viscosity of these Resins it often happens, that when they are taken into the human Body, they pass through intire, without giving out their Spirits to perform their proper Operation, not meeting with Bile enough, or any other saponaceous Liquid to dissolve them, and render them efficacious. By this means the Physician is frequently disappointed, when these are ordered in Pills, as they are then often discharged whole by Stool, without the expected success. In these Resins too there is generally a manifest, acrid, caustic, inflammatory Power, so that if they stick to the Tongue or *Fauces*, by their Acrimony they prove very troublesome, and in the Stomach and Intestines have the same effect, irritating, and inflaming the parts, and thus doing a great deal of mischief. Hence, when these Resins are prepared from *Coloquintida*, Spurge, *Euphorbium*, Hellebore, Jalap, *Mecchoacan*, Scammony, or Turbith, they sometimes bring on a dangerous *Hypercartharsis* that is not easily stopp'd. That both these inconveniencies therefore may be avoided, let these Resins be rubb'd for a good while with an equal quantity of Loaf Sugar in a cold glass Mortar, and when they are reduc'd to a very fine Powder, let them be given in any Syrup, and then they will never pass through the Body undissolved, nor will ever adhere to the Folds of the Stomach or Intestines, but performing their proper office easily and expeditiously, will prove an excellent sort of a Medicine. Or if they are well rubb'd and divided with a little Yolk of Egg, their tenacity will by this means too be destroy'd, and their Operation will be rendered quicker and more efficacious. And by these Methods, even those Resins will purge, which are procured from Vegetables that have no purging quality, as we see plainly in the Resin of Guaiacum.

3. The greatest Masters in the Chemical Art, long ago informed us, that distill'd aromatic Oils, that are very pregnant with Spirits, will grow resinous when their Spirits are separated from them; and this, in some of them, is evidently confirmed by observation: For if the purest Oil of Cinnamon is diluted with Alcohol, and this is intirely drawn off again by Distillation with a gentle Fire, then the Alcohol will carry off the Spirits along with it, and the Oil will remain at the bottom exhausted, and at the same time inclining towards the nature of a Resin.

4. But as the purging qualities of some Vegetables reside partly in the Resin that is extracted from them by Alcohol, and partly in another active principle which is dissoluble in Water, as appears plainly in Jalap; hence, if after you have drawn out all the resinous part with Alcohol, you boil the *Residuum* in Water, you will by this means obtain the other likewise. If you inspissate this Decoction therefore, and reduce it to an Extract, and then mix it thoroughly with the Resin rubbed according to Art with some Yolk of Egg, you will

then have an excellent Compound, which in a small compass will possess almost all the purging quality of the Vegetable.

P R O C E S S LXV.

Extracts call'd Essential ones, from Process 48 : An instance here in Saffron.

A P P A R A T U S.

1. **N**ATURE often, in particular parts of Vegetables, generates a certain kind of Matter, which is of so different a nature from every thing else, that it can scarcely be reduced to any *Genus* of known Bodies, and at the same time possesses very excellent and inimitable Vertues. Of this sort, is that Matter which is contained only in the gold coloured *Stamina* of Saffron. This, the principal of the Chemists have had such an Opinion of, that they call'd it the *Aroma Philosophorum*, and by combining together the first Letters of both Words, sometimes simply, *Aroph.* And indeed, it is incredible how rich this is in Colour, Smell, Taste, and Vertue, how small a compass it takes up notwithstanding all its excellencies, and how tender it is, and easily corrupted. For this reason, therefore, it deserves a particular manner of Treatment.

2. Take, then, of the choicest fresh *English* Saffron, dry'd, and either cut small, or whole, as you have a mind, two ounces, as I have here done before you. Put it into a very clean Cucurbit that has a long narrow Neck, and pour upon it as much of the purest Alcohol, in which you are sure there is nothing heterogeneous, as will rise to the height of 4 or 6 inches in the Body of the Bolthead. Stop the Mouth of the Glass lightly with a conical paper Stopper, and place it in our little wooden Furnace, with a live Coal under it, so covered with sifted Ashes, that it may give out a Heat only of 100 degrees. Let it digest in this manner for the space of three days, every now and then shaking the Vessel; and then let it stand quiet in a cool place for 24 hours, after which you may strain it through a thin Cloth placed in a Funnel, and thus you will have a ting'd Liquor of a very bright Colour, which put into a glass Vessel, and keep stop'd very close. The Saffron at the bottom of the Cucurbit you will then find paler than it was at first, upon which pour the same quantity of Alcohol, as before, and treat it in the same manner, and you will have another Tincture, which mix with the former: The Saffron by this means will be grown still paler. If you have a mind then, as I have sometimes done, to proceed any farther, pour more Alcohol on, and digest, &c. as before, and you will have a third Tincture, which will not be so rich, and which you must keep by itself: The Saffron will then be pale, but will have the same form and size as before. Upon this I once poured Water, and digested and decanted it, and the Liquor was of a yellowish Colour, which being separated, I put on more Water, and proceeded in this manner, till it would extract a Tincture no longer. The *Stamina* were then of an exceeding white Colour, and being gently dry'd, retained their proper Figure, but were thinner a good deal than at first, and had neither Smell nor Taste, nor were easily to be distinguished from Threads of pure Flax. It is surprizing, therefore, to consider, in what place this wonderful Matter should reside, which as appears by this Operation, may be richly diffused thro' so large a quantity of Alcohol.

3. Let the Alcohol in the two first Tinctures be gently drawn off in a glass Cucurbit, with a Heat of 100 degrees, till there remains about an ounce at the bottom, keeping the Vessels very close. When this is cold, let it be poured into a Vial, and stopp'd as nicely as possible. This Liquor will be of a very red Colour, an exceeding fragrant Smell, and a bitter, aromatic, penetrating Taste, and of the Consistence of a liquid Oil; and then it is called the Extract of Saffron. The Spirit that rises in Distillation, will be very limpid, discovering no manner of Colour, but having a fine aromatic Smell of Saffron, and somewhat of the Taste: This, therefore, I always set by for the same use, and by this means it becomes constantly more and more impregnated.

U S E.

1. **T**HIS surprizing Experiment discovers to us a new kind of Matter, which we can scarcely call an Oil, Spirit, Gum, Resin, or Gum-Resin; nor is it a Wax, or a Balsam. What then shall we say of it? Why certainly it is something of a particular kind, but of an oily spirituous nature. The Extract prepared in this manner, suffers itself to be mixed with Water, Spirits and Oil: And its Vertues have such a singular reviving quality, that the immoderate use of it is apt to excite an extravagant, nay indecent Mirth, but a prudent one renders it truly exhilarating. It is said to have a peculiar power of destroying the petrifying quality of the Urine in the Kidneys, and of consequence to be an excellent Remedy against the Stone. This is the true *Aroph* of *Paracelsus*: Nor is it necessary to mix the Saffron with Bread, and let it corrupt with the Heat of Horse-Dung, in order to extract a Tincture from it, for by this means it is worse rather than better; whereas in this Preparation of ours, we retain the whole, without any loss, without any diminution of the proper Vertues, or without any sensible alteration. These Extracts now have this excellence, that they may be mixed almost with any thing, and are of so exceeding subtil a nature, that they are capable of insinuating themselves into the minutest Vessels of the Body, and at the same time are so very mobile, that they diffuse their Vertues through the whole human Frame, tho' they act particularly upon the animal Spirits, and put them into motion. And then besides, they have those peculiar Vertues which the All-wise Creator has implanted in the particular Bodies they are made from, and which are discovered only by their proper effects, nor can be explained from any other principle whatever.

2. Ambergrease, Musk, Civet, Castor, Opobalsam, Balsam à Mecha, Liquidambar, Liquid Storax, Garden Cloves, Aromatic Cloves, Mace, Nutmegs, Angelica, Galangals, Master-wort, Florentine Orris, and Barks and Leaves that have a very fragrant Smell, yield the same kind of Extracts, if they are treated in the same manner. So that hence it evidently appears, that the Spirits of particular Bodies may be drawn out and collected together by the help of Alcohol. And for this reason, their Vertue seems most readily to be brought into action by this Operation; for the Alcohol which is exceeding spirituous, by being united with these very active Spirits, produces a Medicine which very soon disperses its efficacy through all parts of the Body.

3. And when from a number of such Bodies as are above described, you prepare the same Medicine, it easily appears, that according to the pleasure of the

Operator, various kinds of the most beautiful Compounds may be formed, which by their united Vertues will become so much the stronger, so that nothing can be contrived that shall be more efficacious. These Extracts are best taken in Canary, or some such oily Wine.

PROCESS LXVI.

Essential Extracts from Camphire, by the help of Process 48, 49.

A P P A R A T U S.

THIS surprising kind of Body, which we have more than once taken notice of already, deserves to be still farther examined in the following hot manner. Camphire, then, in the very Countries, is found to reside naturally in the Wood, but more particularly the Bark of the Camphire-tree in a true crystalline Mass; of which that in the Islands *Borneo* and *Ceylon* is the finest, and most valuable. Another sort is procured by distilling the Wood, Bark, and Root of the Camphire-tree, or of the *Ceylon* Cinnamon-tree that has the Smell of Camphire, for these Bodies being digested in Water, and distill'd, yield a limpid, and very penetrating Oil, which is strongly impregnated with the Smell and Taste of Camphire, and part of which hardens into Camphire when it comes to grow cold. This wonderful Substance is depurated by Sublimation, in a clean Vessel, with a gentle Fire. It is clear like crystal, difficult to powder, very odorous, and is spontaneously volatile, and will all exhale away. In Alcohol it will intirely dissolve, and this will still remain perfectly pellucid, and will by this means acquire a very fragrant Smell. If you then distill this Mixture, almost all the Camphire rises with the Alcohol, or a very little after it, in form of a homogeneous Liquid. And if you drop a little of this very limpid Liquor into Water, it immediately grows white, and the Camphire appears again in the Water in its proper form. Thus then you see that this heteroclite kind of Body resembles a Resin, but a volatile one; in which respect, therefore, it differs from others. It may be dissolved too in Spirit of Nitre, Spirit of Vitriol, or *Aqua Fortis*, in the same manner as it is in Alcohol. But where again do we find this to be the case in other Resins? Hence, therefore, it appears, that even in the true Resins of Vegetables, there is such a diversity as shews them to be very different from one another. This Liquor too may be inspissated at pleasure by a very gentle Distillation, and then it has the appearance of an Oil.

U S E.

THIS Operation then makes appear the true nature of Camphire as before explained. The Spirit drawn from it by Distillation, is vastly penetrating and volatile, is an excellent preservative against a Mortification and Putrefaction, is drying, promotes Perspiration, and with respect to the Blood and *Serum*, is a Styptic. The application of it to the bare Nerves, however, one would imagine should not be so proper, on account of its very drying quality.

P R O C E S S LXVII.

*Quintessences, as they are call'd by the Chemists, by the help of the Processes
23 to 30, and 48, 49.*

A P P A R A T U S.

1. **T**AKE a choice distill'd, aromatic, essential Oil, put it into a dry, clean glass Vessel, and pour upon it 12 times as much of the very purest Alcohol, that which has been alcalisated in particular, and then distill'd, that it may not contain the very least quantity of Water. Shake them then together, and the Oil will disappear, and will be so intimately united with the Alcohol, as to form one very limpid, clear, homogeneous Liquid. But you must take care too, that there is no Water in the Oil, for otherwise the Experiment will not succeed.

2. Alcohol, therefore, and essential Oils, are of such a nature with regard to one another, that they will bear to be intimately mixed and united together, provided you can keep them perfectly free from Water, for even the Moisture of the Glass, or ones Breath, will prevent their union. And when they are most accurately combined together, upon pouring Water upon them, the Mixture grows white, and opaque, and the Water attracts the Alcohol to it, and separates it from the Oil.

3. If Alcohol, saturated with an essential Oil, is distill'd perfectly close with a gentle Fire, and is cohobated some number of times, the Oil becomes gradually so volatile, that great part of it will rise with the Alcohol. By this means, therefore, these Oils are rendered more subtil and active, and are, like Spirits, advanc'd to the greatest penetrability, and yet with a retention of their proper Vertues.

4. But again, if you distill this Mixture of Oil and Alcohol with a Heat of only 90 degrees, then the Alcohol will rise from the Oil, carrying up with it nothing but the *Spiritus Rectior*, whilst the oily part will remain at the bottom. And if by very gentle Cohobations, you thus artfully separate the thin part from the thicker, you will at last have an Alcohol so impregnated with these Spirits, that it will almost appear pure simple Spirits; but the thicker part of the Oil at the same time will be exhausted, and become quite effete.

U S E.

1. **I**T was the Opinion of the ancient Chemists, that Fire, Air, Water, and Earth, concur to the formation of sensible Bodies; but besides these, they supposed farther, that there is another fifth Principle, which being added to the Compound arising from the combination of the former, gives every Body that proper and peculiar disposition, on which principally depends the Colour, Smell, Taste, and Vertue, of such a particular Body. This, therefore, being superadded to the other four Essences, they called the (*Quinta Essentia*) Quintessence of Bodies. This they imagined to be contained in its Body, in an exceeding small quantity, but at the same time to be vastly efficacious, and when it is

separated from it, to be fit to animate the Spirits of some other Body into which it is infused; upon which head *Isaac Hollandus* and *Paracelsus* deserve to be consulted. There is scarce any Method, now, that is properer for the preparation of this Quintessence, than that which we have mentioned: Certainly one drop of such a preparation from Oil of Cinnamon, diluted in a glass of Canary, in the most grateful manner instantly revives the sinking Spirits. Hence in a *deliquium*, languor, suffocation, or penury of the animal Spirits, of all Remedies it is the most excellent. Nor indeed, do we know that more efficacious Vertues can be extracted from Vegetables by the Chemical Art.

2. If a drop of such a Mixture of Alcohol and Oil is let fall into Water, it soon grows white, and by this means furnishes us with a Method of discovering such an adulteration of these Oils with Alcohol.

3. Hence we understand the Power of Alcohol, which acts particularly upon the Spirits, and Oils of Vegetables, by dissolving them, and then intimately uniting them with itself, and thus forming a Compound, which seems to act afterwards with an equable Vertue. And tho' these Oils are found to exist in Vegetables in various forms, this signifies nothing with regard to their union with Alcohol, provided they are quite free from Water. But in this oily Part, under all its different appearances, the Spirits abovementioned are always found be entangled and retained.

4. Betwixt all these Preparations and Fire, now, there is observed a great Affinity; for if these Quintessences are taken internally, they heat the Body, and being used imprudently in a large quantity, quite burn it up; and if they are applied to the Body externally, they produce all the effects of a pretty acute Inflammation, and carry this on even to a Gangrene.

PROCESS LXVIII.

Dry Quintessences prepared from Process 65, 67, with Sugar.

APPARATUS.

1. TAKE some Alcohol combined with an aromatic Oil, pour it upon ten times as much Loaf-sugar, very dry, and finely powdered, and rub them for a good while in a glass Mortar till they are accurately mixed together. Put this Compound into a China Cup, and place it in a clean glass Cucurbit that has a moderate Heat all round it, that thus the Spirit that keeps the Sugar moist, may very gently exhale, which, by putting on a head, may be collected under the Title of a Liquid Quintessence. In the China Cup will remain the dry Sugar impregnated with the Quintessence desired. This, then, must be immediately put into a Vial, and be stoppt very close, and is then properly a dry Quintessence. If you take 1 drachm of the finest wheaten Flower, and 5 drachms of Loaf-sugar, both very dry, and rub them together in a glass Mortar, and pour upon them 1 drachm of a Liquid Quintessence, and then proceed as before, you will by this means too have a very elegant Quintessence.

2. If you take 1 drachm of the Liquid Quintessence of Process 67, $\frac{1}{2}$ a drachm of the Essential Extract of 65, and of Loaf-sugar, and Flower, each
3 drachms,

3 drachms, and treat them in the manner described, you will have the same kind of Medicine almost, but a compound one.

3. As any of these essential Oils now may be diluted in Alcohol, and tho' many of them are mixed with it will form but one homogeneous Liquor, which may be applied to the same uses, hence it appears, that an infinite variety of noble Compounds may by this means be produc'd, according to the pleasure of the Operator, each of which will vie with the rest in point of Excellence.

U S E.

HENCE we see how greatly the Chemical Art assists the preparation of Medicines, by reducing them to a very small compass, and yet with a wonderful Efficacy. For if a scruple of such a dry Quintessence is mixed with an ounce of Canary, it makes a Draught, which contains all the Vertues that we can expect from Aromatics. When the Physician, therefore, judges that such a kind of Remedy is necessary, he may readily borrow it from the Chemical Art. And these Preparations have this great advantage, that they will keep good for a long while, and one may without any trouble carry them with one in all one's travels and voyages, and so have them ready for use, when one can't have recourse to an Apothecary's Shop, nor ha'n't time for any longer Preparation. And in this particular again, the Excellence of the Chemical Art appears very evident.

P R O C E S S LXIX.

A simple aromatic Spirit from Lavender Flowers.

A P P A R A T U S.

1. TAKE of fresh Flowers of Lavender, just in their maturity, and gather'd on a hot fine day in the afternoon, 6 ounces, of common Spirit of Wine 12 pints, and distill with a Worm according to Art, till there begins to come off a white watery Liquor. In the first place then, you will have a limpid, pellucid Spirit, which will be impregnated with the proper Smell, and Taste of the Lavender, and must be kept by itself. To this there will next succeed a turbid, whitish Liquor, of which you may collect and keep one Pint; and then at the bottom of the Still there will be left a brownish black Liquor, together with the Flowers, which will not retain much of their proper sensible Vertues. The first of these Liquors is the Spirit of Lavender, the second the Water.

2. Take of the same Flowers of Lavender 3 ounces, pour upon them the Spirit and Water of the former Distillation, and distill as before, and you will have a pure, pellucid Spirit, as in the former case, which keep by itself under the Title of a double Spirit of Lavender: But here draw off none of the white Water, for fear of an *Empyreuma*. To the *Residuum*, however, you may add 2 pints of fresh Water, and then distill 1, which will serve again for future Distillations.

3. If in the same manner you distill 2 ounces more of the fresh Flowers with the preceding double Spirit, and the Water drawn off in the way directed, then the Liquor will still be more strongly impregnated with the proper Spirit of the Lavender: The Water is added, that the Flowers may not grow dry, and be burnt, when the last part of the Spirit comes to rise, for this being then left behind prevents it. If you proceed to repeat this Distillation a sufficient number of times, you will at last have a most excellent Spirit. The same Operation, tho' more slowly, may be perform'd in a glass Cucurbit, or even in a glass Retort, and that with but little trouble, and very clean. In this manner I have advanc'd these Spirits to the greatest Perfection. This then is the general Method of preparing these Spirits from aromatic, sweet-scented Flowers. The principal that are made use of for this purpose, are the Flowers of the garden Clove, Saffron, Jessamy, Lavender, white Lilies, Lilies of the Valley, *Marum Syriacum*, Oranges, Citrons, Lemons, Roses, Rosemary, *French Lavender*, and the Lime, all which require the same management. But among all these, that famous Spirit drawn from Rosemary Flowers, called Hungary Water, has the preference, and is every where greatly in use.

U S E.

1. **W**E easily perceive now, that the essential Oil of the Flowers will be carried up in this Distillation, as in Process 25, whilst at the same time the purest part of the Spirit, coming near to Alcohol, will rise with this first Oil, according to Process 48. This Spirit too, like Alcohol, will dissolve the Spirit of the Lavender, and this ascending Oil, by Process 67: But as soon as ever the Alcohol is drawn off, and the Water begins to rise, then the Oil which ascends along with it, makes the Water white, according to the Processes 23 to 29. Hence then we sufficiently understand the Method of preparing these Spirits, and exalting them at the pleasure of the Operator.

2. Hence, likewise, we easily conceive of the Vertues of these Spirits, which are almost the very same with those of the Liquid Quintessences, of Process 67, so that upon this head we need say nothing. That this is the case is evident; for if these Spirits are well prepared, they grow milky upon being mix'd with Water.

P R O C E S S LXX.

A simple aromatic Spirit from the dried Leaves of Mint.

A P P A R A T U S.

TAKE some fresh Leaves of crisp Mint, a little dried in the shade, rub them gently betwixt your Hands, put them into a Still, and pour upon them 20 times their weight of common Spirit of Wine, and then distill with a Worm till you have drawn off one half, which keep under the Title of Spirit of Mint. Put the whole that remains in the Still into a Cloth, and press out all the Juice. Then take half the quantity of fresh Leaves you made use of before, pour upon them the former Spirit and all the Liquor express'd from the

the *Residuum*, and distill again to one half, and repeat this to the third time, and you will then have a Spirit, which you may call a Tripple Spirit.

U S E.

IN the same manner may these Spirits be drawn from any Herbs of the like nature; and the Operation may be perform'd leisurely in our little wooden Furnace. This Spirit of Mint is an incomparable Medicine in Vomitings where there is no Inflammation, in windy Disorders of the Stomach and Intestines, and in Gripings arising from an acid, mucous, cold, watery Cause; for in these cases, half an ounce gives immediate relief.

P R O C E S S LXXI.

A simple aromatic Spirit from green Leaves of Rosemary.

A P P A R A T U S.

BUT the Leaves too of those rich aromatic Vegetables, which when they are green, and in their full strength, are not very juicy, will, by the same management, yield excellent Spirits; of which I will here give you an instance in Rosemary. I take then such a quantity of the tender Leaves of Rosemary crott from the tops of the Branches, as is sufficient to fill the Belly of this glass Retort half full, and pour upon them as much Spirit of Wine as will fill it two-thirds. I then place it in our little wooden Furnace, and applying a large Receiver, distill so long as the streaks in the Receiver discover that the Spirits continue to come over, the ceasing of which indicates that you must proceed no farther. I then press out the Liquor from the *Residuum* that is left at the bottom, and cleaning the Retort, put some fresh Leaves in, and pour upon them the preceding Spirit and expressed Liquor, and distill again as before; and this I repeat to the third time, by which means, I have, as you may here examine, an excellent Spirit. With these same instruments, I formerly repeated this Operation a great number of times, always cohobating the Spirit that came off upon fresh Rosemary, in hopes of having at least an exceeding pure Spirit of Rosemary; but I was baulk'd in my Expectations, for in such a number of Distillations, it had contracted a disagreeable Smell, like that of Wax fresh collected, and by that means was spoiled.

U S E.

HENCE, then, it appears, that in some Vegetables, the very same Spirit resides in the Flowers, Leaves, and tender Branches, and may be extracted from them; for this Spirit cannot be distinguished from that prepared from the Flowers of Rosemary, by Process 49, and has the very same Vertues. The Leaves of Lavender, Thyme, Sage, wild Thyme, *French* Lavender, Rue, Origany, Calamint, and all the hot aromatic Plants, are fit for this purpose. From Barks, Woods, Roots, and Seeds too, both dry and green, may be prepared in the same manner most excellent aromatic Spirits; witness that noble Spirit drawn from yellow Saunders.

P R O C E S S

PROCESS LXXII.

A compound aromatic Spirit.

APPARATUS.

1. FROM what has been hitherto laid down, it sufficiently appears, that the *Spiritus Rectior* of Vegetables is a fine Particle, endued with a singular Vertue, frequently of incredible efficacy; that this is entangled and held down by the essential Oil; that these Oils of different Vegetables may, together with their proper Spirits, be mixed into one homogeneous Liquid, in which all the Spirits will be united and retained; and lastly, that this Mixture may be dissolved by Alcohol of Wine into an aromatic, oily, compound Spirit, of most excellent medicinal Vertues, in which the different Spirits will be combined, and made to conspire in the same Operation. It is evident, therefore, that there can be no particular rule laid down for these Preparations, only take care that the Simples you chuse for this purpose, have some agreement in Smell and Taste, and are such whose united Vertues will make amends for the trouble of compounding them. As an Example of such a composition, you may take the following Process, which I formerly made frequent use of, particularly in the Preparation of a *Sal Volatile Oleosum*. Take of the choicest, fresh, thin, aromatic Peel of *Sevil* and *China* Oranges, Citrons, and Lemons, and Bark of Cinnamon, of each 4 Ounces; of the Flowers of Oranges, Citrons, Lemons, Lavender, Red Roses, and Rosemary, of each 2 ounces; of the Roots of Angelica, and *Florentine* Orris, of each 1 ounce; of aromatic Cloves, Mace, and Nutmegs, of each 2 drachms; of rectified Spirit of Wine 15 pints; mix and distill with a Worm, according to Art, as long as a limpid Spirit comes off, which keep by itself. Proceed then till you have drawn off 2 or 3 pints more of a white Water, which keep under the Title of a compound, spirituous, aromatic Water.

2. If you have a mind to repeat the same Operation, take all the abovemention'd Simples, and the Spirit of Wine, but add to them likewise all the former white Water, and by this means you will have still a finer Spirit. And by saving the Water every time in this manner, and making use of it again, I constantly procured a more excellent Spirit, as is very easy to conceive of, for it was at last almost like a pure Oil.

3. If the Spirit prepared in the manner describ'd, is drawn off again from a few fresh Simples with a Cucurbit, and you tie a little Ambergrease finely powder'd in a Rag, and suspend it in the Alembic, the Spirit as it rises will subtly extract its Fragrance, and be impregnated with it.

4. If a Person has a mind to prepare the same Spirit in our wooden Furnace with a less Apparatus, he must distill a less quantity at a time, viz. in proportion to his Vessels. And then I generally chuse to make use of a Retort, and proceed very gently.

USE.

U S E.

WHoeever considers those things which we have explained in this and the 69th, 70th, and 71st Processes, will easily comprehend what is the proper use of the Spirits thus prepared, and how far their power is extended: For they never can by any Art whatever be converted into our Spirits, but will always, let the Chemists say what they please to the contrary, remain of a nature quite different from theirs. Hence they can never truly supply a proper defect of our Spirits, and for this reason it is no ways true, that these being infused into the Body can perform the office of that power which generates the Spirits, when it is fairly impair'd by old age. In the mean time, however, by their wonderful Activity, their fine Fragrance, grateful Taste, and inexplicable Suitableness to our Spirits, they are greatly disposed to exhilarate them, though the effect lasts but a short time. The too frequent actions of them however upon our Spirits overcomes, and dissipates 'em. And hence, when we once come to be used to 'em, though they quicken a little for the present, they afterwards leave us more languid, and make the application of such a *Stimulus* more frequently necessary. Thus then I think I have sufficiently explained the use of these Spirits, both from Chemistry and Physick.

P R O C E S S LXXIII.

Soap from express'd Oils, and the fixed Alkali of Process 13.

A P P A R A T U S.

1. **I**N this Flask I have some express'd Oil of Olives, and in this glass Vessel the same weight of Oil of Tartar. I pour the Oil now very gently upon the *Lixivium* of the Salt, and you perceive, that the Oil swims at top, and both Liquors continue clear. I shake them therefore together, and hereupon the Mixture becomes white, opake, thick, and somewhat tenacious, and if it is set by, continues thus equably mixed for some time: At last however, by only standing quiet, they spontaneously separate from one another. Hence therefore it appears, that express'd Oils, which always abound with an Acid, are of such a nature, that they'll bear to be mix'd with an Alkali, even though this is diluted with Water; though at the same time it must be observed, that this Union is not so strong, but that the Compound will be easily resolv'd again into its constituent parts. It is probable now, that the Acid here performs the office of a *Vinculum* to keep these different Bodies together; for Oils, that are depriv'd of their Acid, are combin'd with Alkali's with more difficulty.

2. If the Mixture produc'd in this manner is gently boil'd with a slow Fire, that the Water may gradually exhale, it will be reduced into a consistent Mass, of a white Colour, a nauseous oily Smell, and an acrid, alkaline, disagreeable, pinguious Taste, and easily dissolves in the Air. But if, during the boiling, a proper proportion of dissolved Alkali, or Oil is added and mixed with it in such a manner, that the Compound will intirely dissolve in Water without any appearance of Oil, and yet at the same time has nothing of an alkalious Taste, and will keep its consistence in the Air, it is then called a perfect Soap.

3. It has been found now by repeated Experiments, that the more acrid the Alkali is, the more perfect will be the union of that and the Oil into a true Soap. As it appeared therefore, according to Process 13, that the penetrating and igneous power of an Alkali may be wonderfully advanced by Quick-Lime, hence this fiery Alkali prepar'd with Quick-Lime came to be used instead of a simple one. And as it was observed likewise, that this combination was render'd still more perfect by long boiling, and of consequence, that a greater quantity of Water was necessary for this purpose, hence they added this more plentifully. And lastly, they discovered by practice, that a certain proportion betwixt the Oil and the Alkali was here requisite likewise. The following method, therefore, was found at last almost certainly to succeed.

4. In the first place, they take a fix'd, igneous, alkaline Salt, well prepared with Quick-Lime, according to Process 13. This they dissolve in clean hot Water, till the Lye will bear a new-laid Egg; and this the Workmen call the Master-Lye. To a part of this they then farther add such a quantity of Water, that in this second Lye the Egg will just sink to the bottom, and this they call the weaker, or under Lye. With an equal quantity of fresh Oil of Olives, they then mix this weaker Lye, as accurately as possible, so that the Mixture shall be exceeding white, which they proceed to boil with a gentle Fire, keeping it frequently stirring, till by the dissipation of the Water, in particular, these Bodies begin to be thoroughly incorporated with one another. When they observe this to be the case, they then add three times as much of the Master-Lye as they us'd of Oil, and mixing them together, continue to boil them, till a little of the Composition dropp'd on a cold Stone will acquire a proper solid consistence. And if then a bit of this cold Mass will perfectly dissolve in Water, without discovering any Oil, it is a proof that the Oil is sufficiently combin'd with the Alkali; but if some Oil does appear in such a solution, then a small portion more of the Master-Lye must be poured in, and you must proceed to boil, till the Matter will be dissolved intirely. You must then taste the Soap, and if you find it acrid, and alkaline, it is a sign that the Alkali is predominant, for which reason you must then add a little more Oil, and boil as before, till at last you have by this means obtained a Mass, which in the cold will be hard enough to cut, will dissolve perfectly in Water, has not an acrid, alkaline Taste, nor will run *per Deliquium*. This then is properly true Soap.

5. Instead of Oil of Olives, you may make use of the Fat of Beasts or Fish, of which we have an instance particularly in the black Soap prepared with the Blubber of the Whale. The more pure, however, the Alkali is, and the neater the Oil, without any disagreeable Smell and Taste, the more beautiful will the Soap be, and the fitter, especially, for medicinal uses.

U S E.

HERE then we see the intimate union of a native Oil with a fixed Alkali, effected by the help of Water and Fire, whence there arises one homogeneous Mass, which is perfectly dissoluble in Water. So that hence it appears, that the Oil must have lost its pristin pinguious nature, and put on a new one, which is not so repugnant to Water; and that this is brought about by means of an acrid, fix'd Alkali. For this reason therefore, when the Humours of the human

man Body abound with too great a quantity of Oil, the Salts are generally deficient, and hence in such a case fixed alkaline Salts prudently administered are not without their use. From what has been said too we learn by what means the Acrimony of Alkali's may be quite obtunded, so that they shall be intirely deprived of their corroding quality, and rendered mild, viz. by mixing with 'em a sufficient quantity of Oils. In disorders, therefore, where such an acrid, saline Matter is found to be predominant, fresh express'd Oils, taken in a pretty large quantity will help to mitigate it. In very acute cases, and one very bad sort of Scurvy, this has been confirmed by happy success. Nor are they without their use where there is a troublesome Acrimony in any particular part, as when a Stone lodg'd either in the Kidneys, or Bladder, by absorbing the Urine, and retaining it in its Pores, renders it acrid. In this compound Body of Soap now the tenacity of the Oil, which disposed it to foul other Bodies, is destroyed, and at the same time the original deterfive power of the lixivious Salt remains, though without its former corroding quality. For if you dissolve this in Water so as to make a pretty strong *Lixivium* of it, it will then, if assisted with a proper Heat, Motion, and Rubbing, dissolve gummy, oily, resinous, and inspissated, pinguious Substances, and render them saponacious too, or miscible with Water; and hence it resolves, opens, deterges, and cleanses. By this means it attenuates coagulated Juices, and renders them capable of passing on in their Vessels, and hence often overcomes inveterate obstructions, and restores debilitated parts to their proper use. In foul concretions too from an Earth and an Oil, it proves of excellent service. And lastly, it prevents the coagulation of Chyle or Milk, by an Acid; nay, when they are actually curdled by it, it will resolve them again. Hence therefore it appears, that in any of these cases it proves almost a universal aperient, attenuant, resolvent, and dissolvent in the human Body, if it is taken when the Stomach is empty, well diluted, to a considerable quantity, and divided into suitable Doses, and is assisted by proper exercise. Externally applied too in sinuous, fistulous Ulcers, it has a very good effect. If you have a mind, now, to hide the disagreeable appearance of the Soap, you may easily do it, by giving it a Colour with Saffron, Turmeric, or Cochineal. And if it is still offensive to Persons of a more tender make, on account of the unpleasant Smell of the boil'd Oil, you may mend that by the addition of a little Balsam of *Peru*. In Diseases, however, where Life is in danger, from a putrid, broken, and tabid disposition of the Fluids, it does a vast deal of mischief, of which there have been many instances in the Plague, and putrid Small-Pox, as we have faithfully related to us by the honest *Diemerbroeck*. Many more things might be said of this noble Composition, but these may be easily deduced from what has been observed already, both for the use of the Chemist and Physician. I only add therefore, and so conclude, that Soap is capable of effecting that which neither Water nor Oil can do separately, and does those things safely, which simple Alkali's cannot, without danger, and which other Salts cannot at all.

PROCESS LXXIV.

Soap from a distill'd Oil, and the fix'd Alkali of Process 12.

APPARATUS.

1. **T**HE Chemists being convinced by Experiments of the Vertues of distill'd Oils, were concerned, that from their natural disposition they cou'd not be readily mixed with the Humours of the human Body. As they saw, therefore, that express'd Oils might with good success be combined with a fixed Alkali, they attempted the same thing with distill'd; but to their Mortification they found, that by being boiled the Oils were enervated, and even then wou'd not unite with the alkaline Salt. They made a great many other Experiments therefore, in order to bring these Bodies into a lasting union, but commonly in vain. Being incited however by the hint and promises of *Van Helmont*, they at last seem to have discovered a method by which this combination might be effected. Many tedious trials upon this head I formerly went through myself, and at last the thing succeeded in the way which I'll candidly shew you. The great secret lies in this, that the acrid Alkali be exceeding pure, and dry, and the Oil perfectly free from Water. If this is taken care of, every thing else will be brought about successfully enough by the Atmosphere; but if the least quantity of Water, by any means insinuates itself among them, the union will be prevented, and your labour lost.

2. Take some very pure, acrid, fixed, alkaline Salt, prepar'd according to the fifth Paragraph of Process 12, and whilst it is still just red hot from the Fire, in a clean iron Mortar, and with an iron Pestil, reduce it to a Powder, the finer the better, and then immediately throw it into a very pure, dry, thin Glass, such a one as is made use of in the examination of Urine, commonly called a Urinal, which must be first made very hot, and disposed in a very hot dry place; and this shou'd be done on a fine dry day. The very moment then that the hot Salt is at the bottom of the Urinal, drop into it some of the purest distill'd æthereal Oil of Turpentine, made very hot likewise, in such a manner that the Drops shall succeed one another very fast, and shall fall into the middle of the Salt. By this means then the Oil, as it falls in, will, with a great Fume and Noise, be attracted into the dry Salt, even to its inmost parts, and so disperse itself through the whole saline Mass. Proceed in this manner as quick as possible, till the Salt has absorbed such a quantity of Oil, that what is dropt in afterwards continues to swim at top, and thus perfectly secures the surface of the Salt from any contact with the Air, which is always full of moisture. When you perceive this to be the case, set the Urinal by in a place under ground, cover'd only with a Paper, and the Oil will in a short time disappear, being united with the alkaline Salt. Pour upon it then a little more of the same hot Oil, and with a Stick mix it well with the former Mass. Set it by again in the same manner, and thus proceed till there is almost three times as much Oil as Salt in the Composition, and you will then have an equable saponaceous Mass that is wonderful penetrating. And here the more it is stirr'd and rubb'd together, the more perfect and expeditious will be the union; for which reason,
nothing

nothing in this case is more effectual than putting it into a strong Bottle, and fixing it in a Post-Chaise that travels every Day, as was long ago observed by the famous *Grew* and *Bohn*. And for my own part, I can assure you, that when I have had a careful regard to all the circumstances just mention'd, the event has always prov'd successful, though it never did so when I have neglected the very least. If a little of this Soap, then, will perfectly dissolve in Water, without discovering any appearance of Oil, it is a proof, that your Operation is compleat.

3. If the Soap made in this manner is suffered to stand long in the Urinal, there gradually rises upon the sides of the Glass a white, crySTALLINE Salt, of a Smell not disagreeable, and a soft, penetrating, saline Taste, but not an alkalious one. This is wonderfully subtil, and dissolves easily, and furnishes us with a medicated Soap of vast use. And the small quantity that thus ascends, I am apt to think, gave rise to that assertion, perhaps, too free a one, that the fixed Salt of Tartar, by means of an Oil united with it, has been render'd volatile and prov'd a *Succedaneum* to the *Alcabeft*. When I have exposed, however, the Soap well prepar'd in this manner, to the Fire, I confess, I have not met with the promis'd volatile Salt.

U S E.

FROM the Evidence of this Experiment, then, we learn, again, with what greediness a pure fix'd alkaline Salt attracts and unites with itself these Oils; and how this, from an alkaline, acrid, fiery nature, is soften'd to a mild, oily Salt. With regard to its Power of preventing and resolving an acid, austere, or viscid *Coagulum*, I treated sufficiently in the preceding Process, to which I refer you. Here, therefore, I shall only observe, that all the saponaceous Vertues there recited are in this sort of Soap more generous and active, and that this is always considerably heating. Thus then we see the disposition of a distill'd Oil, and a fix'd alkaline Salt, with regard to one another, and the nature of the pound arising from the mixture of 'em together according to Art. The Salt generated in this manner, Dr. *George Starkey*, and his Followers, asserted to be volatile; but, as I observ'd before, I never found it so. This is the Soap which *Matthews*, a Quack at *London*, prepar'd under the name of the *Corrector Matthæi*, to which he added Hellebore, Liquorice-root, and Opium, and then digested 'em together, and form'd 'em into Polychrestic Pills, which were diaphoretic, no longer emetic, or purging, but anodyne, though they often provok'd Vomiting the day following. A better preparation of these Pills Dr. *Starkey* subjoin'd to his *Pyrotechny*, extravagantly, according to the custom of the Chemists, extolling their Vertues, and asserting, not very properly, that the whole Vertue of the Hellebore was retain'd, though its emetic Quality was destroy'd. But let this suffice concerning the preparation of this Soap. The excellent *Homberg* observes, that a strong *Lixivium* of this, upon being mix'd with a sharp Acid, is alter'd, and grows turbid, the Alkali being attracted into the Acid, and the Oil being by this means dislodg'd, and so appearing again, *Hist. de l'Ac. Roy. des Sc.* 1709. If these Soaps, when they are pretty dry, are digested with the purest Alcohol, they are in some measure dissolv'd into the *Elixir parvum Sapientum*, in which there is a Salt, Sulphur, and Spirit combin'd together.

P R O C E S S

PROCESS LXXV.

The Preparation of Tartarified Tartar.

APPARATUS.

TAKE a pretty large quantity of white Tartar, very pure, and in large Lumps, reduce it to a very fine Powder, put it into ten times its weight of clean Water in a brass Vessel well tinn'd, and make it boil briskly, that the Tartar may be sufficiently dissolved; and let the Vessel be plac'd upon an open Fire, that the Water may be kept constantly boiling. The Liquor then will have a very acid Taste, be almost clear, and pretty pure. Into this boiling *Lixivium* of Tartar drop some Oil of Tartar *per Deliquium*, and keep up your Fire in such a manner, that, even whilst you are doing this, it shall continue boiling. Upon every Instillation then of this alcalious Liquid there will arise a very great Ebullition, caused by the Alkali's meeting with the Acid, as appears evidently from the Effervescence's ceasing immediately, which must then be rais'd afresh by dropping in some more of the Alkali. And as this is done whilst the Liquor is kept boiling, there will be produc'd a great many large spherical Bubbles, which will burst asunder, and be immediately succeeded by others. In these Bubbles, the Chemists, by the help of their Eyes and Imagination together, have discover'd, or at least have thought they have discover'd, the proper figure of the Grapes. Proceed then patiently in this manner, till at last a Drop of the Alkali will excite no Effervescence in the boiling Liquor; and by this means the Acid of the Tartar will be saturated with such a quantity of its proper Alkali, *viz.* one produc'd from burnt Tartar, that there will then be no appearance of an Acid, or an Alkali in the Mixture, but you will have a certain third sort of new Salt. And here you must take great care to observe nicely this point of Saturation; for if you leave off too soon, the Salt will be acid; and if you proceed too far, it will be alkaline: About the end, therefore, you must be very careful.

2. Let the Mixture be run speedily through a woollen Bag, till it at last becomes limpid, always observing to keep it boiling hot. The Liquor then will be of a brownish black Colour, of a particular, bitterish, saline, saponaceous, sub-pinguious Taste, and without any Smell. If you inspissate it on the Fire till there appears a Pellicle on the Surface, and then let it stand quiet for a good while in a cool place, at the bottom and sides it will depose some saline little Masses, which being collected together form a Tartar, which easily dissolves in Water, even in the cold, though it was so difficult to be dissolved before, nay, scarcely with the heat of boiling Water. This, therefore, may properly, and conveniently enough, be call'd Soluble Tartar.

USE.

TARTAR, in its hardness, approaches so near to the nature of Stone, that, being indissoluble by its own Wine, it forms a kind of Vessel round it, through which it cannot penetrate, and is hence call'd, very properly, by the

the *Germans*, Wine-Stone. It contains in it an evident Acid, by vertue of which it generally acts beautifully in the first passages of the human Body. And, indeed, the Acidity of it is so great, that it causes a violent Effervescence with the Alkali that may be easily produc'd from it by Process 55. When this Acidity, however, is counterballanc'd by a sufficient quantity of an Alkali, the Tartar then becomes tractable, and dissolves with ease, both the Acid and the Alkali being destroyed, and a new kind of Salt being produced from them. The Salt now, thus generated, is found to have excellent effects in the human Body. If it is diluted with Water, and drank fasting, by its efficacious dissolving, deterfive, and gently purging Quality, it proves an admirable Medicine in many Diseases, and those pretty stubborn ones too. If it is applied externally to foul Ulcers, it cleanses them, and disposes them to heal more kindly. Whether this is the Medicine which *Paracelsus* boasted of, by the help of which, he tells us, all fresh Wounds would unite in the space of a few hours, without any supuration, I won't pretend to determine: This he call'd *Samech*, which seems to be fram'd from a word in *High-Dutch*, which signifies to conglutinate, or glue together. Be this as it will, this I'll venture to assert, that the pure Liquor of this Salt dissolv'd in Water, ought to be rank'd amongst the choicest *Menstruums* that the Chemical Art is master of. If any Person has a mind to be satisfied in this, let him boil Gum Lac, Myrrh, and the like, in this Liquor, and he'll be sufficiently convinc'd, that it can scarcely be prais'd enough. Hence it appears, that the viscid Concretions, form'd in the first passages, may be resolv'd by the use of this Medicine. Nay, and it is believ'd, that by the use of it, constantly continued, and gradually increas'd, even the tartareous Matter of the human *Calculus* in the bilious and urinary Passages may be dissipated likewise. In nephritic, icterical, splenical, and hypochondriacal Disorders it is of service. By a proper attention, now, to this Process, we learn, likewise, what good Effects may be expected from the Cream, Crytals, or Powder of common Tartar, in those cases, where the Bile, in particular, or the other Humours in the *Abdomen*, begin to grow putrid from a burning Fever, or any other causes, and acquire an alcalescent disposition; for this will be mitigated by the native Acid of the Tartar, and will immediately be converted, in the Body, into a mild Salt, which will easily dissolve, and open and remove obstructions, without stimulating the Vessels to too great a degree.

P R O C E S S LXXVI.

Regenerated Tartar.

A P P A R A T U S.

UPON a very acrid, pure, dry, fix'd, alkaline Salt, contained in a large glass Vessel, with a pretty narrow Neck, I pour pure, and pretty strong distill'd Vinegar, till it almost covers the Salt, and there scarcely appears any sensible Effervescence, which certainly is surprizing, as one wou'd naturally expect that such a very strong Alkali shou'd cause an Ebullition with the Acid. It seems, therefore, as if this weak Acid wou'd not produce this Effect, in this case, on account of the Alkali's being too strong for it. I shake them, now,
well

well together, and for a good while, and by degrees an Effervescence begins to arise, which ceases, however, immediately. I pour on therefore more of the same distill'd Vinegar, and the Ebullition is now somewhat greater, and upon shaking the Vessel becomes sufficiently evident. And upon repeating this the third time, you now observe a most furious Effervescence, with a prodigious Froth and Noise, which increases in proportion to the shaking of the Vessel. And this now continues so for a good while, the Acid of the last Vinegar that is pour'd on, always causing a stronger Effervescence, as you approach nearer to the Saturation of the Alkali, which is generally obtain'd, when about fourteen times the Quantity of strong distill'd Vinegar has been pour'd upon a strong Alkali. About the end of the Operation, therefore, the Mixture must be heated, and briskly shook about for some time, that we may be sure not to add more Acid than is just sufficient to saturate the Alkali, which may be discover'd at last by cautiously adding but a little at a time, and shaking it about till the last Quantity, though assisted by Heat and Motion, will cause no farther Effervescence. This being done, set it by in a warm place for the space of twenty four hours, and then shake it about, and if it don't discover any Ebullition, drop in a little more Vinegar, and if upon shaking it then too no Effervescence is excited, you may be satisfied that you have obtained the true point of Saturation. In this Experiment now the violent Effervescence diffuses an exceeding elastic Vapour, as you perceived by the *Halitus* that bursts out at the top, notwithstanding the Belly of the Vessel in which the Salt and Vinegar were shook together is so capacious; for as I stop'd the Mouth with my Thumb whilst I was shaking them, upon suddenly removing it afterwards, and giving the confin'd Vapour a vent, you heard with what a noise it issued out. Nay, if you persist to keep it perfectly stopt during the Effervescence, the Vessel will be burst asunder. The Liquor then that is produc'd from the Acid of the Vinegar, and the fix'd Alkali by this Operation is pellucid, of a singular Smell, not an acid one, and of a Taste that is neither acid, nor alcalious, but of a third saline sort. And as for Acrimony, this Liquor is scarcely discover'd to have any, but it is of a mild, innocent nature, and yet has a most efficacious power of attenuating, resolving and evacuating by the Intestines, the Kidneys, and the Skin; and hence, in chonical cases, where there is a thick obstructing Matter, it proves an excellent Medicine, taken at a convenient time, and in a proper Dose.

2. If this limpid Liquor, depurated from its *Fæces*, is distill'd with a Cucurbit and Alembic, it yields a pure simple Water; and at the same time the *Residuum* in the Vessel becomes of a light brown Colour, then more upon the black, and so on by successive degrees, till it becomes quite black, pinguious, thick, and of a very subtil Taste, even such a one as discovers its saponacious, penetrating, dissolving Power. Take then a little of this Liquor, and mix with it a little Vinegar, and if there arises any Effervescence, it is a sign that the Alkali is still predominant, and therefore by a proper admixture of distill'd Vinegar it must again be saturated. And as this very often happens in this manner, the point of Saturation must be carefully sought for.

3. When you have obtained this, let the Liquor by standing quiet be separated from its *Fæces*, and then draw off all the Water with a gentle Fire, and there will remain at the bottom a saline Mass, of a blackish red Colour, and of an exceeding penetrating, and perfectly singular, saponacious Taste. This

now has attracted and retained all the Acid of the Vinegar made use of, and has expell'd all the Water that was in the Vinegar, and diluted its Acid. And by a very careful Examination of Mons. *Hombert's* it appear'd, that the Alkali was, by this attraction of the Acid into it, increased about $\frac{2}{3}$ ths of its weight; and the Acid extracted from the Vinegar, was about $\frac{1}{3}$ th of the whole, so that the other 36 parts were pure Water. *Hist. de l'Ac. Roy. des Sc.* Vol. I. This then is the preparation of the Salt, which the Artists call *Tartarus Tartarizatus*.

4. If this tedious, costly Salt is urg'd with a somewhat stronger Fire, it becomes volatile, flies off, and cheats the Operator. When it is carefully dried with a gentle Heat, and is then exposed to the Cold, it appears as if it was form'd by application of fine *Lamellæ*, or Flakes, to one another, like the *Lapis Specularis*, or Talc. With Heat, however, it dissolves into a pinguious Oil; and yet in the Cold it recovers again the same form as before. Hence this Salt has been called likewise *Terra Foliata*. This, *Zwelfer*, in his Defence against *Otho Tachenius*, charges him with boasting of, as dissolv'd Talc.

U S E.

THERE is not any one Experiment in the Chemical Art, that makes more discoveries to us than this does. Here we observe a new, and intirely unexpected *Phænomenon* in an Alkali, and an Acid, with regard to their exciting an Effervescence. Here we see Colours produc'd from a Liquor as limpid as Water, and then chang'd through successive degrees to a perfect Blackness. And here we discover a pinguious, inflammable Oil, regenerated from an Alkali calcin'd in the intensest Fire, and a very thin, sharp Spirit of Vinegar; for when this Salt is dry it will flame in the Fire, and if it is distill'd with the last degree of Heat, will yield a true Oil. Hence then we learn, that the Salts form'd by the mixture of Acids with Alkali's, do not consist only of an Acid and Alkali that may be separated from them again, but that there is by this means somewhat new actually produc'd, of which there was not the least appearance before. By this Operation too we may farther inform ourselves, what proportion of absolute Acid there is in any given acid Liquor, to the quantity of Water it is diluted with; and what proportion of acid, with respect to the Alkali, is required to make the Saturation complete. And here, lastly, we learn the true method of converting the most acrid, fiery, fix'd, alkaline Salt, into a mild, compound, oily, saponacious, volatile one. This Salt, now, rightly prepar'd in the manner describ'd, is one of the most excellent *Menstruums* we are acquainted with, and being mix'd and digested with its proper Objects, dissolves them into a uniform Mass, which is very penetrating, and richly endued with their particular Vertues. In the human Body it is the most noble resolvent yet known, and has this admirable quality, that both in hot and cold cases it is used with success, and indeed is suited to almost every Patient. All these things, then, being maturely consider'd, I have been frequently in doubt whether this was not the *Sal volatilis Tartari* of *Van Helmont*, to which he gave such prodigious encomiums, as to make it even a kind of *Succedaneum* to the *Alcabest*; especially as it runs in the Fire like Wax. Certainly it ought to be look'd upon as the *Acetum Radicatum* of the ancient Chemists, as here the Vinegar returns back, and becomes united with its proper *Matrix*, the calcin'd

Tartar. If a Person however is too curious in dissolving, depurating, filtering, inspissating, and calcining this Salt, in order to make it white, he'll find, that it will by this means be dissipated into the Air, and lost, so that hence he will learn its Volatility, indeed, but will otherwise lose his labour. And this I give the more particular caution of, because the Author of this Preparation, the famous *Daniel Sennertus*, too much commends great diligence in the Affair, which, when it is applied to things but of little consequence, makes the Operator's Pocket suffer for it.

PROCESS LXXVII.

A Tincture of Tartarified Tartar.

APPARATUS.

TAKE some tartarified Tartar, well prepar'd according to Process 75, dried, and reduc'd to a fine Powder, put it into a tall Bolthead, and pour upon it as much of the purest Alcohol of Wine as will cover it to the height of four inches. With a Paper only stop the Mouth of the Glass, place it in our wooden Furnace, and with a very gentle Fire make the Alcohol boil for the space of a night and a day; and then the Liquor that swims at top will be of a golden Colour, and have an aromatic Smell, and a penetrating warm Taste. If you repeat this in the same manner with fresh Alcohol, there will at last be a white Salt left at the bottom. Let the Tinctures then be inspissated with a moderate Heat, till there is but one tenth part remaining.

USE.

THIS Operation serves to discover to us that part of this Salt, that may be dissolv'd by Alcohol. The Tincture thus prepar'd is aromatic, heating, cleanses Ulcers, and consolidates Wounds. The remaining Salt too, being purer, and more simple than it was before, teaches us, that by extracting a Tincture from them by Alcohol, even Salts themselves may be render'd whiter.

PROCESS LXXVIII.

A Solution of regenerated Tartar by Alcohol.

APPARATUS.

UPON very dry regenerated Tartar, prepar'd as nicely as possible without destroying its Vertues, and dispos'd in a tall Bolthead, pour six times its weight of the choicest Alcohol, and boil them very cautiously with a gentle Fire in our wooden Furnace. By this means they will become united together into one equable Compound, and there will be some *Fæces* deposited at the bottom. Let the Vessel stand quiet till the Liquor is well settled, and then gently pour off the clear Tincture from the *Fæces*, and if there is then any thing saline still remaining, it may be dissolv'd in the same manner with fresh Alcohol. Let these

these Liquors be put together, and with a very gentle Fire be inspissated to one half, and you will then have a Tincture of this Salt.

U S E.

IN this Operation you have a vegetable Alkali, an oily vegetable Acid, and an oily vegetable Spirit compounded together. Hence you possess here the most active Principles of Vegetables, freed from their inert Earth, and at the same time not dangerous on account of their Acrimony. This Composition seems to be the *Elixir parvum Sapientum*, which the antient Chemists so much recommended for preserving and restoring of Health. And certainly it resolves almost all Obstructions, insinuates itself through all the Vessels of the Body, and by a gentle *Stimulus* makes the animal powers to throw off the morbid Matter by Sweat. In the Chemical Art it proves a most excellent *Menstruum*, resolving Bodies into their minutest active parts, and thus disposing them to penetrate, with their full seminal Power, into the inmost parts of the Body, and there to overcome the most stubborn resistance. In external Disorders too, as Ulcers, Wounds, and Tumors it is not used with less success. Nor is this valuable Medicine so costly, that the Poor may not share in it, for the regenerated Tartar may be readily prepar'd, by mixing Pot ashes with fifteen times their quantity of the sharpest Vinegar, and then filtering and inspissating, and then it will cost but little Money or Labour, and yet will be very fit for use. This was known to the ancient Romans. *Plin. XXIII. in Proemio. The Ashes of Vine-twigs sprinkled with Vinegar are drank for disorders of the Spleen.*

P R O C E S S LXXIX.

Dr. Harvey's Tincture of Salt of Tartar.

A P P A R A T U S.

ITAKE the very black alkaline Salt, that remains in the Retort, after the volatile part has been forc'd out by the strongest Sand Heat in the Distillation of Tartar, according to Process 55. Upon this, briskly reduc'd to Powder in a hot iron Mortar, and with a hot Pestil, and then put into a tall Bolt-head, I pour as much of the best common Spirit of Wine as will cover it to the height of four inches. I then place the Vessel in our wooden Furnace, and with a gentle Fire boil the Mixture for the space of twenty Hours. By this means I have a black thin Liquor, of a bitter, aromatic, lixivious Taste, which I pour off clear, and keep in a close Vessel where it will continue good for a long time. This is *Dr. Harvey's Tincture of Salt of Tartar.*

U S E.

COMMON Spirit of Wine, consisting of Water, an Acid, and Alcohol united together, by being boil'd with this Alkali of Tartar which still continues oily, makes a *Lixivium* that is mild and safe, as it is here render'd less acrid by the Acid, the Oil, and the Alcohol, whence arises a kind Medicine,

and *Menstruum*, of considerable Vertues. This being chemically boil'd, and digested with Vegetables is very efficacious in dissolving them. In Surgery it is an excellent remedy for cleansing, deterging, drying, and consolidating moist, purulent, putrid, sanious, virulent Ulcers, as well fistulous, as sinuous: In fungous Excreescences too it is used to eat them down with good success, especially if it is mixed according to art, with a small quantity of Oil. Taken internally likewise, it has admirable effects, in those Diseases, where an acid, rough, watery, mucous, pituitous or earthy Matter abounds, as also in Coagulations, provided there is no putrid dissolution of the Humours. Hence it is recommended in stubborn obstructions of the Bowels, in watery defluxions, a *Leucophlegmatia*, Chlorosis, Jaundice, and cold Gout. It acts pretty strongly by Urine, Sweat, and sometimes by Stool; and may be given safe enough in a pretty large Dose. If two or three drachms of this Tincture, soften'd with an Ounce of the Syrup of the five opening Roots, and then diluted with distill'd Fennel-water, are drank fasting for three or four Mornings, they often perform more than can be effected by other Medicines. Hence therefore the famous Dr. *Harvey* very justly extolls the Vertues of this Medicine. Nor were the ancient Physicians unacquainted with such kind of Preparations for the same uses, as you will be convinced by consulting *Dioscorides* I. 186.

P R O C E S S LXXX.

Van Helmont's Tincture of Salt of Tartar.

A P P A R A T U S.

TAKE the black Salt of Tartar, which remains at the bottom of the Retort, in the Distillation of Tartar: Put this into a large Crucible, and with a strong Fire burn and calcine it, (take great care that no Coal, or any thing else, falls in) till it becomes white from the intire consumption of its Oil. Or, if you are in haste, take some of the best Tartar, tie it up in wet brown Paper, and then cover it perfectly with bright live Coals, which will by this means be gradually extinguish'd. Remove the Ashes whilst they continue hot, and at the bottom you will find a saline, alkaline Matter compacted into one Mass, which is called common Salt of Tartar. Let either of these then be dissolved in Water, strain'd, inspissated, and dried in a clean iron Pot, exactly in the manner described, Process 12, Paragraph 4, and be then calcined, in the very same way as is mentioned Paragraph 5, so that it may be reduced to a fine Powder, which, in proportion to its subtlety, will be the fitter for this Operation. This is the best Salt of Tartar.

2. Let there be ready at the same time a very dry clean Bolthead, with a pretty large Mouth, and one third full of the choicest hot Alcohol, and let the whole Neck be made hot, for otherwise it wou'd crack when the hot Salt of Tartar came to run through it.

3. Make a kind of Funnel with Paper, and fasten it round the Mouth of the Bolthead, and when the Powder of the Salt of Tartar comes vastly hot from the Fire, and consequently is exceeding dry, pour it through the Paper Funnel into the Alcohol contained in the hot Vessel. If all these Circumstances then

are

are rightly attended to, the Salt will run into the Alcohol, with a hissing noise, and the Alcohol will immediately boil with the Heat of it. When you have pour'd in enough Salt, stop the Bolthead lightly with a Cork, and as soon as all is grown cold, add such a quantity of Alcohol more as is sufficient to fill the Belly of the Bolthead three quarters full, and be sure shake it well about, that no Salt may hang upon the Sides of the Neck, but may be absolutely cover'd with the Alcohol, for otherwise these saline Particles wou'd be dissolved by the moisture of the Air, and running down wou'd mix with the Alcohol, and so render this tedious Operation ineffectual.

4. Let the Bolthead, thus charged, be plac'd in a Heat of a 100 degrees, stop'd slightly, that the moisture of the Air, which is here so mischievous, may not be able to insinuate itself; and let the Vessel be frequently shook about. By this means then you will have a Liquor, of a beautiful deep red Colour, which will, by its Colour and Smell, tho' scarcely by any effervescence, plainly demonstrate, that it is impregnated with the Vertue of the alkaline Salt, particularly, if the Liquor is examined after it has been very cautiously inspissated by Distillation, for then it is evidently saponacious, and in some measure saline.

5. When there is the least quantity of Water mixed with either of these Bodies, there will be no Tincture extracted, but the pure Alcohol will appear pellucid, and colourless, upon the Alkali, and will continue so, let it stand ever so long, and there will appear some mark of the moisture, let it be ever so small. It is not so strange, therefore, that some famous Authors have asserted, that such a Tincture as this is impossible, for the slightest neglect of but one, out of so many necessary cautions, will always render the Operation unsuccessful. And as for what other Professors in the Art have asserted, *viz.* that the Colour thus impress'd upon the Alcohol by our method, is in reality owing to the spontaneous alteration of the Alcohol by Time, this is confuted by the thing itself, as well as by the Qualities of the Tincture above-mentioned. Where so much Pains is necessary, an Error is very easy. I have not found this Tincture now to be alkaline, but rather of a compound, saponacious nature.

U S E.

1. **T**HIS very tedious Experiment demonstrates again the averfeness there is in the nature of a pure fix'd Alkali to being alone, and its strong disposition to attract into it almost all kinds of Liquids. That it very greedily attracts Water, Acids, and Oils, has appeared already in the preceding Processes, and here we see it attracts even Alcohol itself, though not so strongly or tenaciously, as the former. Here too we discover a new sort of Soap, and that an exceeding fine one, produced from an Alkali and Alcohol; for this Tincture evinces its true saponacious quality, by the deterfive power one perceives by rubbing it betwixt ones Fingers, whereas pure Alcohol only dries away. By its Taste, too, it appears to contain a pretty acrid, igneous Salt. It does not, however, evidently cause an effervescence with Acids; nor does it readily precipitate Bodies dissolv'd in them. If the pure Tincture is inspissated by Distillation, it leaves a saponacious, saline *Coagulum*, considerably acrid, scarcely alkaline, and of a very deep red, nay, almost black Colour. By this *Menstruum* distill'd Oils are speedily and thoroughly dissolv'd; and by this are extracted excellent

Tinctures.

Tinctures from Gum Lac, Myrrh, and Amber. It is recommended internally by the Chemists, in those Diseases that arise from very obstinate, tartareous Obstructions; but to speak honestly, it cannot be given safely, except it is diluted with Water, Wine, or some such soft Liquor, for otherwise it instantly burns up those parts of the Body to which it is applied. And since it is necessary, that it shou'd be weaken'd in this manner, to what purpose is the laborious depuration of the Alcohol, and troublesome combination of it with the Alkali? For my own part, I confess, it is my Opinion, that the preceding Process, which is performed with a great deal less trouble, affords us a more efficacious Medicine. This Operation, however, ought not, on this account, to be look'd upon as an insignificant one, for we learn a great many things from it, and it has some excellent uses, some of which we just now mention'd, and shall now proceed to relate the rest.

2. I have often reflected upon that assertion of the great *Helmont*, p. 58, 86, that Spirits of Wine distill'd from Salt of Tartar that is thoroughly calcin'd, will be one half converted into Water. This I understood of strong Spirit of Wine, once rectified, especially, as p. 151, he says, the same thing may be done with Vinegar; as I took notice before, Process 49. As the principal Followers however of *Van Helmont* maintain, that this must be understood in a very different manner, and that his true meaning was, that pure Alcohol wou'd unite one half of its Body with the Salt of Tartar, whilst the other being turned into Water wou'd be repell'd, both from the former part, and the Salt combined with it, and that hence simple Alcohol consists of two distinct parts separable from one another, one of which is, by this means, together with the Salt of Tartar, converted into that noble Balsam, the *Samech* of *Paracelsus*, which to a miracle heals Wounds, without any inconvenience; for this reason, I say, I thought it worth while, candidly to lay before you, what I myself, without being sparing of my Labour, have been able to discover. I prepar'd then a very choice, strong, red Tincture of Salt of Tartar, according to the method describ'd, which was of a very fragrant Smell, and an exceeding acrid, igneous, and almost alkaline Taste. This I digested for some months with its Alkali, and then set them by for the space of four years, after which time there was a very dry Salt at bottom, and an exceeding red Tincture at top. I inverted the Bolthead, and poured out all the Salt with the Tincture into a very dry clean Cucurbit, and I found 'em exceeding fragrant. With a gentle Fire, and perfectly close Vessels, I drew off all the Alcohol with an Alembic, and it was very limpid, subtil, and fragrant, whilst the Salt at the bottom was of a scarlet Colour, though before it was white. I pour'd the Alcohol back again upon its Salt, and distilled as before, and then the Alcohol, which was of a fiery Taste, rose with a little more difficulty, and the saline Mass that was left behind was of a deep red Colour, inclining to black. I cohobated in this manner one and twenty times, and then the saline *Residuum* was black, and the Alcohol that came off exceeding acrid. I urged this black, saline, alkaline Mass, with the strongest Sand Heat, and then there ascended a Water, and not Alcohol. Hence then I saw, that though I had taken the greatest care to prevent the access of any Water, yet Water might thus be drawn from the Alcohol and Salt, but by no means to half the quantity of the Alcohol. And, indeed, I am hitherto in doubt, whether even the Water which was thus procur'd was not in reality communicated

communicated to the Tincture; for in pouring the Alcohol so many times back again, and distilling it, perhaps some of the Moisture of the Air might insinuate itself into that and the alkaline Salt. This however I certainly discover'd, that Alcohol united with the Salt of Tartar in the manner describ'd, then digested for so many months, afterwards set by for the space of four years, and at last drawn off by Distillation two and twenty times, did not, after all, render this Salt volatile, but left it fix'd, and perfectly black. I then broke the Glass, and took out all the Salt, put it into a glass Bason, and exposed it to the Air in a subterraneous place, by which means it ran *per Deliquium* into a brown Liquor, of an acrid, alkaline Taste, which I kept by itself. This Operation I went through, Gentlemen, in order to determine something certain concerning this Tincture of Salt of Tartar; concerning Alcohol's being by this means converted into Water; concerning the Nature of Alcohol distill'd from Salt of Tartar that it was combin'd with; and concerning Salt of Tartar's being render'd volatile by the assistance of Alcohol. How easy is it for Persons to grow rich in imagination from others promises? *Exitus acta probat*. The Alcohol now cohobated so many times, in the manner describ'd, was very limpid, fragrant, and of an igneous Taste, and burnt away without *Fæces*, nor wou'd cause any effervescence with an Acid. This, Gentlemen, was the Reward of my Labour.

P R O C E S S LXXXI.

An Elixir Proprietatis, with distill'd Vinegar.

A P P A R A T U S.

TAKE of the choicest Aloes, Saffron, and Myrrh, cut and pounded, of each half an ounce, put 'em into a tall Bolthead, and pour upon 'em twenty times their weight of the sharpest distill'd Wine Vinegar. Let them boil gently in our wooden Furnace for the space of twelve hours, and then let 'em cool, and stand quiet, till the *Fæces* are subsided. Pour off the pure Liquor through a thin coarse Cloth, taking care that none of the thicker part comes along with it. Upon the *Residuum* pour half the former quantity of fresh Vinegar, and then let 'em boil, cool, subside, and be strained, as before. Fling away what remains in the Bolthead, mix the Tinctures together, and distill with a gentle Fire till you have drawn off two thirds: The Vinegar that rises set by for the same use another time; and the *Residuum* keep under the Title of an *Elixir Proprietatis with distill'd Vinegar*.

U S E.

YOU have here an aromatic, acid Medicine, of infinite use in Physick. Externally it corrects, cleanses, preserves from corruption, and by its true balsamic Vertue defends putrid, sanious, foul, sinuous, fistulous, virulent Ulcers. It cures Gangrenes and Ulcers too of the Lips, Gums, Tongue, Palate, and *Fauces*. Internally it has the same happy effect, in those Cases where a putrid Matter, a fetid Bile, pituitous Concretion, or Worms, infest the first passages, and in an infinite number of Diseases that arise from these four causes; nor is it much

less efficacious in the Blood, and the inmost recesses of the *Viscera*, as is easily conceivable from the Nature of the Ingredients which are here dissolved by a subtil Acid. This Elixir shou'd be taken in a morning fasting, twelve hours at least after the last Meal. It may be given from one drachm to two or three, in Honey and Water, Mead, or some sweet soft Wine, and the Patient shou'd walk after it, or have his *Abdomen* gently rubb'd; and this may be continued and repeated as is necessary. If it is taken in a larger Dose, and with a coolish Regimen, it always purges by stool. When it is divided into smaller Doses, it purifies the Blood by the secretion of a thick Urine, and for the most part effects both successively. But if it is given in a pretty large Dose, and the Patient is put in Bed, and well covered with Clothes, it excellently performs the Office of a generous Sudorific, in this particular scarcely yielding to any thing; and then it generally afterwards provokes a discharge, both by Stool and Urine, and thus all three ways is of service. This therefore I look upon as an admirable *Elixir Proprietatis*, truly endued with many Vertues, and at the same time sufficiently safe. *Paracelsus* asserted, that an Elixir prepared from Aloes, Saffron, and Myrrh, by intimately insinuating itself into the vivifying, and preserving Balsam of Life, wou'd protract it, free from all Diseases, to the utmost Limits it is possible for human Nature to reach to: This he called by the grand name of the *Elixir Hominis*, but conceal'd the Preparation. *Van Helmont* says, it can't be done without the help of the *Alcabest*: And honest *Crollius* adds Oil of Sulphur *per Campanam* for the *Menstruum*, knowing that, according to *Paracelsus's* Doctrine, an *Acidum Esurinum* shou'd be one Ingredient in Medicines for the Stomach: But then both the Aloes and Myrrh are burnt, as it were, and grow as hard almost as a Stone, nor so readily afterwards dissolve in Alcohol, and when the Elixir is used, it requires somewhat to dilute the acrid Acid. Hence I imagine, that a mild, oily, vegetable Acid is in this case a convenient and proper Solvent, with regard to medicinal Purposes. If to the *Elixir* prepar'd in this manner you add an equal quantity of Alcohol, it renders it more mild, balsamic, and efficacious. The *Pilulæ Ruffi*, or *Pestilenciales*, it resembles in every Quality, and may be used successfully instead of 'em.

P R O C E S S LXXXII.

An Elixir Proprietatis, with a distill'd simple Water.

A P P A R A T U S.

UPON Aloes, Saffron, and Myrrh, of each equal parts, reduced to a Powder, and put into a tall Bolthead, pour 20 times their weight of Scurvy-grass-water. Then treat them in the same manner, as in the preceding Process, and let them be inspissated as is there directed.

U S E.

THIS excellent Elixir has this great fault, that if it is kept a good while, it grows mothery. Setting aside this, it has very valuable Vertues, like those

those we described in the preceding Process, if you allow for the acid quality of the former: In particular, it purges exceeding well by Stool. Instead of Scurvy-grass-water, you may make use of any other aromatic one.

P R O C E S S LXXXIII.

An Elixir Proprietatis by the help of the fix'd Alkali of Process 12.

A P P A R A T U S.

1. **T**AKE the same *Species* as before, put them into a tall Bolt-head, and pour as much Oil of Tartar *per Deliquium* upon them, as will reduce them to a kind of Pap of a moderate thickness. Stop the Mouth of the Bolt-head, and digest them in our wooden Furnace, the longer the better, in a Heat of a 100 degrees, and by this protracted Digestion the Alkali will intimately resolve the Aloes and Myrrh, and so properly dispose them for this Operation.

2. The Bodies being thus prepared, let them be treated with any aromatic distill'd Water, in the same manner as was directed in the preceding Process, and then you will have an alcalifated *Elixir Proprietatis* with a distill'd Water.

3. Or upon the *Species* prepared in this manner, pour 20 times as much of the choicest Alcohol, and boil, according to our method, for the space of 12 hours. When the Liquor is grown cold, and settled, gently pour off the clear Tincture from the subsiding *Fæces*. Add more Alcohol, boil, depurate, and decant as before, and so proceed till the Alcohol will dissolve nothing more. Mix the Tinctures together, and inspissate them with a gentle Fire till you have reduced them to an *Elixir*, nearly of the thickness of Oil of sweet Almonds, which keep under the Title of an Alcalifated Alcoholifated *Elixir*, whose Vertues cannot be enough extoll'd.

4. If instead of Alcohol you make use of Spirit of Wine once rectified, you have a thicker Elixir, that is equally valuable.

5. Sometimes instead of Alcohol, or rectified Spirit of Wine, I have used a distill'd aromatic Spirit, both simple and compound (Process 69, 70, 71, 72.) and by this means I have procured a noble *Elixir*, particularly with the compound Spirit of Process 72.

U S E.

THESE Preparations afford us a Medicine, which is very frequently made use of, and with great Success, in all acid, austere, watery, cold, and pituitous Disorders, Schirrus's, and Obstructions, without any Inflammation. It purges through almost all the Emunctories of the Body, and in the mean time is grateful to the Nerves, and assists the Spirits. To the Female Sex it is a friendly Medicine, promoting the *Lochia*, *Menses*, and Milk. In Worms it does service, and is used with success in one sort of Scurvy. It is good for creating an Appetite, and happily supplies the defects of the Bile; and for this reason, Practitioners in the Art should have great regard to it. It acts by vertue of the Alkali, the *Species*, and the Spirits, or distill'd Water you make use of, as you design it for various purposes.

PROCESS LXXXIV.

An Elixir Proprietatis with tartarified Tartar.

APPARATUS.

UPON the same *Species* reduced to Powder, and put into a tall Bolt-head, pour 3 times their weight of the Liquor of tartarified Tartar, nicely prepared according to Process 75. Stop the Vessel, and digest for the space of three days in a Heat of 150 degrees, and you will find the *Species* intirely dissolved into a homogeneous Pap, much more efficaciously than either, by Vinegar, Water, or an Alkali. Add then 20 times as much Alcohol, in respect of the *Species*, and boil gently for the space of twelve hours. When the whole is grown cold, and the Liquor by standing has deposited its *Fæces*, pour it off gently, and on the *Residuum* pour fresh Alcohol, and proceed as before, and repeat this till you have almost dissolved the whole, and you will find that you will here have as little *Fæces* as in any of these Processes. Mix all these Tinctures together, and with a gentle Fire inspissate to the thickness of an Oil, and keep the Alcohol that comes off for the same use another time. You will then have a tartarified alcoholified *Elixir*.

USE.

THIS Preparation being made with a Compound Salt that is wonderfully aperient, is more efficacious than the preceding *Elixirs*. Hence it is of admirable service in inveterate Obstructions in chronical Diseases, which it most powerfully resolves, without any injury from an acid, or alkaline Acrimony: For these compound Salts pass more freely with their dissolved Substances through the Vessels of the human Body.

PROCESS LXXXV.

An Elixir Proprietatis with regenerated Tartar.

APPARATUS.

UPON the Powder of the aforementioned *Species* disposed in a tall Bolt-head, pour 3 times as much of the Liquor of regenerated Tartar, and digest for three days, by which means the Aloes and Myrrh will be almost wholly dissolved, and the Saffron will be perfectly opened. Of the choicest Alcohol, then, add 20 times the weight of the Powder, and boil very gently for the space of twelve hours. Proceed in the same manner as before, and at last there will remain a few *Fæces* to be thrown away. Inspissate the Liquors to one half, and keep the Alcohol for the same use. You will by this means then have a thick, turbid *Elixir*, which will always continue so.

USE.

U S E.

1. **I**N this Process, almost the whole *Species* is so equally dissolv'd, that it is render'd potable, and hence in most chronical cases I have found this *Elixir* to have an incomparable resolvent and aperient Power; for it kindly dissolves the Concretions with which the Vessels are obstructed, and at the same time gently stimulates the nervous System into a regular motion, by which it dislodges and propels onwards the dissolved Matter. Hence it resists Putrefaction, which happens so frequently, and with so pernicious an effect in these cases, it frees the *Viscera*, and restores them to their proper office which was before prevented by the obstructing Matter, and thus resolves Tumours, and cures many Distempers which will not easily give way to any thing else. This therefore seems almost to me to be the *Elixir* of *Paracelsus* and *Van Helmont*.

2. From all these Operations, then, we have an example of a chemical Solution, and Preparation of the same thing with various Solvents. Hence too we learn, how wonderfully these Bodies differ in their power of acting, according to the difference of the *Menstruums* they are dissolv'd with; and consequently, that to answer various views of the Physician, the Solution and Preparation must be varied likewise. According as they are variously determined too by the mixture of other Medicines with them, they are found likewise to have different effects. If they are given, for instance, with *Theriaca*, they promote Sweat; if with a purgative Medicine, they purge by Stool; and if with Whey, or medicinal Waters, and the Patient walks about in the cool, they operate by Urine. All these *Elixirs*, except that prepared with a distill'd Water, preserve the Bodies that are put into them from Putrefaction; and to carious Bones too, they are particularly beneficial, except those that are made with Acids. In Practice, therefore, let a great regard be had to them, for they have truly many excellent Vertues. Nor indeed, if we will but reflect upon the Ingredients, will this appear at all surprising: For Saffron greatly enlivens the animal Spirits; Aloes is a safe, and beautiful Purge; and Myrrh most efficaciously resists Putrefaction. In those cases, however, where the *Crisis* of the Blood is broken, there are large Hæmorrhages, Hæmorrhoidal Disorders, or too swift a circulation of the Fluids, these are by no means convenient, but on the contrary, prove prejudicial.

P R O C E S S LXXXVI.

The Analysis of Soot.

A P P A R A T U S.

1. **I** Here take some very black, dry Soot, collected from a Baker's Chimney where they bake nothing but Bread, for which reason I had it from the publick Bakehouse, appointed for baking the Bread for the Poor: And it ought to be procured when the Weather is very dry. With this I fill a very large glass Retort almost to the Neck, and after I have carefully wiped the inside of the Neck, with a common Lute made of Linseed-flower, I lute on a large Receiver.

C c 2

2. Let

2. Let there be then raised a Fire of 150 degrees, and let it be kept just to that height, and there will come off a large quantity of pure Water. And this will rise with some *Impetus*, so that if the Fire is made too strong at first, the Receiver will be easily crack'd. Proceed with this Heat so long as any of this limpid Water comes over, which generally continues a pretty while, tho' the Soot is so dry.

3. Having removed this Water, and put it into a Bottle, fix on the Receiver again, and raise the Fire to 200 degrees, and somewhat more, and you will then have a white, milky, pinguious Water, which will come off plentifully too, and with a considerable *Impetus*. Proceed to increase your Fire gently, so long as any of this Water rises, and keep this again by itself.

4. Your Receiver being applied again, make your Fire still stronger, and there will ascend a yellow volatile Salt in great quantity, which will fix itself to all parts of the Receiver: Urge this so long as it appears to rise.

5. At the same time too, with the strongest and Heat, *viz.* a suppressing one, you will have a black, thick Oil.

6. The whole, then, being suffer'd to cool gradually, you will find a Salt in the Neck of the Retort, which notwithstanding the violence of the Fire, was able to rise no farther. And at the bottom of the Retort, there will remain a black *Caput mortuum*, whose upper Surface, however, will be cover'd over with a very thick, greyish, saline Crust, which in its colour, figure, manner of concretion, and *Striae*, is exceeding like the common *Sal-Ammoniac*.

7. If the milky Water is rectified, it yields a very penetrating volatile Spirit, and somewhat of an oily volatile Salt that is considerably acrid.

U S E.

THIS Process, Gentlemen, was absolutely necessary to be added to the preceding; for they have exhibited to us only those parts of Vegetables, which by various Methods of treatment, and with different degrees of Fire, have either remained fixed, or have been transmitted from one Vessel to another. But here we learn farther, what it is that an open Fire, whilst it is consuming Vegetables, puts in motion, changes, expells, and dissipates into the Air, first in form of Smoke, then of Flame, and then of an Exhalation, and to what a considerable height it carries them. For a Chimney is a kind of converging Alembic, open at top, and often more than forty feet high, to the very highest part of which the Soot fixes itself, and a black Smoke is still carried out of the Mouth, and dispersed through the Air, in which one perceives it gradually vanish. When you reflect, therefore, upon these things, you conceive what an immense quantity of such Corpuscles must be carried up from the whole Surface of the Earth by the infinite number of Fires that are continually burning upon it. But we learn likewise, that a combustible Vegetable, its Smoke, the Flame arising hence, the Soot by this means produced, and the black Clouds dispersed through the Air, consist of one and the same Matter, put in agitation by the Fire. What Bodies are they, now, that enter into the Composition of this Matter? Why,

1. A fetid, oily, bitter, disagreeable, nauseous Spirit, which discovers itself in the Water that first comes off, and is dispersed likewise through

all the other parts, hereafter mentioned. This seems to be the most subtil oily part of the Vegetable, separated by the action of the Fire.

2. Elementary Water, which is here in great abundance; for it is contained in this Spirit, in the first limpid Water, in the second milky one, in the saline Spirit, in the volatile Salt, nay, and even in the Oil itself. This Water, however, can scarcely be rendered pure by any Art whatever, for it always retains a bitterness, and a disagreeable Smell of the Spirit, from which it cannot be freed.
3. An acrid, oily, volatile, alkaline Salt, which comes off first, rises quite into the Receiver, and fixes itself to its sides: For this Salt, by its Smell, Taste, caustic Quality, violent Effervescence with Acids, and Concretion with them into a compound Salt, I have found to be truly alkaline. Hence the Fires that are perpetually burning must fill the Atmosphere with vast quantities of a volatile Alkali.
4. An acrid, pinguious, alkaline Spirit, which consists of the Salt just mention'd dissolv'd in Water, and thus by its liquidness, penetrability, subtlety, and volatility, resembles a Spirit.
5. A thick, black, fetid Oil, which is exceeding bitter, nauseous, inflammable, acrid, and almost caustic, and is mix'd with an oily Salt.
6. A true *Sal-Ammoniac*, which rises to the lower part of the Neck of the Retort, and covers over the black *Fæces* at the bottom: For if you carefully collect, and nicely separate this from the Salt that came off before, you will find it a true *Sal-Ammoniac*: It is of a whitish Colour, subpellucid, of a saline Taste like that of *Sal-Ammoniac*, almost of the same Smell, will not cause an Effervescence with Acids, but being mixed with fix'd Alkali's yields a true volatile alkaline Salt, as *Sal-Ammoniac* does. From Soot, therefore, we learn the true origin of this Salt.
7. An exceeding fix'd black Earth, which being calcin'd with an open Fire till the Oil which very tenaciously adheres to it is consum'd, leaves an earthy white *Calx*.

This then, Gentlemen, is the true *Analysis* of Soot. Consider this well, and hence you will learn what parts of Vegetables become volatile, when they are exposed to an open Fire, and what remain fix'd; and what parts of Vegetables are dissipated by Fire into the Air. But here you see likewise, that even the Earth itself, which when it is separated from the other parts is found to be so fix'd in the most intense Fire, may nevertheless, when it is combined with them, be raised by the action of the Flame and Fire to the height of more than forty feet, and be then carried along in the Air in form of a thin Cloud. But should I, with a philosophical view, enter into these things too minutely, there would be no end. I leave the matter, therefore, to your own meditation, and will only add, that some Persons recommend Pills made of dry Soot, and then gilt over, as serviceable in very cold Disorders: The volatile Salt of Soot too is prescribed for the same purposes, as that of Animals, and used with the same success: And the last Salt *Hartman* praises, as having a power of mitigating Cancers; and certainly *Sal-Ammoniac*, prudently administred, resists its putrid disposition, and so does this. But here it is absolutely necessary to remember, that that Soot generated from pure burning Oak, our bituminous Turfs, or fossil Coals, by a chemical *Analysis* will be found to be different. And that would be still of a more

more different nature, that should be collected from the Chimney of a great Man's Kitchen, which is constantly full, not only of the Smoke of the Fuel, but of the Fumes likewise of all sorts of boiled, roasted, and fried animal Substances. Have an Eye therefore to these circumstances, and you'll sufficiently understand the Composition of Soot.

P R O C E S S LXXXVII.

The Analysis of Amber.

A P P A R A T U S.

1. **I** Take a large Retort, whose Neck is cut off so low, that the diameter of its Mouth is two inches or better. Into this I put such a quantity of pieces of common Amber, well freed from Sand, Dust, and other heterogeneous Bodies, as will fill the Belly of it two thirds full, and then, with the common Lute, lute on a large Receiver.
2. I then proceed to distill with a sand Head a little greater than that of boiling Water, and by this means there comes off a large quantity of a thin, limpid Oil. This degree of Fire I keep up so long as the Amber gives out any of this Oil, which ceasing, I remove it, and keep it by itself.
3. The Receiver being again fix'd on, there rises another Oil which comes over plentifully likewise, and is yellow, and as yet pellucid. Patiently then keep up the Fire just to the same height, till no more of this Oil ascends, which will be a considerable time. This again, which is yellow, inclining to red, and thicker than the former, if you would proceed accurately, must be kept by itself.
4. This being remov'd, and your Fire being still gradually increased, there will begin to appear some white saline Flakes in the Receiver, especially in the Neck, upon which you must gently raise your Fire till no more of this Matter comes away; for otherwise, the volatile Salt will be mix'd with the succeeding thick Oil, and so the greatest part of it will be lost. It's better to collect it by itself, and remove it. All the time, however, that this Salt continues to rise, there rises with it a red Oil, which is nearly pellucid.
5. The Fire being then raised to the greatest degree, you have another, thick, tenacious Oil, nearly of the consistence of Turpentine.
6. And lastly, this being separated, and the *Residuum* being still farther urg'd with a suppressing Fire, a black flatulent Matter ascends all together into the Neck of the Retort, which it fills up, and in this manner comes black, and hard into the Receiver. And hence it has happen'd, that where the Mouth of the Retort has been narrow, this pitchy stuff has quite stop't it up, by which means the Vessel has been burst with a violent explosion, and this combustible Matter has in a dangerous manner set Fire to the things about it: If you mix a pretty deal of Sand, however, with this last *Residuum* before you urge it with this extreme Heat, it will by this means be so divided that it won't unite again, but will without any inconvenience come over black and hard into the Receiver. By proceeding in this manner, I have found there has been left but very little brittle *Fæces* at the bottom of the Retort, scarce worth taking notice of, so that the whole becomes volatile.
7. If

7. If the Operation is performed with proper care, the Amber may be separated into all the distinct parts we have mentioned, which being afterwards distilled by themselves, may be depurated, and rendered thin and limpid. As for the volatile Salt, this being collected by itself is perfectly acid, and this is the only method I am acquainted with of obtaining a true Acid, in a solid, saline form; for this, I confess, I have not met with besides, either in the Vegetable, Animal, or Fossil Kingdom: Tartar, tho' it is acid, is scarcely a Salt dissoluble in Water; and Oil of Vitriol, purified in the most skilful manner, will harden indeed with the Winter's Cold into pellucid Globules, but as soon as ever the severity of the Cold is a little abated, will melt again, and become fluid. This Salt of Amber keeps its solid form for a considerable time.

U S E.

BY this Process then, it appears, that Amber is a pretty singular Body. In its Oils, it comes near to *Petroleum*, *Naphtha*, and the like, and consequently to pinguious Fossils. In the part that remains after the first and second Oil are separated, it very much resembles the black *Lapis Gagates*, or Jet. And again in its acid Salt, it has some resemblance to Vitriol. I have been at a loss, therefore, where I should properly place this *Analysis* of Amber, and at last I placed it here, that we might resolve it into its parts, if it had been for no other reason, than that it will almost totally dissolve in Alcohol, and will not by this means be separated into different parts, but only become loosely as it were concreted together according to Process 58. How vastly different now is the same Substance, whilst it continues in one Mass, from those parts into which it may be reduced by the Chemical Art? Who could imagine that Amber, its Powder, a liquid Solution of it in the purest Alcohol, the Powder precipitated from this Tincture inspissated and then mixed with Water, and the Oils, Salts, and Colophony produced by Distillation, should arise from the very same Matter? Who can discover any agreement in the Vertues of these different Bodies? Or who by compounding them together, can ever produce Amber again? These Oils properly rectified by a fresh distillation, have an acrid, balsamic, inciting, diaphoretic, and diuretic Vertue, are useful in hysterical cases, and bring down the *Menses*. Externally too they are rubbed with success upon torpid, contracted, weak, and paralytic Limbs. The volatile Salt is a true oily, acid one, valuable for its grateful, balsamic, pinguious, penetrable, antiseptic Acidity, by which it stimulates the Nerves, and raises the Spirits. Hence it holds the first place among the Anti-hysterics, and Diuretics, especially if it is rectified by a new Sublimation.

P R O C E S S LXXXVIII.

Putrefaction of Vegetables.

A P P A R A T U S.

1. IF the soft succulent parts of fresh Vegetables, are put in the Summer time into a wooden Vessel open at top, and press'd down in it till the Vessel is almost

almost full, and are left in these circumstances exposed to the open Air, they will in a short time spontaneously grow warm, and the Heat will daily increase more and more, especially in the middle, till it will at last exceed that of boiling Water, rising so much the higher, as the Herb is more compress'd together, and is less watery, provided it is not dry. When this Heat is arrived to its greatest degree, it gradually diminishes again till it returns to the common temperature of the Atmosphere, and then the whole Vegetable Substance is reduc'd into a pretty equable pappy Matter. This Heat, now, begins to be generated in the center of the Body, is greatest there, and thence disperses itself on every side, till it has taken possession of the whole Mass. Nor does it at all signify what kind of Vegetable you treat in this manner, whether it is the most alkaline, as Scurvygrass; the most acid, as Sorrel; or the most insipid, as Grass. And here, whilst the Heat continues moderate, *viz.* not exceeding 80 degrees, these Herbs, if they are naturally fragrant, diffuse their proper Smell, and so long too they retain their particular Taste; but as the Heat increases, the natural Smell is changed into such a one as Hay, that is not well dry'd, gives out when it comes to grow hot; and when it is arrived to its greatest degree, the proper Smell, Taste, and Colour too, are intirely destroy'd, and instead of them, there arises a putrid stink resembling that of Dung, and a cadaverous Taste, like that of putrified Urine: The *Spiritus Rectior* too is then quite gone off, and from the most different Vegetables, the Smell and Taste are the same.

2. If Herbs cut down and half dry'd, but otherwise retaining their natural Juices, are flung up into large heaps, there will be a pretty strong Smell diffused around, by which it will appear, that an igneous Motion begins to arise in the internal part of the heap, where it is most compress'd, tho' in the external there will as yet be none perceiv'd. If the whole heap is then flung abroad, and the Herb is exposed to the Wind, the Putrefaction is prevented; but if it is left to itself in these circumstances, the Heat increases to such a height, that the middle intirely putrifies, grows very hot, and at last bursts out into open Flames. And here the bigger the heap is, and the heavier the Matter of which it consists, so much the speedier will the Putrefaction happen, and the Fire be excited. If the Heat now proceeds so far as to set the Vegetable on Fire, it will then suffer the very same alterations, as when it is burnt in a common Chimney: But if the heap grows very hot, but yet does not take fire, it will then putrify, and be converted into just such a pappy Matter, as the preceding. That this is often the case with Hay is known sufficiently.

3. This physical action in Vegetables proceeds so much less efficaciously, as they are naturally drier, and less juicy, or are more dried before the Experiment is made with them; but even then, if you pour Water enough upon them to wet them thoroughly, a Putrefaction may be excited. The lighter too the Herbs lie upon one another, so as to leave empty spaces between, the less are they disposed to generate this Heat; whereas when they are soft and succulent, and are stronger compress'd together, they grow hot, and putrify more certainly, and to a greater degree. Hence it comes to pass, that the drier, harder Herbs, such as Rosemary, for instance, scarcely putrify, if they are put into a Vessel, except they are press'd together with a great weight, or there is a vast heap of them; tho' on the other hand too, if they are mix'd with too great a quantity of Water, they will acquire indeed a kind of rancidity, but will not generate such a degree of Heat.

4. If

4. If you take this pappy Matter, when it is just thoroughly prepar'd, and put into a large glass Cucurbit, and distill it very close almost to a dryness, you will have a limpid, fetid Water, which keep by itself. Let the *Residuum* then, rendered by this means almost dry, be put into a Retort, and be urged through all the successive degrees of Heat, quite to the greatest, and it will give out white Fumes, a large quantity of a thin Liquor, a white Salt, and a black, thick Oil. Let these be kept all by themselves. The few black *Fæces* then that remain at the bottom of the Retort being taken out, burnt, and calcined with an open Fire, leave a mere Earth, without any fix'd Salt at all, tho' it is procured so acrid, and in such abundance from most Vegetables when they are burnt before they have undergone this Putrefaction.

5. If you separate the last Liquor from the Oil, and distill it to one half in a tall Vessel, and with a gentle Fire, you will have an acrid, saline, alkaline, volatile Liquor. And if you treat this again in the same manner, you will still have a stronger; and if you proceed to repeat this Operation, keeping your Vessels very close, you will at last procure a Liquor very much resembling rectified Spirit of Hartshorn, which with a gentle Fire will yield a true volatile Salt, in great quantity, nay in a greater than the Herb would have produced fix'd Salt before the Putrefaction. From the first Liquor too you may in the same manner obtain such a Spirit, and a Salt, which being thoroughly rectified, are perfectly like the Salt, and Spirit of Animals, without any chemical difference. And this is the case with the sourest Sorrel.

6. The thick black Oil, too, that is forced out with the last degree of Heat, and stinks intolerably, and retains its fetid Smell very strongly, by these qualities, as well as its pitchy tenacity, exactly resembles that Oil which animal Substances yield when they are exposed to the extreme torture of the Fire.

U S E.

THE physical action we have now explain'd is call'd Putrefaction; which, without any assistance of Art, happens spontaneously to Vegetables, whenever they are juicy, and are laid in great heaps, or compress'd together. And the power of this action extends to all Vegetables in general, and converts them all into the same kind of Matter, tho' they are ever so different before. And it renders the whole of them volatile, except only a small quantity of Earth, so that no Operation fills the Atmosphere with more acrid, and even pestilential Particles: This the Stench that spreads itself to such a distance from putrifying Bodies sufficiently evinces, which drives People, even without design, from such infected places. Since therefore this Putrefaction, sooner or later, intimately resolves both the Fluids and Solids into a soft, stinking, tabid, liquid Matter, it is plain that by means of this, and the Rain that dilutes it, every thing that grows out of the Earth may penetrate and insinuate itself into the Earth again. Nor is this the case only with those parts that continue upon the Earth after Putrefaction, but even those, that become so volatile by this means as to be carried up into the Air, intermix themselves with Dew, Fogs, Rain, Hail, and Snow, and with them descend again, and sink into its Bosom. Neither in Art or Nature, now, do we find any one Operation so general as this; for it acts upon every kind of Vegetable, in the same manner, and with the same effect.

Acid, austere, alcalescent, aromatic, hot, cold, oily, watery, and saline Plants it reduces to the very same circumstances. The particular Make, Smell, Taste, Colour, and proper Vertue of them all, are by this means absolutely destroy'd, and they become one and the same Matter, *viz.* a liquid Pap, of a greyish Colour, resembling in every Character the gangrenous *Sanies* observed in the corruption of Animals; or coming pretty near to that Alteration which Vegetables undergo in healthy animal Bodies, when they pass out of the Body in form of putrid Excrements. And here the stronger and more violent the vital Actions of Animals are, either from Motion, or a Fever, the nearer does the effect it has upon vegetable Substances come to the true Putrefaction of them. Of all Operations therefore, both artificial, and natural, Putrefaction best explains the first Action of the Mouth, Stomach, and Intestines; and consequently, the Opinion of *Plistonius*, who asserted that our Food receives the greatest alteration in the Stomach and Bowels from Putrefaction, ought not to be so intirely exploded. This Putrefaction now must be absolutely distinguished from that Fermentation which we regularly explained, Process 42, from p. . to p. . and for this reason in particular, because some famous Men in the Art too much confound together these two things, which I think ought to be regarded as intirely distinct from one another. With the leave then of those Gentlemen, who differ from us, I'll freely propose the Circumstances in which it appears to me that they principally differ; which are as follow.

1. A greater Thickness, Compression, and Density, seems necessary to the Putrefaction of Vegetables, than to their Fermentation.
2. Putrefaction acts upon all Vegetables, of every kind whatsoever, provided they are soft and succulent: Fermentation acts upon some sorts only, and does not at all affect others.
3. The Heat which is necessary to Putrefaction, and is spontaneously excited by it, begins at the degree of Heat of a Man in health, and rises even to bursting out into Flames; whereas, if in Fermentation the Heat increases to that of a healthy human Body, the fermenting Cause is dissipated, and the Liquor grows vapid. Nay indeed, the Heat excited by Fermentation, does not exceed 75 degrees, except in the Fermentation of Vinegar, and even then if it is not immediately check'd, the true acetose Fermentation will not proceed, but the Liquor will be corrupted, and grow flat.
4. But the Effects of them are different likewise: For Putrefaction renders all the Salts volatile and alkaline, the Oils very fetid and volatile, and almost volatilizes the Earth itself; Fermentation on the contrary makes the Acids volatile, thin, and of an opposite nature to that of an Alkali, renders the fragrant spirituous parts inflammable, produces an acid Tartar, and leaves that Matter, which the Fire converts into an Alkali, as fix'd as it was before.
5. But there is a difference betwixt them too in their Salts, those generated by Putrefaction, which from all vegetable Substances are the very same, being simple, alkaline, fetid, and exceeding volatile; whereas those which Fermentation produces, are acid, for the most part fix'd, and compounded of a Spirit, Oil, Salt, and Earth.
6. And lastly, Putrefaction furnishes us with a method of absolutely, and certainly

certainly converting all the saline Matter of Vegetables, into one and the same simple volatile Alkali: Fermentation changes a certain small portion of the vegetable Salts only into a volatile, acid Liquid, and leaves the rest almost without alteration. If any Person now, after duly considering what we have here offered, is still of Opinion that these Operations ought not to be distinguished, and that this would be only multiplying *Species* of things to no purpose, I shall oppose it no farther, for indeed I know no other kind of Arguments that can be made use of in the Chemical Art. It may be added too, that Fermentation, with a small degree of Heat dissolves the latent Air, which by the concurrence of its Elements puts in motion, attenuates, agitates, and dissolves the viscosity of the fermentable Substances, with a constant Ebullition, and for a certain space of time, and generates, or sets free the inflammable Spirits: Putrefaction, by means of a greater Heat, soon puts in motion, and expells the same Air, and quite changes the whole Matter. But let me caution you, that I am now treating only of the Putrefaction of Vegetables. Here then I put an end to these Processes upon Vegetables, as this last changes them to a resemblance of the humours of Animals, which now therefore we will proceed to examine. But upon the head of Putrefaction by all means consult the famous Dr. Cox. *Phil. Transf.* No. 100. p. 7002. No. 101. p. 4.



CHEMICAL OPERATIONS,

PART II.

Upon ANIMALS.

INTRODUCTION.

IT appears therefore from the preceding Operation, that it is possible, nay, and that it very frequently happens, that Vegetables of all sorts, having their different properties quite destroy'd, are converted into the same kind of new Matter, which can afterwards be scarcely distinguish'd. This I say is the case, whether they are acid, acrid, alkaline, bitter, aromatic, rough, smooth, hot, sweet, inodorous, insipid, medicinal, odorous, saline, sapid, poisonous, or caustic; for all these sorts, and others, if there are any, lose entirely their proper disposition, and acquire a new common one, by which their Salts become alcalious, and are rendered volatile, and their Oils easily grow putrid, and become volatile likewise. And the very same thing happens to those Vegetables which are taken as Food into animal Bodies. The chemical management of Vegetables, therefore, being already treated of, we shall be the better prepared to understand those things which this Art performs upon Animals. But in order to do this still more successfully, it is necessary, from the *Historia Medica*, to lay before you the following Observations.

1. All Animals that we know of, by the very actions of Life, continually lose those parts, both fluid and solid, of which they consist at any particular time. Their Hair, Nails, *Epidemis*, the extremities of all their Vessels, and their internal and external Surfaces, teach this sufficiently. This constant loss now, happens from the casting off of numberless minute Particles, which are either abraded, or simply expell'd, and which on account of their fineness are not discovered at all, or appear only in the form of Fluids. Perspiration, Exhalation, Sweat, the *Mucus*, *Saliva*, Urine, Excrements, Seed, Hæmorrhoidal, and menstrual Discharges, *Fætus's*, After-births, *Lochia*, and Milk, are perpetually carrying off these Solids and Fluids both from Male and Female. And the restoration of the Bones to a sound state within a few weeks after they have been broken, nay and have even lost part of their Substance, certainly evinces that there is in these a vital motion likewise.

2. In this respect, therefore, Animals do not ever continue the same as they were but a little before, but continually supply the lost Particles from their Meat and Drink, and perhaps the Air; for *Bellini* found that the Chicken that came out of an Egg was, by being set upon, grown heavier than the Egg was when it is put under the Hen. The Body therefore consists of those Particles by which it is nourished; for by means of these it grows from a Corpuscle scarce weighing a grain, to the size it has when it is come to maturity. And as it thus increases by means of foreign substances, so when it is adult, and wears away, it is renewed again by the same, after they are first properly altered by the Animal Powers.

3. The Food of Animals consists either of Vegetables, or other Animals, as the same, and Water furnishes them with their drink. Fossils have nothing at all to do here, except, perhaps, you wou'd add Sea-Salt, *Sal-Gem*, and Fountain-Salt; but that a Person may live without these, has appear'd by the example of whole Nations. The *Brachmans*, *Pythagoreans*, and others, by the assistance only of Vegetables, and Water, are healthy, and live to great ages.

4. Most of the Animals that Mankind makes use of for Food, live upon Vegetables, witness, *Bullocks*, *Deer*, *Sheep*, *Goats*, *Hogs*, *Rabbits*, and *Hares*. Some of the larger Fish, indeed, eat the less, or Insects; and some Birds too prey upon Insects, or other Animals: But those Animals that help to support others, very often live themselves upon Vegetables, and therefore these we have first examined in the preceding Eighty eight Processes.

5. The human Body therefore consists principally of an aggregate of vegetable Substances: Thus if a Person eats Cow-Milk, Butter, Cheese, or Beef, the Animal that supplies him with them was itself made up intirely of Grass, Hay, and Water.

6. Before the Chemist takes into consideration the Body of an Animal that lives solely upon Vegetables, it is necessary, by his Art, to examine those Vegetables. If he neglects this, he won't properly understand the Bodies of Animals; and hence has happened so much confusion in this affair.

7. All the alterations that happen to Vegetables, and are observable by the Chemical Art, being explained, in our Chemical Examination of Animals we ought first to take under consideration that part, which being of a vegetable Origin, begins in the animal Body to lose its former nature, and put on the animal one, and which may be separated from all the rest, and examined by itself; that thus we may discover the successive alterations of it, and then in particular when it retains a good deal of its natural disposition: For by proceeding thus gradually, we shall get a clearer insight into the Animal Nature of the human Body, for the sake of which we take all this pains, than if we first set about examining a part that has been exposed to all the actions of the Body, as is often preposterously done. An Animal consists of a Matter, which at first was not that Animal, but by the powers of it was converted into the Animal Nature. This therefore you will best understand by beginning with the first alteration that happens in this foreign Matter, and then examining all the subsequent ones in their proper order through all the successive degrees. After a good deal of consideration, therefore, from whence

I should

I should begin these Experiments, I perceiv'd that this cou'd not be done with the Contents of the Stomach; for as soon as the Vegetables come to be changed there, they pass off in form of Chyle: And as for the Excrements that go off by Stool, they are depriv'd of the Chyle after it is made: And the Chyle of the Mesentery, and Thoracic Duct can scarcely be obtained in sufficient quantity to be properly examined, nay, and then the greatest part of it is lymph, discharged into it by the lymphatic Veins. The Milk therefore seems to offer itself as first to be considered: For it is true Chyle, much less diluted with Lymph than the same is when it enters the subclavian Vein, and consequently in Nature comes nearer to the Aliments: This has circulated through the Veins, Heart, Lungs, and Arteries, and of course has been mixed with all the animal Humours, and being afterwards separated by the particular make of the Paps, may be examined by itself. The Milk then is a Liquor produced from the Aliments chew'd, swallow'd, and digested in the Stomach; rendered more perfect by the Action, and Juices, of the Intestines; still farther advanced by means of the Mesentery, its Glands and Humours, and the Thoracic Duct; having been exposed to some of the actions of the Veins, Arteries, Heart, Lungs, and Humours of the Body; and consequently beginning to be assimilated to the Animal Nature; and derivable out of the Body in such a manner as to be examined alone.

9. By this their Milk, prepared from the proper Matter of the Chyle, all known Animals, that make Milk, are nourished, both Male and Female: For in Men, as well as Women, there is always Milk generated from the Chyle; as there is in Virgins, barren Women, and those that never gave suck, as well as in Mothers and Nurses. Hence therefore every such Animal consists of, is nourished by, and lives upon its Milk alone, and from that alone, by its vital Powers, forms all its parts, both solid and fluid. But it has appeared farther, that by the sole assistance of Cow's, or other Milk, a Man may live for years in perfect health, and from thence prepare all the solid parts of the Body, and all the variety of Fluids in the greatest perfection; as Bones, Cartilages, Membranes, Vessels, Blood, *Serum*, Lymph, Spirits, &c. If a person therefore may live for a great number of years upon Milk alone, it necessarily follows that this must contain in it the Matter of all the parts of the human Body. Milk, now, approaches nearer to the Animal Nature, than Chyle: The Chyle of the Intestines has more of the nature of Vegetables: That in the Stomach most of all. And hence it comes to pass, that in the Stomach and Intestines are observed the proper *Phænomena* of Fermentation and Putrefaction, as *Flatus's*, *Ructus's*, the generation of an Acid, a fetid Smell, and rumblings of the Bowels. For this Chyle is in reality a true Emulsion (Process 21.) form'd by the action of the Teeth, Tongue, Stomach, and Intestines, with the assistance of the *Saliva*, and the gastric, pancreatic, hepatic, and intestinal Juices; and from this is procured the Milk. This, if it is good, when it comes to stand quiet in a Vessel, at first appears exceeding white, and equally so throughout, but afterwards casts up to the top a white, thick, pinguious Cream, whilst that part which remains underneath, becomes clearer, bluish, thinner, and less fat than it was before, and is then call'd Skim-milk; and if you cautiously take off this Cream, the remainder will again give out more. In Emulsions too,

too, the case is the same. In this property now the Milk of all Animals agrees, as likewise in the whiteness of its Colour. In the Consistence and Taste, however, there is observed some difference: Thus human Milk is very sweet and thin; to this succeeds that of the As's; then Mare's; next Goat's; and last of all Cow's. And hence to consumptive Persons whose *Viscera* are exceeding weak, we prescribe them in the order here mention'd. Tho' Milk however, in so many of its qualities, comes near to the nature of vegetable Emulsions, yet it is not quite the same: For the Runnet prepared from the Juices of the Ventricles of those Animals that chew the Cud, upon being mixed with Milk, reduces it to a uniform, coagulated, scissile Mass, which soon separates into a Whey, and a Curd fit for making of Cheese; which is not the case with Emulsions. If it boils a good while upon the Fire, the Liquid part is dissipated, and it becomes thickened into a Butter, and Cheese, and is not converted into a homogeneous Mass that will stand against the Knife, like *Serum* of Blood, or the white of an Egg. It has a sweet Taste, a Smell that is by no means disagreeable, and is exceeding soft. It is a kind of middle Liquor between the *Serum* of the Blood, and an animal Emulsion, or Chyle: And hence it is of various sorts, according to the difference of the Aliments it is made from, and the Animal that produces it. These things then being premised, let us now take it under a Chemical Examination.

P R O C E S S LXXXIX.

Cow's Milk is not acid, contains no Alkali, is scarcely saline, nor has any of the Spirits in it of the Processes 45 to 49.

A P P A R A T U S.

1. **N**EITHER the Smell, nor Taste of Milk, discovers any thing in it acid, alcalious, or saline; nor does it, when it is dropp'd into a sound Eye, excite any sense of Pain.

2. Into this, which is warm'd, I pour successively a pure volatile, and fix'd Alkali, and there is not the least indication, as you observe, of a latent Acid by any Effervescence, but it is disturb'd, and somewhat inspissated.

3. With another portion of this, I successively mix the Acid of Vinegar, Nitre, Salt, and Vitriol, nor does there arise the least Effervescence, by which we may infer the presence of an Alkali; but it is coagulated, and thickened.

4. But this Milk now, which has some Oil of Tartar *per Deliquium* in it, I mix, in this cylindrical glass Vessel, with this which contains some Oil of Vitriol, and there is excited in an instant the most rarified, rapid, violent Effervescence, much greater than would have happened from mixing together the same quantity of pure Acid and Alkali, as were in the Milk.

5. In this clean glass Cucurbit, with a Heat of about 160 degrees, I am distilling some new Milk with an Alembic; and there rises a watery Liquor, which has not the least appearance of a fermented vegetable Spirit. Nor does it by any Chemical Trial give the least indication of its containing an Alkali, or an Acid: This you are eye witnesses to, whilst I mix it with opposite Salts,

and other things which we make use of to discover latent Acids and Alkali's. Nor farther does there appear the least token of any thing saline in it; for it is inodorous, and insipid, nor gives any pain to the very sensible external Coat of the Eye. At the bottom of the Cucurbit there remains a yellowish, thick, pinguious Mass, which has a grateful sweet Taste: Nor even in this, examine it in what manner you please, can you yet discover any thing in the least acid, alcalious, or saline.

U S E.

THUS far then, Gentlemen, you truly understand the nature of that Fluid, produced from a vegetable Matter, which has been expos'd to the action of chewing, deglutition, rumination, and concoction of the Stomach, Intestines, Mesentery, Thoracic Duct, Veins, Arteries, Heart, and Lungs, in the animal Body; and which besides was mix'd with the *Saliva*, the *Mucus* of the Mouth, *Fauces*, *Æsophagus*, Stomach, and Intestines, the Bile of the Gall-bladder, the hepatic and pancreatic Juices, the mesenteric and thoracic Lymph, and that of the Head, and lastly with the Blood itself. Hence therefore there is no true Fermentation here, producing any thing acid or spirituous, no Putrefaction that causes an Alcalescence in the Salt, or a fetid Smell in the Oil, at least as far as we can hitherto discover, notwithstanding a great part of the animal humours are here mix'd with the vegetable Juices. We have a very different notion, therefore, of the chylopoietic and galactopoietic Functions, from what the Chemists generally give us. As Cows now are milk'd twice a day, hence this whole Operation must be perform'd in the animal Body within the space of twelve Hours. If the Milk is retain'd any longer, it begins to change and degenerate from its proper Nature, and be corrupted. These Experiments I have made with Cows Milk, because they live solely upon Vegetables, either green, as Grass, or dried, as Hay, and Water. In Womens Milk, on account of the great variety of their Food, there is sometimes found some difference, though, when it is new, scarcely to be distinguished. There have been some Persons, now, who have asserted, that there is actually a latent Acid here, though it does not discover itself by the Experiments above-mention'd: But sure these Gentlemen must allow, that an Acid is call'd an Acid, either as it affects our Senses in a certain manner, or as it produces some particular effects; but neither of these is the Case here.

P R O C E S S XC.

New Cow's Milk is coagulated with Acids, even in that Heat which makes it boil.

A P P A R A T U S.

IN these very clean Vessels there is boiling some new Cow's Milk, diluted with a small quantity of Water that it mayn't thicken too much as it boils. Into this then I pour some Vinegar, and the Milk turns immediately, forming a Curd with one part, whilst the other still remains fluid. Into a second I pour Spirit

Spirit of Nitre; into a third Spirit of Salt; and into a fourth Oil of Vitriol; and the effect is in every one the same: Nor can this Coagulation be prevented even by a Heat of 212 degrees. It happens too with every other Acid, as the Juice of Sorrel, Berberries, and Citrons, Cream of Tartar, unripe Grapes, Currants, Tamarinds, Tartar, &c. So that here the Milk, which was of itself so thin as to be able to pass through the finest arterial Canals, produces now a thick tenacious Substance, call'd the Curd, whilst the other part, called the Whey, is a good deal thinner than the Milk was before. If this thick part, prepared either with an Acid, or common runnet, is very strongly press'd in a thick Cloth, it forms a fat Cheese, which consists of Cream, and that Substance which is properly called Cheese. This with age grows very strong and acrid, does not become acid, but nearer in some measure to an alkaline disposition, and acquires a particular strong Smell, and a penetrating Taste, which often inflames the Mouth. But if you first let the Milk stand, and take off the Cream, and afterwards turn it with an Acid, or Runnet, then the Cheese that is made from it will be exceeding dry, and grow hard, like Horn, and if you hold it to the Fire, it will, perfectly like that, grow soft, toast, burn, and stink. What a surprizing change do we here observe then of the very liquid Matter of Milk! But are not all the Solids form'd from this?

U S E.

THIS then is the Nature of Milk as it is contained in the milky receptacles of the Breasts. In them therefore, by the admixture of a salt Matter, like Runnet, or an Acid, it may be coagulated likewise. Hence the thin Whey will run out at the Nipple, whilst the curdled part will remain in the Vessels: Does it hence produce a Hardness, Swelling, Inflammation, Suppuration, Schirrus, and Cancer? May the same thing too happen in the chylous Glands of the Mesentery? In all these Coagulations with an Acid, however, the Milk retains its white Colour. Hence therefore it appears, that weak Bodies will be able to make chyle, and white Milk, but will with more difficulty make red Blood from them: And for this reason they abound with Acids, the Wind that breaks from their Stomachs is Acid, their very Sweat is Acid, they smell sour, and are all over of a pale Colour. These things then being rightly considered, the Physician may hence understand a great many Disorders that happen to the human Body.

P R O C E S S XCI.

If new Cow's Milk is boil'd with a fix'd Alkali, it is coagulated, and grows yellow and red.

A P P A R A T U S.

INTO new Cow's Milk, diluted with a little Water, and boiling in a clean Vessel, drop in some Oil of Tartar *per Deliquium*, and it will grow yellow, and proportionably deeper, as you add more of the Alkali, and it boils longer; so that it will gradually from a pale yellow change till at last it becomes almost of a very deep red. But at the same time too it will be more and more coagulated

gulated, separating into curdled Masses, which however are not so large, nor so solid, nor harden so easily as those from the Acid. By this means, then, if you continue to boil it long enough, you will have a thick, red Curd.

U S E.

HENCE therefore we see, that though Milk, when it is turn'd with an Acid, or its proper *Coagulum*, Runnet, even when it is hot retains its white Colour, yet it immediately grows yellow, by being mix'd with Alkali's in a great Heat, and by means of the Alkali and the Fire has its Colour gradually heighten'd more and more, till at last it becomes nearly red. And thus when a Woman that gives suck has a high Fever, the Milk corrupts in her Breasts. Hence, from white, it grows yellowish, from sweet, salt, from a moderate thickness, thin and sanious the thicker coagulated part remaining in the Breasts, and from inodorous, inclining to be fetid, so that the Child is not able to bear it. Where Milk therefore is observ'd coagulated with a yellow Colour, in a burning Fever, the Physician must not look upon this as arising from an Acid, but from too great Heat, and possibly an *alcalescent* degeneration of the Humours. And perhaps a Physician may see Milk coagulated in this manner a hundred times by a Fever, where he sees it once happen from an Acid. In the last Murrain among the Cows, when the Ailment remain'd in the Stomach without being either brought up in chewing the Cud, or expell'd downwards by Stool, and underwent a true Putrefaction there with such an incredible Heat as burnt and consum'd the Stomach, perfectly as in Process 88; then the Milk that was either milk'd from them, or spontaneously dropp'd out of their Teats, was thin, acrid, yellowish, and somewhat fetid. If with Milk now that is coagulated, either by an Acid, or Runnet, and still remaining hot, I mix an Alkali, this does not, you observe, as is generally asserted, reduce the Curd again to its former Liquid; so that Alkali's do not always resolve those Substances that are coagulated by Acids. But from what has been said, we farther understand, that Milk, which is exceeding white, will for a long time continue white in Bodies that are very weak and cold, nor can be brought to the natural redness of the Blood: Hence such Persons are always pale, and have a pale-colour'd thin Blood; though if by any means they are again restor'd to Health, they soon overcome this Paleness, and their Blood acquires a proper Colour. And for the same reasons, when the vital Actions are capable in some measure of turning the Milk into Blood, but cannot quite perfect it, then the Colour of the Blood will be yellowish, not red; or greenish, like that of Girls that have the Greenickness. But on the other hand, when the Body is healthy and strong, and carries the Milk swiftly about, and gives it a considerable degree of Heat; then the white Colour is soon chang'd to a very red one, and the Blood often from the intenseness of its Colour appears almost black. In the last place, from these Experiments we learn still farther, that in Bodies that abound with Acids Milk will retain its Colour for a considerable time; whereas, if Alkali's are predominant, it will first acquire the Colour of Bile, and then gradually grow deeper and deeper, till it comes to be red. The white Colour now, according to the Observation of the famous Dr. Lower, disappears by the twelfth hour from the last Meal.

P R O C E S S

PROCESS XCII.

Urine is not acid, nor alcalious, but fetid.

APPARATUS.

I HAVE here the Urine of a Person in Health, made twelve hours after he had either eaten or drank. This Liquid, therefore, was so long at least in the human Body. And it did not circulate for much less time through the same Body, being mix'd by the vital Actions with all its Humours, and being propell'd, perhaps, through all its Vessels. It is an aqueous *Lixivium* therefore that wash'd off, united with itself, and now exhibits without the Body, whatever was capable of being dissolv'd in Water, and transmitted through the fine uropoietic Vessels of the Kidneys. For this reason it contains particularly the spirituous, saline, and saponaceous parts of the Blood, and those too pretty well concocted into the true nature of the animal Body, as they have been acted upon by the vital powers for the space of twelve hours. Since therefore Milk itself loses its natural disposition in that time, and begins to be converted into *Serum*, hence for this chemical Examination I chose that Urine, which was made when the cruder, separated by the Kidneys before the twelfth hour after eating and drinking, had been discharg'd. Such Urine therefore may be always collected without the Body, and yet will perfectly discover to us the proper disposition of the natural Humours, and their Elements. This Urine then is not acid; for it has not the least Smell or Taste of an Acid; it does not give those vegetable Juices a red Colour that are observ'd to grow red with Acids; nor does this which is warm discover, as you see, the very least sign of an effervescence, when I drop into it, in one Vessel, Oil of Tartar *per Deliquium*, and into another an alkaline Spirit of *Sal-Ammoniac*. Nay farther, which is more surprizing, I examin'd the Urine which a Person made twelve hours after he had drank a very large quantity of *Rhenish* Wine, which was considerably acid, and stale Malt Liquor, and had at the same time eaten a good deal of Vinegar with his Victuals, besides ripe Fruit, and yet even then it did not by any Experiment discover the least sign of an Acid. Nay, Urine that has been twelve hours in the tender Bodies of little Children that have liv'd almost intirely upon acedcent Vegetables and Cow's Milk, has not appear'd to be acid by any effect. The vital powers therefore of the animal Body overcome both the natural disposition of Vegetables to Acidity, and their real Acids. *Van Helmont* therefore asserted, with a great deal of reason, that an Acid is an Enemy to the Veins: But his Followers were absolutely in the wrong, who hence, imagining Acids to do harm in the first passages, proscrib'd them as Poisons, both out of Diet and Medicine. These Truths the Chemists will be dispos'd to admit of: But they'll be a little shock'd, perhaps, when I assert, that this Urine is no ways alcalious; but this is absolutely true, as you yourselves may be Witnesses if you'll please to attend. Into different portions then of this Urine made hot, I pour Vinegar, the Acid of Lemons, and Spirit of Nitre, Salt, and Vitriol, and there does not arise the least Effervescence but the Acids mix with the Urine, without making any Noise, or forming any Bubbles, just as Water does with

Water. Nor does it change those Juices of Vegetables green, which all alkaline Salts do.

U S E.

HENCE then I infer, that the human Nature makes such an alteration in Acids, that they continue so no longer, and that it prevents acescent Vegetables from growing actually acid. Whilst a Person, however, continues in Health, he never generates alkaline Salts, but neutral ones. Nay, I have observ'd this to be true even in the Urine of Persons, parch'd up with Heat in inflammatory Distempers, where, from the accelerated circulation of the Fluids, the Urine has been very high coloured, fetid, acrid, and in small quantity; for upon examining their Urine in the manner above-mentioned there has not appear'd the least sign of an Alkali. I was still in doubt, however, whether in a perfect *Iscuria*, after the Urine has been retain'd, heated, and agitated for a considerable time, it might not by this means become truly alkalious. This I had afterwards an opportunity of examining, being sent for to an old Gentleman who fell into this disorder, and made no Water for more than five days. On the sixth, however, to his great joy, he on a sudden discharg'd some ounces of a red, thick Urine, that smelt very strong; but the omen prov'd deceitful, for he never made a drop more till he died. This therefore I immediately carried home, and examined it in a chemical manner, but it did not even then appear alkaline by any Experiment. Hence therefore I learn'd, that Urine detain'd in the human Body for the space of a hundred and twenty hours, was not, by the effect of its Heat and the action of Circulation, yet become alkaline; for this Water was not lodg'd in the Gentleman's Bladder: So that upon the whole it appears very evident, that no Alkali can be generated in any of the sound Humours of a healthy Person, though it may be taken into the Body from without: Nay, that this never happens in the most putrid Distempers, whether acute or chronic. I confess, indeed, in an old Man, who was terribly afflicted with a large Stone in his Bladder, and was not fit to be cut, I observ'd the Water to have a urinous alkaline Smell. And as, from a Stoppage in his Water, he was often forc'd to have his Surgeon remove the Stone with his Catheter from the neck to the bottom of the Bladder, upon which the Urine spontaneously discharg'd itself, it happened once, when he wanted his assistance, that he was out of the way, so that he was forc'd to retain his Water for a good many hours after he had occasion to discharge it; and hence when the Surgeon return'd, upon performing the usual Operation, the Urine that flew out had such an acrid, alkaline, fetid Smell, just as when it is putrified, that the Operator unwarily receiving the Vapour of it into his Lungs, felt the ill effect of it for some days. Hence therefore I am apt to believe, for the Water being spilt upon the Ground I had not an opportunity of examining it chemically; I say, I am hence apt to believe, that the Urine, by being attracted into the Pores of a spongy Stone in the Bladder, and lying there some time, may possibly, by means of the Heat it is expos'd to, acquire a true alkaline Acrimony. But be this as it will, this we are sure of, that there is no natural alkaline Salt in the Urine. Neither is there, therefore, in any of the Humours of the human Body; for the Urine contains more Salt than any other Humour, and the Salts of the Urine are more acrid and alcalescent,

cent, and become sooner truly alcalious than those of any other Fluid in the Body. How much therefore are those Artists mistaken that maintain, that oily, alkaline volatile Salts are natural to the human Nature? This is an error which the chemical Art, cultivated not so cautiously as it shou'd be, has introduced into Physick, and which sound Chemistry alone has corrected. The particular fetid Smell, therefore, of healthy Urine, is owing to an attenuated, putrid, volatile Oil, and not to a volatile, alkaline Salt. And the bitter, disagreeable, salt Taste of it depends upon a compound Salt, and an Oil, and generally some Sea-Salt, which is almost always amongst it.

P R O C E S S X C I I I.

If fresh Urine is distill'd in close Vessels, it yields a fetid nauseous Water, neither alkaline, nor acid, but saline, nor spirituous like that which is drawn from Wine.

A P P A R A T U S.

THE concocted Urine of healthy Persons I distill in a clean glass Cucurbit, with a gentle Fire of 150 degrees, equably continued till there is only one twentieth part left, and there comes off a clear Water. The Urine, in the mean time, from its natural straw-colour, grows gradually reddish, and in proportion, as more of this pellucid Water ascends, it acquires a deeper and deeper Colour, till it at last becomes of a very deep red, nearly black, and is very thick, turbid, opaque, and retains its Froth very tenaciously. The first limpid part distinguishes it self by a singular, disagreeable, nauseous, fetid Smell, but not a volatile, alkaline one. And, which is pretty surprizing, if you repeat the Distillation of it a great many times, yet it always retains this fetid Smell; nay, if it stands expos'd a great while to the open Air, it does not lose it. This fracid Smell, therefore, is intimately imprinted on this Liquor, even in such a manner as not to be destroyed by the admixture of an Acid. Nor does it resemble any thing so much as that strong Smell which issues from the *Abdomen* of a living Person, when it happens to be laid open by a Wound, or that which rises upon opening the Body of a Person that is just destroy'd by some sudden Death. The Taste of this Water is nauseous, disagreeable, putridish, not alkaline, nor saline, in any degree, perform your Distillation in what manner you please. Nor in this Distillation do there appear any Streaks in the Alembic, such as spirituous Liquors discover themselves by. Nay, if you take the Water that comes off first, and distill it again, you will not even then perceive the least indication of any such Spirit. And whenever I have examin'd it, it has by no means supported Flame, but always extinguish'd it, though it has been depurated ever so nicely. Nay, even from the concocted Urine of Persons that have been used to drink freely of generous Malt Liquor, strong Wine, and distill'd Spirits, there can no such Spirits be drawn, which to some perhaps may seem a little surprizing. When I have mixed now this first Liquor that rises from Urine, with any Acids whatever, I never cou'd excite the least Effervescence; nor wou'd it change those vegetable Juices green, which Alkali's will; nor cause any considerable precipitation of Bodies dissolv'd by Acids; nor by rectification

rectification ever yield any visible Salt; nor lastly, ever convert any Acid into a compound neutral Salt: This Liquor, therefore, is not alcalious. And upon examining it by proper Experiments, it does not discover the least appearance of an Acid, as you yourselves are Witnesses, whilst I mix with it fix'd and volatile Alkali's, pour various Juices into it that grow red with Acids, and make the other Trials upon it formerly mention'd. What I asserted therefore appears very evident.

U S E.

FROM this trifling Experiment, as it seems, we may learn a great many beautiful Truths, of very considerable consequence in the Medicinal Art: Some of which give me leave to lay before you. The most light, thin, volatile part, then, of the animal Humours, in a sound state, is a Water, which is nearly elementary, except that there is inseparably combin'd with it somewhat else, which is as light, thin, and volatile, and is fetid likewise, and discovers something putrid, as it were, in it, being produc'd, not from a saline principle, but rather an oily one, and yet being by no means spirituous, fermented, or inflammable. In these Humours, therefore, there is no such physical action as is observ'd in Fermentation, no production of such Spirits as that generates, which are very easily separated from their Water, whereas this fetid part cannot be separated from its Water by any Art whatsoever. There is no volatile inflammable Spirit, therefore, in our Humours. The Oil in the human Body is rendered much more volatile by the vital Powers, than any of its Salt, tho' Persons generally believe the contrary. This particular, fetid, oily principle now discovers itself scarce any where, but in *Sanctorius's* perspirable Matter, Sweat, and the Vapour, which is naturally contain'd in the cavities of the Body. Fermented, vegetable Spirits do not we see pass to the urinary passages? Do they tend upwards, therefore, and disturb the Brain, the *Sensorium Commune*, and the Origin of the Nerves? Do they hence so wonderfully affect the functions of the *Cerebrum* and *Cerebellum*? And is this the reason that they exhale so easily from the surface of the Body? But from what has been said we learn farther, that there is no Salt in the human Body so volatile as to rise with the * Heat of boiling Water, notwithstanding what the Chemists and Physicians think to the contrary. Nor is there any volatile Alkali there, either simple, or oily; nor any thing at all of a volatile Acid. What room therefore is there for correcting the modern medicinal Art upon this head? But again, this fetid Smell of the Urine increases in a healthy Body, as the Strength increases, and goes off again, proportionably, as that decreases. The more Exercise too a Person uses, the stronger does his Urine smell; and the contrary. Upon the whole, then, if there is any thing in the animal Humours that, on account of its acrimony, volatility, lightness, and penetrability, ought to be call'd a Spirit, this is not vinous, or saline, but truly arises from an Oil degenerated into such a putrid State as is described Process 88.

* This does not seem to appear from this Process, for the Heat of boiling Water is about 212 degrees, that made use of here but 150.

P R O C E S S

P R O C E S S X C I V.

The fresh Urine that remains after the preceding Process is neither acid, nor alcalious, but salt, and fetid, nor yet truly saponacious.

A P P A R A T U S.

IF the thick *Residuum* of the preceding Process is mix'd with any kind of Acid, or Alkali, whatever, it does not give the least sign of any effervescence, by which one can infer it to be either acid or alkaline. Nor does this appear to be the case by any other Trial. It is very acrid, indeed, and has a very salt and bitterish kind of Taste, but not an alkaline one: Nor has it an alkaline Smell, but nearly such a fetid one as it had before. If it is used in this condition by the Fullers, or the Persons that clean Wool, it will not scour off the impurities, and consequently, it has not then a lixivious, saponacious Quality, though it acquires so excellent a one by Putrefaction. During all this Inspissation now there is never the least appearance of any thing either milky or wheyey: Nor cou'd I ever, upon the nicest Examination, discover the least sign of any such *Coagulum* as the Lymph of the Lymphatic Vessels, and the *Serum* of the Blood always form, when they are exposed to Heat; nor, lastly, does it ever discover any thing of the Nature of Cheese, treat it in whatever manner you please. But the more it is inspissated by the Heat, the more acrid it constantly grows, and the deeper colour'd. And thus, through various degrees it alters, and increases in Colour, Consistence, and Acrimony, and by this means runs through all the varieties of Urine, which one finds in acute and chronical Diseases, as has been elegantly observ'd by the famous *Bellini*. In acute cases, certainly, the higher the Fever is, and the more it dissipates the Fluids, the redder, more acrid, and thicker is the Urine.

U S E.

TH E R E is naturally therefore no Alkali, either fixed or volatile, in the Humours of a healthy Person; nor is there any fixed or volatile Acid there. But the Salt here is of a singular nature, which we shall hereafter examine, and is much less volatile than Water, not rising even with the Heat that will make that boil. And, which is somewhat surprizing, there is no nutritious Matter ever contained in this Urine; for the Chyle, Milk, Cheese, and *Serum* that will be coagulated with Heat, and which the Physicians, with a great deal of reason, look upon as the only original Matter of Nutrition, are not discover'd here. No Nutriment therefore is carried out of the Body with the Urine. But on the contrary, the most acrid, putrid, subtle Particles, that are unfit for supplying any farther Nourishment, and wou'd injure the Body, having discharg'd their office of Nutrition, and being then separated from the Chyle, Milk, Blood, and Fluids that are hence derived, are at last evacuated by the Kidneys. The Urine, therefore, exhibits to us those Humours, that of all are by far the most changed by the powers of our Nature, and indeed too much to be of any farther advantage to the Body. The deficiency,

ciency, therefore, acrimony, colour, and thickness of the Urine, elegantly point out many things to the Physician, indicate the necessity there is of a supply of Water, discover the condition of the Humours, the state of Diseases, the Remedies that are to be made use of, and what in particular proves fatal to the Body, by breaking too much the *Crafs* of the Blood. How very injurious here is too great a degree of Fluidity!

P R O C E S S XCV.

The same Urine being inspissated to one fortieth part, and then mix'd with Sand, and distill'd, yields an alkaline Spirit, a volatile alkaline Salt, a very fetid Oil, and a saline Caput Mortuum.

A P P A R A T U S.

IF you continue the preceding Distillation of Urine till out of forty Pounds you have but one left, or if you take the same fresh Urine, and in a large, low, cylindrical, open Vessel, evaporate it to one fortieth, and then mix either of these thick, blackish, acrid *Residuums*, with three times as much of the purest Sand, perfectly free from Salt, and distill in a glass Retort, with a Sand Heat, beginning with a gentle degree, and often removing the Receiver to examine the Liquors that come off; then, you will in the first place have a limpid Water, as in the preceding Process. Afterwards, when the Mass begins to grow almost dry, there will be a thin, limpid Liquor come over too, but it will be acrid, igneous, and alkaline: Continue the Operation so long as this ascends, and keep it by itself. Then lute on the Receiver as close as possible, and gradually increasing your Fire, urge the *Residuum*, and there will begin to appear white Clouds, which will continue to rise for a considerable time; after these you will observe some pinguious *Striæ*; then you will have a kind of oily yellowish Liquor, and with it a solid, alkaline, white Salt, a little inclining to the yellow; and lastly, by the extreme torture of the Fire there will rise a yellow or gold-colour'd Oil, which ceasing, you will have some saline terrestrial *Fæces* at the bottom. The first Water now is scarcely alkaline, acrid, or saline, and by no means oily, but like the Water of the preceding Process. The second watery Liquor has an evident, acrid, alkaline Smell; is caustic upon the Tongue, and has a perfect alkaline Taste; causes a pretty violent Effervescence with all Acids; and saturated with a particular Acid, becomes concreted with it into a compound, neutral, semi-volatile Salt, then resembling *Sal-Ammoniac*, but various in its Nature, according to the variety of the Acids it is combin'd with: It is truly alkaline, therefore, but volatile, like that of Process 88. But all these things appear still in a greater degree in the third pinguious Liquor, which is much more strongly alkaline, but at the same time, oily: Hence as it consists of a Water, Salt, and Oil united together, it is call'd an alkaline Spirit. But again, all the Salt is constantly alkaline, but being render'd impure by the very fetid Oil that adheres to it, is very disagreeable. And lastly, the Oil that rises with this afterwards is vastly fetid, contaminates every thing else with its stink, and is perfectly intolerable itself, not only diffusing a urinous, but something like a stercoraceous stench likewise. The *Fæces* then

then that remain at the bottom, being calcin'd with an open Fire and with Water made into a *Lixivium*, will give you a true Sea-Salt, if the Person whose Water you examine uses to eat it.

U S E.

HENCE then it appears, that our urinous Salt is not alkaline, but that it may be render'd so in a certain degree of Heat. It is evident likewise, that the Salt of our Urine is not a *Sal-Ammoniac*; for *Sal-Ammoniac* which is volatile in a certain degree of Heat, by sublimation never becomes alkaline, but always remains compounded, and that, repeat the Operation ever so often; whereas Salt of Urine, which is of a semi-fix'd Nature, when is expos'd to such a Heat as to render it volatile, becomes immediately alkaline, and intirely loses its former character of a compound Salt. It approaches therefore both towards an alkaline, and an ammoniacal Salt, but is in reality neither one nor t'other. But hence we learn farther, that the Salt, saline Spirit, and first Oil, are nearly equally volatile in a sound state. It appears likewise that this pinguious Spirit is truly compounded of three different Principles, *viz.* a Water, Salt, and Oil, into which it may be conveniently resolv'd again. From what has been said too we understand the power of the human Nature, which thus converts the soft, white, inert, inodorous, pinguious part of the Aliment, Chyle, Milk, Fat, and Marrow, into something acrid, yellow, inflaming, thin, and fetid, from which arises that disagreeable smell of the Urine. And lastly, hence we perceive that there is no fixed alkaline Salt in our Humours, as, in the greatest quantity treated in this manner, I never cou'd discover the least grain, but that Sea-Salt may enter into the Blood, be mixed with it, and may be carried off by the urinary passages, without any alteration, and consequently, that it exerts its effects through most of the Vessels of the Body, but is not chang'd by their reaction. These things then being properly consider'd, you'll acknowledge, that this single Experiment is of vast use in Medicine, the honour of which is due to *Van Helmont*.

P R O C E S S XCVI.

Fresh Urine inspissated and distill'd with a fix'd Alkali.

A P P A R A T U S.

INTO fresh Urine, inspissated in the manner describ'd, pour an equal quantity of Oil of Tartar *per Deliquium*, or Pot-Ashes, upon which there will instantly rise an acrid, alkaline, volatile Vapour, just such a one as exhales from putrified Urine when it begins to grow hot. If you immediately then distill this Mixture with a Cucurbit and Alembic, there will come off a limpid Liquor, running down as it were with *Striæ* like Spirits, which will be acrid, very alkaline, more volatile than Water, and in every mark resembling a true strong Alkali. If instead of the Oil *per Deliquium*, you use a very dry Salt of Tartar, you will frequently have a dry alkaline Salt rise the first time from the Urine in Distillation. If the first alkaline Liquor is again distill'd in a tall Cucurbit

with a gentle Fire, the first part that rises is a white alkaline Salt, the Oil remaining at the bottom with the fix'd Alkali, as if it was thence render'd more fix'd. At last, however, after all is grown dry, if you urge the *Residuum* with an intense Fire, there will ascend a fetid yellow Oil, likewise, but after this Salt.

U S E.

FROM this Operation then it appears, that our urinous Salts are of such a nature, that a fix'd alkaline Salt is capable of making such an alteration in them in an instant, as the action of a strong Fire did in the preceding Process. Hence likewise we learn, that fix'd alkaline Salts, being mix'd with our Humours, will immediately render them acrid, alkaline, very active, more volatile than our Water, or our Spirits themselves, and will communicate to them a corroding, caustic Quality, and very soon reduce them to a state of Putrefaction. If the Salt and saline Spirit, produc'd in this manner, are distill'd again some number of times with a gentle Fire, they become as purely alkaline as the Salt and Spirit prepar'd from Hartshorn, and other more valuable Substances. If they are mix'd with Acids, they cause a most violent effervescence, particularly, if they are shaken together; and they are by this means so qualified, that they continue no longer acrid, so alter'd, that they are no more alkaline or caustic, and so fix'd, that they will not fly off with the heat of the human Body; and thus they lose the power of acting proper to volatile Alkali's, that particularly of dissolving our Humours with an almost fatal solution. But in the last place, which most nearly concerns us, hence the Physician may understand the changes of our Salts from their natural disposition, to various others, together with their proper effects under every alteration, and the Remedies that are suited for the correcting every *Species*, and all the degrees of it. This the ancient Physicians from careful Observations were well acquainted with. Hence in Fevers, with a great degree of heat and motion, *Hippocrates* allow'd nothing, either for Food, Drink, or Medicine, but those things that were acescent, or actually acid. And certainly fix'd Alkali's prove destructive to our Bodies, when there is too much heat and motion in 'em, the Urine smells strong, is high-colour'd, and is discharg'd in too small a quantity, and the *Crafsis* of the Blood is broken: Hence in the Plague the use of these Salts is particularly fatal.

P R O C E S S XCVII.

Quick-Lime being mix'd with fresh healthy Urine, especially when it is inspissated, communicates a fiery Spirit to it, not an alkaline one.

A P P A R A T U S.

IF you throw Quick-Lime into very fresh Urine, there instantly exhales a Vapour which affects the Nose with a kind of fiery pungency; and if you then immediately distill it in Vessels accurately clos'd, you have a very limpid Water, of an intolerable fiery smell, like the former, but much more acrid and volatile. But if you first inspissate the Urine to one fortieth part, and with this *Residuum* mix an equal quantity of Quick-Lime, then the smell that rises

rises will be much stronger, and by distillation you will procure a Spirit to which there is no other comparable, whether you consider its igneous acrimony, or its incoercible volatility. If after you have according to Art drawn off all this Spirit, you commit it to distillation again, you will never be able to procure a solid Salt from it, as in the preceding Process, but will constantly find it very liquid. And mix it with what Acid you will, it never causes the least effervescence; though at the same time, by its combination with Acids it loses a great deal both of its fiery quality, and volatility. But let me caution you, that some care is necessary in this Operation; for as soon as ever the Quick-Lime comes to touch either the natural or inspissated Urine, there is instantly excited a prodigious Ebullition and Heat, and at the same time there is produc'd an exceeding acrid Spirit, and the most volatile of all that we know of, which being agitated by the violent Heat, rages furiously, and is put into a most rapid Motion, so that if a Person shou'd unwarily receive it into his Lungs, it might in a moment prove of the most dangerous consequence, by causing a sudden Inflammation in the tender Vessels, and being directly applied to the vital Blood as it passes through the Lungs. For if this Spirit is kept applied to the Skin of a warm Body, which is hard in comparison of those Vessels, it will instantly produce a Gangrene there, fatal to the Part. What then must be the consequence in the Lungs, where the thickness between the pulmonary Blood and the Air in the Vesicles is not, perhaps, the thousandth part of an inch? If this urinous Spirit, however, prepar'd with Quick-Lime, is expos'd to the open Air, it soon loses this acrimonious part, a watery kind of Liquid remaining behind.

U S E.

HENCE we learn the action of Quick-Lime upon the saline and urinous Humours of the human Body; for by means of the vital Motion and Heat of it, it immediately produces such fiery Spirits as have been describ'd, which prove fatal to the tender Pulp of the Brain and Nerves. And the hotter the Body is, or the more it is in motion, or is affected with a more burning Disorder, the more destructive is the use of it. But when, on the other hand, the Body abounds with acid or watery Humours, or a soft pituitous Matter, the prudent administration of it may be attended with more success. But we may observe that a *Lixivium* of Quick-Lime is particularly efficacious in correcting and extricating the more fix'd, muriatic Salts, and disposing them to pass more easily out of the Body. And hence this proves a singular Remedy in that kind of Scurvy, which arises chiefly from these Salts; though in that sort which proceeds from a putrid cause, and consists in an acrid Oil and Salt, it does a great deal of harm. From which consideration, perhaps, one may in some measure account for the very ill success, which some famous *French* Physicians tell us they observed of a *Lixivium* of Lime in *France*, whereas in *Germany* they had seen it have excellent Effects. All these things, now, are in a greater degree true of Lime made of Stones, than of that made of Oyster-shells. From what has been said then, give me leave to deduce the following Corollaries.

1. The violent Corrosion that happens to a human Body from the application of Quick-Lime to it, depends more upon the igneous saline Spirits which the Lime produces from a Salt that was not acrid before, than upon any corrosive Quality of the Lime itself.

F f 2

2. Hence

2. Hence in acid, aqueous, austere, flow, mucous, and pituitous Disorders, where there wants both Motion and a *Stimulus*, it may be of service.
3. But in alcalescent, bilious, saline, hot, acute, and dry ones, and where the *Crafs* of the Blood is broken, and there is some degree of Acrimony, there it does mischief.
4. The soft Salts of the human Body may, by being simply mix'd with a Substance not acrid, in a moment become exceeding acrid, fiery, and poisonous.
5. Something vastly acrid may be generated from a sound Humour, which shall be neither Salt, Spirit, nor Oil; for this Liquor can by no Art that I am acquainted with be brought to appear in the form of a solid Salt, but when it is separated from all its Water, it becomes invisible.
6. These Spirits, which by no Experiments with Acids appear to be alkaline, are much more acrid than any Alkali. Nor is there any other known Spirit that gives out more of a very acrid strong Vapour that stings the Nose. Hence then we see, how very soon, from our Salt which is almost inodorous, a Smell and Taste may be excited of quite a different nature.

P R O C E S S XCVIII.

The Native Salt of Urine.

A P P A R A T U S.

TAKE some very fresh well-concocted Urine of persons in perfect Health, put it presently into a very clean Vessel, and with an equable Heat of 200 degrees, evaporate it till you have reduc'd it to the consistence of fresh Cream, and whilst it continues thus hot strain it through a Bag, that the tenacious Oil may in some measure be retain'd there, and separated from it; and the more accurately this is done, the better. Put a large quantity of this thick inspissated Liquor into a tall cylindrical glass Vessel, with a paper tied over it, and let it stand quiet in a cool place for the space of a Year. By this means, then, you will have a solid, hard, sub-pellucid, brown, saline Mass, fix'd all about the bottom of the Vessel; and over this a thick, black, pinguious Liquid, separated and rejected as it were from the concreted Salt. Decant this Liquor, take out the saline Mass, put it into another Vessel, pour some very cold Water upon it, and shake it about to free it from its oily Impurities, which may be done pretty easily, as it will not readily dissolve in cold Water. Keep this saline Matter under its proper title. If this is dissolved in hot Water, and strained till the *Lixivium* becomes exceeding limpid, and evaporated to a Pellicle in a very clean glass Vessel, then, if you set it by in a cold place, it will shoot into saline Glebes of a particular kind, that are perfectly distinct from every other Salt. In their figure, and solidity, however, they come pretty near to the Crystals of Sugar. These are not fetid, nor alkaline, but very volatile. This is the native Salt of Urine.

U S E.

THE Chemical Art, by the production of this Salt, elegantly teaches us the nature of those Salts, which, in a healthy Body, are the most acrid, and calefcent, though not yet alkaline, and which therefore are now to be expell'd out of the Body by the same vital powers, to which they owe their origin. The Physician, therefore, hence understands, that the Salts that are contained in the other Humours are much less acrid, or alkaline. These Salts are generated by the human Nature from the Meat, Drink, and Sea-Salt taken into the Body. Nay there is a true Sea-Salt here, but not alone. This Salt is saponacious, but not very pinguious. If it is diluted with Water, and drank, it proves a great diuretic; and with a proper Regimen it easily provokes Sweat. Upon Metals it has such a wonderful effect, that some Persons have promis'd themselves strange things from it. The pinguious Matter that remains in the inspissated Urine, after all this Salt is form'd and separated from it, is excellent for making Phosphorus with, and therefore it may be sav'd for that purpose. By this Experiment then we see, that the Salts that reside in this inspissated Urine, do not grow so putrid, or alcalious, as to become volatile, and readily fly off, tho' in other respects they are so easily alter'd. How is this Salt concern'd in the human Calculus?

P R O C E S S XCIX.

Milk, being digested, casts up a Cream, and grows acid.

A P P A R A T U S.

1. I PUT some new Cow's Milk into a large cylindrical Glass, and set it by in a cool place, cover'd only with Paper. In a short time, then, there is a very white, thick, oily, soft Fluid, collected at top, which is neither acid nor alkaline, and is call'd Cream. I take this off carefully, and put it into another clean Vessel. Soon after this, there is a new Cream form'd upon the remaining Milk, but in less quantity than before, which I take off likewise, and add to the former, and proceed in this manner till there is no appearance of any more. What then remains is call'd Skim-milk, and is thin, pretty clear, and bluish. This Cream, of all Balsams, is the most excellent, used, either internally or externally. It is friendly to the human Body, and softens all kinds of Acrimony, and hence in consumptive, nephritic, and gouty cases it yields the greatest relief, and is of excellent service applied to a Wound, or a painful Ulcer. And the Skim-milk too being now freed from its Oil, is an incomparable Medicine in acrid Disorders of fat, and bilious Constitutions. Hence it appears, that there is a great Similarity betwixt Milk and the vegetable Emulsions of Process 21, though there is some difference, arising from the animal Humours the Milk is mix'd with, and the Heat it is expos'd to.

2. If Milk stands quiet in a pure Air, free from fetid and putrid Exhalations, and about 60 or more degrees warm, it begins to grow sour, and afterwards perfectly acid, its Acidity gradually increasing till it rises to a pretty

considerable degree. Then the whole Milk, both the Cream, and the thinner part underneath, are become acid; as the Smell, Taste, Acrimony, and other qualities demonstrate.

3. If you separate the Cream carefully whilst it is fresh, and set it by in the same manner, that grows acid likewise, and pretty much so; and then it supplies us with a Balsam, which, both for internal and external use, is exceeded by none, in hot, putrid, bilious Cases. All these things, now, happen sooner, and rise to a greater degree in hot weather, than cold; in the Milk of an Animal that feeds upon Grass, than of one that lives upon Hay; and in that of one that is exercised but little, than of one that is used to a great deal.

4. If the Milk is taken from an Animal, that is of too hot a temperament, whose Body has been heated with very hard labour, which has liv'd upon animal Foods in particular, or alcalescent Vegetables, with very hot Sauces, and drink not stale, or whose Humours have been roasted, as it were, with a burning Fever, or dissolv'd by a putrid Consumption: I say, if such Milk is treated in the same manner, it grows fetidish, with a kind of urinous Smell, or one like that of Sweat, of a yellowish Colour, thin, and resolved as it were, and is of a salt, disagreeable Taste, not a sweet one: And if it is digested, it does not then grow acid, but acquires an unpleasant Smell like that of rancid Cheese, and inclines to be alcalescent. Hence Children abominate such Milk, and as soon as ever they taste it, cry and leave it, tho' they take it again greedily, when it comes to be good.

U S E.

THIS Experiment, I think, is one of those, which under a simple appearance contain a great many useful things for the information of the Chemist, and service of the Physician, and which are necessary to be known by them both. Hence it appears, that there is a greater quantity of Oil in the Milk than in any other Humour of the human Body, tho' at the same time it more easily recedes from the watery part in this, than in the other Humours: That Milk therefore contains a little Salt, not well work'd together, and united with the Oil, for which reason it differs greatly from a Soap consisting of an Oil and Salt combin'd together; and that Oil, consequently, is very slowly divided and intimately mix'd with the other Humours, which makes it separate so often, and so easily in the Body, and collect itself in the adipose and medullary Cells appointed for its reception, in which, however, it may be dissolved again by Heat and Motion, and so return into the Veins, mix with the acrid saline Particles, and by this means, at last pass out of the Body, in form of a fetid, greasy, yellow Sweat, or a high-coloured, putrid, and very acrid Urine. But here we learn, likewise, that this Oil in vegetable Milk, retains a good while in the Body an acescent disposition, and may sometimes be converted into an Acid; and that all acescent milky Aliments from Animals, or Vegetables, enjoy their proper Nature for some hours there, and operate by it. But if the vital Powers, a great degree of Heat, the absence of an Acid, and a putrid state of the Air act upon this Cream, or Milk, then the Cream losing its acescent Nature, may grow bitter, rancid, and alcalious, as was observed before in Tartar. We must not, therefore, without a great deal of caution, pretend to pronounce concerning

cerning the animal Humours ; for the Milk lodg'd in the Breasts of a Woman in a Fever, may acquire such an acrid rancidity, and produce surprizing disorders as daily Observation sufficiently evinces. And why mayn't the same thing happen to the Milk, whilst it circulates mix'd with the Blood ? The Oil of Milk then may grow acid, bitter, rancid, and at last putrid ; its cheesy part is disposed to become rancid, putrid, very acrid, and alcalescent ; whilst its wheyey part grows acid chiefly, and seldom undergoes any other alteration.

P R O C E S S C.

Urine, by being digested, grows alcalious, and is altered in its Colour, Smell, Taste, and Powers.

A P P A R A T U S.

IF such Urine, as is described in Process 92, stands in an Air 33 degrees warm, in glass, wooden, earthen, or metal open Vessels, it in a little time begins to grow strong, and putrid, to have its Colour changed from a citron to a dark brown, to deposite thick *Fæces*, and thus in a few days to acquire an alkaline, lixivious disposition, and in the mean time to fix an alcalious Crust on the whole surface of the Vessel. And in proportion, as the Heat of the Air increases, the more considerable and speedy is this Alteration, so that in the hottest Summer weather, these *Phænomena* appear most remarkable. In order now to discover how far this mutability would reach, I took some very fresh Urine, fill'd a Bottle with it, cork'd it up, and set it by in this condition in a place of a middle temperature, and after three months I found the Urine was spontaneously chang'd in the manner just mention'd. This alteration now consists principally in the following circumstances. In the first place, the fresh Urine of a healthy Person is of a citron Colour ; the digested is of a deep brown inclining to black, the former changing gradually every day, till by successive degrees, it has acquired this dark one, so that it grows proportionably deeper, as the Urine becomes more putrid. And this the Physicians observe in the Urine in Fevers, and hence from the Colour of it safely conclude concerning the condition of the Humours. But then again, fresh Urine has a disagreeable Smell, but not an alkaline one ; digested, sends forth an evident fetid, volatile, alkaline one, very different from the former. The Taste too of fresh Urine is bitter, and salt ; that of digested, putrid, acrid, alkaline, and perfectly lixivious. Nor does fresh Urine by any mark discover the presence of any Alkali in it ; but digested, as you here see, causes an Ebullition and Effervescence with every Acid that is mix'd with it, and by every quality makes appear a true alkaline Nature. And lastly, fresh Urine has not a deterging saponaceous quality ; but that which is digested and putrified, is used by the Fullers and Dyers as the sharpest Lye they can get to scour their Wool, Silk, and other Bodies ; but this Power belongs properly to fix'd Alkali's. As I have certainly found now, that this happens in a small degree of Heat, and in a close Vessel, and every Body may be satisfied of the same without any trouble, it's idle to deny Urine to have such a disposition, as some Persons versed in the Chemical Art have done.

U S E.

A Watery Fluid then, containing those Salts and Oils which are the nearest to a state of Putrefaction, is separated by the urinary passages, and so discharged out of the Body; for we do not find any other Humour, which is altered so soon, and with such a digestion, nay even in a close Vessel. The Urine therefore which is designed for excretion, purges the Blood from those putrid Particles, which would otherwise prove injurious. If it happens therefore to be retain'd in the Body by any Disease, it brings on fatal consequences, being by the heat of the Body soon render'd more acrid, and hence in a short time growing intolerable to the very fine Vessels, and causing a destructive solution of the Humours. As Urine now acquires these new qualities so easily, so soon, in a moderate degree of Heat, and in a close Vessel, hence we learn, that the human Nature does not generate Vinegars, or inflammable Spirits from the Substances received into the Body, and consequently does not act by Fermentation, but causes the same alterations that Putrefaction does, and therefore in its effect, comes nearest to that. See *Process* 88. For if the sole stagnation of Urine changes it in this manner, how very prone is it to Putrefaction? How necessary, therefore, are Water, Acids, acrescent Substances, and Saline ones, to those Persons who live in hot Climates, or are daily exercised with hard Labour? For by Meats, Drinks, and Sauces, of this kind, too great a disposition to Putrefaction is prevented. Hence too arises a daily necessity of a supply of a soft, acrescent, new Chyle, to sheath and soften the acrimonious Particles produced in the Blood. But it is farther evident, that the beneficial qualities of this new Chyle, do not remain for the space of four and twenty hours, and consequently that a fresh recruit from the same kind of Bodies becomes necessary within that time: In the most burning Fevers, therefore, there is the greatest necessity of acidish, watery, soft Aliments, as like as possible to the Chyle, too great abstinence in these cases being highly prejudicial. Hence Ptisans made of Barley, and mix'd with *Oxymel*, are of such excellent service here, as *Hippocrates* wisely inculcates in that incomparable Book *De Vi&tu Acutorum*. But the Physician, likewise, in examining the Urine of his Patients, may be greatly assisted by these Experiments, as by these he will be able to discover the alterations of the Oil, and the Salt. Hence too he understands that a true Stone may be generated from the Urine of the most healthy Person, only by its standing quiet, even whilst it putrifies, and grows alcalious; and consequently, that neither Attenuation, an Alkali, or Putrefaction, will prevent the breeding of a Stone, since this will be form'd even in putrified Urine, and will not afterwards be dissolved in it. Hence, therefore, as Tartar is generated from the best Wine, so a Stone is produc'd from Urine thoroughly concocted by the vital Powers, without a future resolution. In vain therefore shall we drink volatile alkaline Salts to prevent the Stone. I fill'd once a very clean glass Bottle with the Urine of an healthy Person, and stop't it, and set it by. When the Urine was putrified, I poured it out, in order to distill it, and was shock'd to see how the inside of the Bottle was covered with a stony Crust: Without washing this off, I put in some more fresh Urine, and after it had stood a pretty while, poured it out as before, and when this had been repeated some number of times,

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the internal surface was perfectly incrustated over with a calculous Matter. How pernicious to the human Body is the generation of such a Matter? But still it is necessary. Perhaps some Persons now may be ready to say, why then don't the human Body itself putrify by its vital Heat and Motion, since it renders the soundest Humours putrid in so short a space of time, and dead Bodies, by being exposed in the open Air to a Heat of 80 degrees, dissolve with Putrefaction in a few hours, and becoming volatile are dissipated into the Air, their Bones only being left behind? Why to this the prudent Chemist will answer, that such a Putrefaction, which would otherwise certainly happen, is prevented by the Air, and those sorts of Drink, Food, Sauces, and occasionally Medicines too, that resist such a kind of Corruption; for otherwise, in burning Fevers the whole Frame would soon be dissolved by Putrefaction.

PROCESS CI.

Urine digested and then distill'd, yields alkaline Spirits, a very fetid Oil, a volatile, alkaline, oily Salt, Phosphorus, and Sea-Salt.

APPARATUS.

IF Urine digested according to the preceding Process, is distilled in a glass Cucurbit with a gentle Fire, there first rises a Liquor that discovers itself by *Striæ* running down like those of Spirits. When this is drawn off, and you fix on a fresh Receiver, and make your Fire a little stronger, there follow dewy drops like those of Water, which will continue to be separated till the remaining Matter becomes almost dry. This, however, if it is urg'd with a very great degree of Fire, will give out a yellow, and very fetid Oil, with which there will at the same time rise somewhat of a Salt. There will then remain some black *Fæces*, which by the help of Water may be resolv'd into Sea-Salt, and a fine, fix'd, insipid Earth. The first Water now, is fetid, acrid, igneous, perfectly alkaline, and with Acids causes a most violent Effervescence: If this is exposed to a gentle Fire, in a tall Vessel, it will yield a white, acrid, solid, and perfectly alkaline Salt, and at the bottom there will be left a Water of a very disagreeable Smell and Taste. If the second Water is distill'd for a good while in a tall Vessel, and with a gentle Heat, it will yield somewhat of the former Spirit. When this is accurately drawn off, if you distill the remaining Water in a clean Vessel, you will have a Liquor, which the great *Van Helmont*, in his Treatise *De Lithiasi*, extolls as the noblest Lithontriptic. In this Operation there is no appearance of a fix'd alkaline Salt, but a true Sea-Salt, if the Person whose Urine you thus examine, used it pretty freely. In order now to procure a considerable quantity of this volatile Salt, I have often proceeded in the following manner. I take a hundred Pounds of the Urine of healthy Persons, and putting it into a large, low Vessel that grows wider upwards, boil it till it is inspissated to about the thickness of Honey, taking care that none of the pinguious Matter runs over, and is lost. When I have got a good quantity of this, I pour it into an open cylindrical Glass, and set it in a warm place in a Granary for some months, that this pinguious fetid Matter may grow thoroughly putrid. I then put it into an iron Pot, to which I can lute on very close a large earthen Alembic, and

to the long Beak of this I apply one of the largest Receivers. This being done, I gradually raise a Fire under it, and there ascends an incredible quantity of a white alkaline Salt, and then a yellow Oil which renders the former Salt impure, and with this another Salt somewhat more fixed than the other. I then urge the *Residuum* till the Pot begins to grow red hot, and then comes off an Oil, and the last Salt. The iron Pot being a little cool'd, but the fix'd Matter still remaining very hot, I remove the Receiver, and keep all that is come off stoppt very close in glass Vessels, which may be resolved into a Spirit, Salt, and Oils, as before. If you then mix the *Caput Mortuum* that remains with twice or three times as much Charcoal and put the Compound into small coated earthen Retorts, disposed in such a manner that the Mouths of them shall lie under Water in their Receivers, then if you urge it for the space of sixteen hours with the strongest Fire, it will at last give out some bluish Corpuscles, which fall to the bottom of the Water, and lie collected under it. And if you then set the Receiver upon the Fire, and make it very hot, the Matter of the Phosphorus will not dissolve in the hot Water, but will melt like Wax, and run into one Mass, which will retain its Properties for twenty years, or longer, if it is kept under Water. See *Boyle's Noctiluc. Aer. Act. Lips.* 1683. p. 457. *Homberg. Mem. Math. & Physiq.* 1692. p. 74. to 80. *Nieuwentyd.* p. 520. *Hoffman Dissert. Phys. Chem.* 336. Or if you take part of the fixed Matter that remains in the Pot, and reduce it by an open Fire to a white *Calx*, and then mix it with clean Water, it will communicate a Salt to it, which being separated and collected together, will give you a true Sea-Salt, which has remained such, after having undergone all the digestions of the Body, so long a Putrefaction, and such a violent Distillation. That it is really now true Sea-Salt appears by its Taste, but particularly by this property of it, that if it is mix'd with *Aqua Fortis*, it will dissolve Gold. Nor is there any fixed alkaline Salt at all found here, every thing saline being either volatile, or Sea-Salt.

U S E.

THIS then is the true *Analysis* of Urine after it is putrified. It yields intirely the same things as fresh Urine distill'd does, but with a less degree of Heat, and in a different order. The Putrefaction rendered the Salts more volatile than Water, and from non-alkaline, made them alkaline. The Oils it rendered more acrid, fetid, and volatile. It generated, however, no inflammable Spirits, nothing of a fixed or volatile Acid, nor any thing of a fix'd alkaline Salt. There are two Salts here, however, that differ in degree of volatility, the first of which rises soon and easily, and is separated almost pure, whilst the other comes off later, and with more difficulty, some of it with a great, and some with the greatest degree of Fire, and is mix'd with a good deal of Oil that is not easily separated from it. And indeed, when I have been urging the *Fæces* of Urine, prepared in the manner abovemention'd, with the intensest Fire in the Preparation of Phosphorus, I have been surprized to see how long the Salts wou'd still rise, notwithstanding they had been so long exposed already to the violence of the former Fire. But what a thick, yellow, fetid Salt remain'd here fix'd to the Neck of the Retort? All Acids, then, are by the vital Powers converted into a neutral Salt. But this neutral Salt is chang'd by Putrefaction into a true alkaline one,

one, and by this means acquires the greatest degree of volatility we know of, it being more volatile, not only than Water, but even Alcohol itself. This renders volatile all the Salts both of Animals and Vegetables, but Sea-Salt, *Sal-Gem*, and Fountain-Salt, it is neither able to volatilize, nor turn into an Alkali. Some of the greatest Masters of the Art, indeed, even in our days, have asserted, that an Acid, by an extreme Fire, may be forced out of the *Caput Mortuum* that remains after the Distillation of Urine. And this I have found true, when a considerable quantity of Sea-Salt, that was taken in with the Food, was contained in these *Fæces*; for this, as I mentioned before, remaining unaltered, if it is mixed with a good deal of Earth, will by the torture of the Fire exhale an Acid of Sea-Salt, which has too hastily been look'd upon as an Acid truly prepared from the Animal Humours. Tho' this is my Opinion, I must however allow, that in Phosphorus spontaneously dissolv'd in the Air, there is an Acid not very different from Oil of Vitriol, or burnt Sulphur. *Homburg, Mem. de l'Ac. Roy des Sc.* 1706. p. 340. And hence with Mercury it makes a kind of compound Body. *Id. Mem. de Mathem. & Physic.* 1692. p. 80. But whence now comes this Acid? For my part, I confess I am ignorant. Certainly it is like none, either in the Animal, or Vegetable Kingdom. Was not there Alum used in making the Phosphorus? This is the best way of preparing it, and its Oil is exceeding like that of Vitriol. In the mean time it is certain from other Experiments, that Fowls kept up in a Coop, and living only upon acescent Meat, and Water, upon being burnt together with their Dung in an open Fire, yielded *Fæces* in which there was not the least acid, or fix'd Alkali. If the Spirit of this Process, which is highly saturated with a volatile alkaline Salt, is rectified, it becomes exceeding limpid, but by keeping, grows brown, and gradually deposits something earthy, as it were, on the sides and bottom of the Vessel. Is this that volatile Earth that rises with the first Spirit of putrified Urine, and fixes such a Cloud upon the Glass as can't be wiped off, but which spontaneously dissolves with the following Spirit, which is scarcely saline; concerning which, *Helmont* talks so much in that noble Book *De Lithiasi*? You may think of this and try it: The thing is easy enough, nor is it without its use. Alkali's now, in their Nature, rather tend to generate Stones than otherwise; if this second Spirit, therefore, which is not alkaline dissolves them; then in the Urine there is contained both the Matter they are form'd of, and its Solvent. Sea-Salt, therefore, does not produce Stones in the human Body, but dissolves them rather, and prevents them, as by its saltness it preserves the Humours from growing putrid, and alcalescent. Hence Vinegar, Sea-Salt, and Sulphur, with a *Vinum Picatum*, were looked upon by *Van Helmont*, as the chief anti-pestilential Medicines of *Hippocrates* in that most putrid of all Fevers, the Plague. And for this reason, the Adepts cry out, that in *sale & sole* Nature has placed absolute Perfection. When a Stone is formed, however, from the Urine, it cannot be easily resolved, any more than those stony concretions can, that are generated in the Gout.

P R O C E S S CII.

The Origin of Sal-Ammoniac.

A P P A R A T U S.

THE modern *Sal-Ammoniac* is brought chiefly by the Merchants from *Egypt*. It is almost pellucid in the middle, lying in long parallel *Striae*, being black at bottom, and formed into pretty thick large Cakes that are plain at top, and spherical underneath. It scarcely diffuses any Smell, when you examine the pure middle part of it. It has a taste like Sea-Salt, but much more penetrating. In the open Air, it spontaneously, and soon dissolves into a very limpid salt Brine. A Salt so exceeding like this, I have prepared myself from Soot (*Process* 86. *Apparat.* No. 6. *Use* No. 6.) that it cou'd scarcely be distinguish'd from it. And this they make now-a-days with inspissated Urine, of those Animals to chuse which drink but little, as Camels 10 parts, Sea-Salt 2 parts, and the best wood Soot 1 part. These they mix together, boil in Water, filter, dry, sublime in proper Vessels, and then dissolve again, depurate, and coagulate. *Ol. Worm. Mus.* p. 20. *Cæsius de Fossilibus*. This Salt therefore is produc'd by both these Methods.

U S E.

THE Origin, therefore, of *Sal-Ammoniac*, is pretty surprising. The ancient *Sal-Cyrenæicus*, or *Ammoniæcus*, was produc'd from the Urine of Camels in *Lybia*, where they principally make use of them, which sinking in large quantities into the Sand, was dry'd, and sublimed by the excessive heat of it into a Salt. Some of this sort the famous *Tournefort* gave *Pomet*, which was very different from the common *Sal-Ammoniac* of the Moderns. See *Pomet de Drogues*, and compare what he says with *Pliny*, XXXI. 7. and *Dioscorides*. This now should seem to be purely animal. But there is another sort, said to be produced and gathered in the hot Countries about the burning Mountains, which one would think should be of the sooty kind. *Mem. de l'Ac. Roy. des Sc.* 1705. *Hist.* 83. From Soot I have made it myself. But that compound one, mentioned above, must consist of an animal, vegetable, and fossil Matter compounded together. For Urine spontaneously putrifies into an alkaline Salt, this the Sea-Salt overpowers, fixes, and converts into *Sal-Ammoniac*, and the vegetable Soot supplies the same. This Salt, now, is as surprising in its Properties, as it is in its origin. If it is dissolved in Water, filter'd, and inspissated to a Pellicle, it shoots into Crystals that are exceeding subtil, like Down, and as white as Snow. If these are dried, and are carefully secured from all moisture, upon being mixed with Water they produce a greater degree of Cold, the instant of Solution, than can be excited in any other way we are yet acquainted with. It beautifully preserves all animal Substances from Putrefaction, and its Brine penetrates into the most intimate parts, and is the noblest aperient, attenuant, resolvent, stimulant, errhine, sternutatory, diaphoretic, sudorific, antiseptic, and diuretic.

P R O C E S S

PROCESS CIII.

Sal-Ammoniac is neither acid, nor alkaline.

APPARATUS.

IN this clean Glafs I have some very pure *Sal-Ammoniac*, dissolved in 3 times its weight of Water, filter'd into a very limpid Brine, and then heated to a 100 degrees. Into different Portions of this, now, I pour successively Vinegar, Spirit of Nitre, and Spirit of Sea-Salt, and there does not, as you observe, appear the least sign of any Effervescence, nor does the Liquor grow turbid. In the *Sal-Ammoniac*, therefore, in this respect, there is no Alkali. Upon pouring in Oil of Vitriol, indeed, there does arise some Fume, and some degree of Motion, but this is owing to another Property of it, which will be more conveniently explain'd hereafter, *Process* 106, 107. but more particularly 143; for whilst the Oil of Vitriol lays hold on the latent Alkali of the Salt, it renders the acid Spirit of the Sea-Salt volatile. Upon the same Brine, in another Vessel, I here pour a fix'd Alkali, and there is no Effervescence excited, but there immediately arises from it a very penetrating, volatile, alkaline Smell. This Salt, therefore, is of such a nature, as is mention'd in the Title of this Process.

USE.

IN this, therefore, *Sal-Ammoniac* agrees with the Salt of our Humours, that it causes no Effervescence, either with an Acid, or an Alkali, tho' upon the affusion of a fix'd Alkali, it presently gives out its volatile alkaline part, with a very pungent Smell. Nor does this Salt act in the human Body, or any where else with an Acid, or alkaline Vertue, but with the more penetrating one of common Salt. That this is the case, appears by all its Effects, but by this in particular, that if *Sal-Ammoniac* is mixed either with Spirit of Nitre, or *Aqua Fortis*, it will communicate to it a power of dissolving Gold, or convert it into *Aqua Regia*, which nothing can effect but Fountain-Salt, *Sal-Gem*, and Sea-Salt: In this respect, therefore, it is a semi-volatile Sea-Salt.

PROCESS CIV.

Sal-Ammoniac sublimed into Flowers.

APPARATUS.

TAKE some *Sal-Ammoniac*, reduce it to Powder, dry it, and put a pound of it into a Cucurbit made of *Hessian* Earth, and almost of a cylindrical Figure. Fix on a very large Head, and close the Joints with Clay and Sand work'd together in equal quantities. Place 'em then in a sand Furnace in such a manner, that the Beak of the Alembic may decline a little downwards, that if any Water should come off first, it may run out of the Head into a Bottle applied to the Beak. Let the Cucurbit be covered with Sand, almost to the lowest

lowest Limb of the Head, and let there be raised under it a Heat of 150 degrees, to be continued till all the Moisture is distill'd into the Bottle. Then changing the Bottle gradually increase the Fire till the Alembic begins to be clouded with a very white Snow, and keep it up in that degree, without letting it slacken, for the space of eight or ten hours. Let all grow cold, remove the Sand, and take out the Cucurbit and Alembic very gently, lest the Salt in the Alembic should be shaken out. Lay the Cucurbit in a horizontal position upon a Table, with a Knife take the Lute clean off, wipe off the Sand, Dust, and Lute from the Cucurbit and Alembic, and then whilst they continue in this situation, very gently draw off the Alembic, and it will be full of a fine, light, sublimed, snowy Salt, of which too there will be a good deal upon the upper rim of the Cucurbit. All this Salt being removed, and put into a very dry, clean, hot Glass, with a wide Mouth, you will find about the upper part of the Cucurbit, a white, thick, dense, compact Crust of the same Salt, but which did not ascend into the cavity of the Head, but stopp'd and fix'd here. Take this off with the sharp Edge of a Knife, and put it into a Bottle as before. Then very gently turn the Cucurbit upside down over a clean Paper, and there will fall out a pretty deal of the first white Flowers, which dropped off in moving the Vessels, and which if they are perfectly pure, may be added to the former. At the bottom of the Cucurbit, there will then appear a few black, saline *Fæces*, which may be shook out, but are of no great use, yielding only a bitter, black, fæculent Matter. When the first part is pure by itself, it is called the true Flowers of *Sal-Ammoniac*, the *Aquila alba Philosophorum*, and the *Aquila Ganymedem in cælum Jovis rapiens in sublime*. The other Salt which was at the upper part of the Cucurbit, goes by the name of sublim'd, or rectified *Sal-Ammoniac*. If the Flowers, or sublim'd Salt, are dissolved in Water, they excite Cold, as I took notice before of the Salt itself. If you dissolve them, heat the Solution, and mix Acids with it, there is no Effervescence produced, except upon pouring in Oil of Vitriol, as I observed concerning the Salt in the preceding Process. Nor does it cause any Effervescence with a fixed Alkali, but immediately gives out such a Vapour, as is there described likewise. If you repeat this Sublimation of *Sal-Ammoniac*, it gradually rises with more and more difficulty, till it at last becomes almost fixed, tho' it still retains its former qualities.

U S E.

HERE then you have a Salt of the nature of Sea-Salt, but semi-volatile, for it is not so volatile as to rise with the heat of boiling Water, nor yet so fixed as Sea-Salt. When it is thus putified, it loses that clearness which I observed appeared in some measure in the common *Sal-Ammoniac*. By Sublimation it does not acquire an alkaline quality, in which particular it differs from Salt of Urine; but it remains just as it was, only of a more beautiful Colour. It has this wonderful property now, that whilst it thus rises dry in a close Vessel, it carries up with it almost all fossil, vegetable, and animal Substances, and by this Sublimation surprisingly attenuates them. Hence it comes to be called the *Pistillum Chemicorum*, as the same attenuation can scarcely be accomplished by any other means. And if these are sublimed with *Sal-Ammoniac*, a considerable number of times, they at last become fixed with it, and thus often give rise to

to the most beautiful Medicines, as *Paracelsus* found in Colcothar, rendered very pure by Water, and then rubb'd with Sulphur and sublimed with this Salt.

P R O C E S S C V.

Sal-Ammoniac, with Quick-lime, yields a fiery Spirit like that of Process 97.

A P P A R A T U S.

TAKE some very dry Flowers of *Sal-Ammoniac*, put 'em into a clean, hot, glass Cucurbit, and pour upon them an equal quantity of Lime reduced to Powder as expeditiously as possible, in a dry, hot, iron Mortar, taking care that the Flowers are well cover'd with the Lime. At the same time have by you a clean dry Alembic, properly fitted for this purpose, so that the fine exhaling Corpuscles may be immediately confined: For the very moment that these two Bodies come to touch one another, tho' they were at rest, and inodorous before, there instantly rises a Vapour from them, than which perhaps there is not a more acrid, or violent one in nature; certainly, in both these qualities, it is superior to that excited from Urine in the same manner, Process 97. Fixing on the Alembic then, and luting it close, distill this Mixture with a gentle sand Heat into a Bottle applied to the Beak of the Alembic, and you will by this means have a very small quantity of a Liquor which is the most volatile, and most acrid of any we know of, but which nevertheless, is not alkaline. If you then increase your Fire to a considerable degree, the *Sal-Ammoniac* will not be sublim'd, but by means of the Lime the whole Mixture will become fix'd; nay, if it is then put into a Crucible, and urg'd with the strongest Fire, it will not leave the Vessel, and become volatile: But when it comes to be cold, if it is broke in the dark whilst it continues dry, it will throw out a Light from it like Phosporus. *Du Hamel, Hist. de l'Ac. Roy. des Sc. p. 305, 306, 307, 308.*

2. Or take some Quick-lime, put it into a large glass Cucurbit made a little warm, pour upon it a Brine, made with one third as much *Sal-Ammoniac* dissolved in three times its weight of Water, fix on an Alembic immediately, lute it on as expeditiously as possible with a thick Lute made of Linseed-flower, and apply a very large Receiver to be luted with the same, and there will be soon excited a Heat, and most violent Ebullition, by which means there will be diffused an incoercible Spirit, which wou'd burst the Vessels unless the Lute yielded to it a little, and gave way; for the *Impetus* of it is so great, that it blows, as it were, like a Wind through the Lute, and disperses a Smell all around, and at the same time a Liquor distills into the Receiver, and in a very short time is collected there in great quantity. After this spontaneous Heat of the Mixture is abated, let the Vessels be luted closer, raise a little Fire under them, and gradually distill to a dryness. Let the Spirit then thus produced be stopp'd up very close in a Bottle, and kept under its proper Title.

3. In the bottom there will remain a new and surprizing kind of Body, which being dried with a strong Fire, appears almost of a glassy Nature, but gradually puffs up in the Air, tho' it does not dissolve like *Sal-Ammoniac*, but is

resolv'd

resolv'd into sandy Grains, as has been taken notice of by one of the greatest Masters of the Chemical Art. See *Du Hamel*, in the place just cited, p. 408.

U S E.

HERE then you have a farther agreement betwixt the proper Salt of the human Body, and *Sal-Ammoniac*; and here you see a Liquor produc'd from dry Bodies, and from inodorous ones too, that affects the Organs of Smelling more than any thing else. In this Operation too, you observe the generation of Spirits, which are vastly, nay spontaneously as it were, active, in the greatest degree of Cold; and here you have a Spirit not alkaline, but vastly acrid, nay which in its Acrimony comes very near to Fire. It must be confess'd however, that if this Spirit, as it exhales through the Air, meets with a volatile Spirit of Nitre, it will with that produce white Fumes. This Process, again, furnishes you with a new *Species* of Phosphorus, and here you see a fixation in some measure of *Sal-Ammoniac*.

P R O C E S S C V I.

Sal-Ammoniac, distill'd with a fix'd Alkali, yields alkaline Spirits, and a volatile alkaline Salt.

A P P A R A T U S.

1. **T**AKE of the driest Flowers of *Sal-Ammoniac* 10 ounces, put 'em into a glass Retort, and pour upon them of the purest dry Salt of Tartar, reduc'd to a fine Powder, 3 ounces: Shake 'em well, that they may be thoroughly mix'd together, upon which there will rise a very acrid, alkaline Vapour, for which reason you must immediately apply a large clean Receiver. Place the Retort in a Sand-Furnace, and gradually raise the Fire to the greatest degree, and there will be sublimed a very white, pure, simple, volatile, alkaline Salt, which being impatient of rest, will fly off immediately if it is exposed to the Air, and will make its way out of a Bottle through almost every thing it is stop'd with except Glass. With all Acids, it causes a most violent Effervescence, and becomes combined with them into a neutral Salt of a particular kind, according to the nature and origin of the Acid. This Salt, on account of its prodigious fugacity, can scarcely be manag'd or restrain'd; nor is it easy to take it out of the Receiver in a solid form. At the bottom of the Retort there will remain a fix'd Salt, which cannot be sublim'd with the greatest degree of Fire.

2. Or to 10 ounces of the Flowers, add 3 ounces of Salt of Tartar, and then pouring on 9 ounces of Water, shake 'em about, and distill immediately through various degrees of Heat, into a Receiver accurately luted on to the Retort. There will presently then ascend a fine moist Vapour, which will be quickly congealed on the concave surface of the Receiver into a solid Salt, and will proceed in this manner every moment. When the principal part of the Salt is thus come over, it will then begin to be dissolved by a Liquor less volatile, and more watery than the former Salt. Then remove the Receiver, and applying another, urge the remaining Salt with a stronger Fire, till it becomes

comes quite dry. This being done, take the Liquor, and put it into the former Receiver, and shake it well about till the Salt is attenuated, and almost dissolved, and then put 'em into a clean glass Vial, which stop very close with a glass Stopple. By this means then you will have a Salt at bottom, and a Liquor at top, which is a very saturated, true, volatile, alkaline Spirit. But here, if there happens to remain no solid alkaline Salt at bottom, it is a sign that the Spirit is not so strong, but is watery, and hence in a great many Experiments it will not answer. At the bottom of the Retort there will be left a fix'd Salt, exceeding like the fix'd one in the preceding Process.

U S E.

THE *Sal-Ammoniac*, as soon as ever it comes in contact with the fixed Alkali in this Operation, is, from the disposition of its own Nature, and the assistance of the Fire, divided into two parts, which are perfectly distinct, though both of 'em saline, one of which constitutes a very acrid, alkaline, igneous, volatile Salt, which is the purest that can be prepar'd by Art, and at the same time the most simple, and hence is settled as the standard of volatile Alkali's, to which all that are a-kin may be reduced, whilst all that differ from it are distinguish'd by some other Title. The true volatile alkaline Spirit of *Sal-Ammoniac* therefore is a Water containing in it as much of the purest alkaline Salt as it is capable of dissolving. To this too, as their Head, may be referr'd all other volatile alkaline Spirits. No other volatile alkaline Salts or Spirits however are ever so pure and simple as these are, being always render'd impure by an Oil, on which account they act in a very different manner. But in this property again, *Sal-Ammoniac* agrees with the Salt of Urine of *Process* 96; for that Salt and Spirit cause a sudden and violent effervescence with all Acids. If a Vessel, in which there is contained this Salt or Spirit, is left open, and there is another set by it full of strong acid Spirit of Nitre, there is presently excited in the Air a pretty considerable effervescence, arising from the concurrence of the volatile Alkali, and Acid, as they exhale from the Vessels. If this Salt is applied to the Skin, and so covered with a Pitch-Plaister that it can't fly off, as soon as ever it comes to be heated, it causes an intolerable pain, and produces the highest inflammation, with a black Gangrene in the part, so that no poison acts with more violence. Do those Physicians therefore behave altogether prudently, who order this Salt or Spirit to be smell'd to very freely, by which means they become applied to the olfactory Nerves, the *Membrana Pituitaria* of the Nose, and the exceeding tender Vesicles of the Lungs? Certainly a topical inflammation and corrosion seem in such cases much to be feared. Both this Salt, now, and Spirit become still more acrid and fiery, if they are sublim'd again from a fresh, pure, dry Alkali.

P R O C E S S CVII.

An Examination of the fix'd Salt that remains in the preceding Process.

A P P A R A T U S.

UPON the Salt, remaining at the bottom of the Retort in the preceding Process, pour as much very clean hot Rain-water as is sufficient to dissolve it intirely, and then filter the Liquor till it becomes exceeding limpid. Inspissate this, and reduce it to Crystals, till you have almost consum'd the whole in this manner. By this means then you will have a Salt, which, by its Taste, cubical Crystals, and dissolving Power, almost resembles Sea-Salt. Put this into a Crucible, cover it with a Tile, and let it decrepitate and calcine for some time, and then dissolve and coagulate, and you will have a very pure Salt. This being taken in intermittents to the quantity of a drachm, about 2 hours before the Fit is expected, often prevents the return, if the Body is well warm'd at the same time. Hence it has obtained the name of the *Sal Febrifugus Sylvianus*.

U S E.

THIS then is the other fix'd saline part of the preceding Process, arising from the mixture of a fixed Alkali with *Sal-Ammoniac* exposed to the action of the Fire. This Salt now is neither alkaline nor acid, but a compound neutral one, nor yet is it an ammoniacal, but a fixed one. In order then to account for this, we must consider, that the *Sal-Ammoniac* was produc'd from a volatile Alkali of Urine, a volatile vegetable one of Soot, and an acescent, or acid Sea-Salt. The fix'd Alkali, then, which is a most powerful attractant of an Acid, attracts into it the Acid of the Sea-Salt, and separates it from the volatile animal Alkali, or that of the Soot. Hence the Acid of the Sea-Salt being combin'd with the fix'd Alkali, returns again into a fix'd Sea-Salt; and the volatile Alkali of the *Sal-Ammoniac* being freed at the same time from its fixing Salt, becomes perfectly volatile, and being collected together, appears in form of a pure Alkali: And this again being saturated with an acid Spirit of Sea-Salt, produces a regenerated *Sal-Ammoniac*, as will be demonstrated *Process 147*.

P R O C E S S CVIII.

The best volatile alkaline Salt, or the purest alkaline Spirit, and the best Spirit of Vinegar, produce a salt Spirit.

A P P A R A T U S.

UPON the purest alkaline Salt, or Spirit, put into a clean large glass Vessel, pour a little of the strongest purest Spirit of Vinegar, shake 'em, and mix 'em well together, and proceed in this manner, 'till it will cause no farther effervescence.

vescence. Heat the Mixture, and add a little more Salt or Spirit, and if there is then no appearance of an ebullition, it is a sign that the saturation is complete. By this means, if you proceed in a proper manner, you will have a salt Liquor, compounded of a volatile Alkali and Acid, which will not be easily reduc'd to a solid Salt, and is a most penetrating Medicine.

U S E.

THIS Liquor is not only the most penetrating of any that are used in the human Body, but it exercises its Office without any corrosion, and by its saline, antiseptic quality, admirably resists the Putrefaction of the Humours. And hence perhaps, as an aperient, attenuant, diaphoretic, diuretic, and sudorific, it is scarcely exceeded by any. Externally applied, by way of Fomentation, it proves an excellent discutient and resolvent. But above all, it is remarkably useful in Diseases of the Eyes, when there is any thing opaque, either in the *Cornea* or aqueous Humour, if it is properly applied by way of Fomentation. Of all compound neutral Salts, now, perhaps this is the most subtil, which, without any great impropriety, may be call'd an ammoniacal one.

P R O C E S S C I X.

The White of a new-laid Egg is neither acid nor alkaline, nor contains any fermented Spirits.

A P P A R A T U S.

SOME Whites of new-laid Eggs, well clear'd from their Shells, Membranes, and Yolks, I have here in these clean glass Vessels. Into every one of these I pour different Acids, and shake and mix them together, and yet there does not in any of them appear the least sign of an effervescence: These therefore for a while I set by. In these other two Vessels I have two portions of the same Whites, with one of which I now intimately mix a fix'd Alkali, with the other, a volatile one; and you see they continue perfectly at rest, without discovering any sign of Ebullition. But please to attend carefully now to the following Experiment, which is pretty surprizing. In this tall cylindrical Vessel there is half an ounce of the Whites, and 2 drachms of Spirit of Nitre; in this other, half an ounce of the Whites likewise, and 4 drachms and a half of Oil of Tartar *per Deliquium*; both of them heated to 92 degrees. The Whites now with the Alkali, I throw at once into those with the Acid, and you see what a furious Ebullition is excited, and how prodigiously they rarefy, so as to run out of the Vessel though it is ten times as big as wou'd contain them, their Colour, in the mean time, being scarcely alter'd. But now the Effervescence is over, how soon do they contract themselves again into the same space they took up before? But again, if the fresh Whites of Eggs are put into a Cucurbit, and distill'd with a heat of 100 degrees, an insipid Water comes off, which contains nothing at all of Spirits. And lastly, if these Whites are applied to the Eye, or the bare Nerves, they don't excite the least degree of Pain; held to the Nose, they scarcely affect the Smell; applied to the Tongue, they taste as insipid, and

inert as any thing can do; and to the touch they feel viscid, and mucous, by no means with any indication of penetrability.

U S E.

HENCE therefore it is evident, that in the fresh White of an Egg, there is contained neither an Alkali, nor an acid, nor yet these two combin'd together: But it is a thick, viscid Liquid, quite inert, and perfectly insipid. It has appear'd however by observation, that from this truly animal Liquid, within the space of one and twenty days, and in a heat of 93 degrees, a Chicken has grown under the Hen from a Corpuscle, scarce weighing the hundredth part of a grain, to the perfect Body of an Animal that weigh'd more than an ounce. Here therefore we see a Liquid, distinct from every other, out of which, by proper causes, may be produc'd Fibres, Membranes, Vessels, *Viscera*, Muscles, Bones, Cartilages, all the parts, both tendinous, and ligamentous, the Beak, Claws, and Feathers, and all the Humours too contain'd in all these parts. And yet in this Liquid we find a softness and inactivity, without the least appearance of any thing acid, alkaline, or spirituous, or any disposition to an Effervescence. Nay if there shou'd happen any Effervescence there, the Egg certainly wou'd presently burst asunder. The whole substance therefore consists of such a Matter as has been describ'd, and demonstrates to us, from how tenacious and inactive a Mass may be form'd all the parts of the Chicken, both solid and fluid. And yet this very substance, by a somewhat greater degree of heat, is render'd absolutely unfit for the production of a Chicken, it scarcely bearing 100 degrees to any good purpose, whilst at the same time a little less proves equally prejudicial, fewer than 80 degrees not being sufficient. By a Heat however, about the middle, betwixt 80 degrees and 100, there is such a wonderful attenuation of this tenacious, viscid Matter, that the greatest part of it will exhale through the two Membranes, and the Shell, hardly any thing remaining but the Yolk, Treads, and *Sacculus Colliquamenti*; for the Yolk which is the *Placenta* of the Chicken is not consum'd in its nourishment. In the mean time, however, the ingenious *Malpighi* has demonstrated, that this White is not a Liquid every where equally fluid, as the *Serum* of the Blood is which circulates through the vital Vessels, but that this is a compound fabrick, consisting of a great many membranous Bags that are distinct and fill'd with their proper Liquor, almost in the same manner as we see in the vitreous Humour of the Eye. And hence seem to arise those Waves, as it were, concentric to the *Sacculus Colliquamenti*, by which the nutritious Juice being gradually attenuated, is at last strain'd into the *Amnion* of the Chicken.

P R O C E S S CX.

The fresh White of an Egg, with the Heat of boiling Water, hardens into a solid Mass.

A P P A R A T U S.

- I. IF an Egg is expos'd to a continual Heat of 80 degrees, the White soon loses its tenacity and thickness, and becomes so subtil as to perspire thro'

the

the great end, where the Membranes being separated from the Shell, are depress'd towards the Yolk from a large cavity. The other part of the White at the same time will be dissolved, grow thin, and ichorous, nor will afterwards harden with the Heat of boiling Water, but becomes fetid, putrid, and very acrid, and destroys the vital *Stamina* of the Chicken.

2. The fresh White of an Egg, being thrown into Water 160 degrees hot, loses its pellucidity, grows white and opaque, and becomes concreted into one thick, scissile Mass. Or if into Water boiling in a glass Urinal, you drop a little White, it will be coagulated in a surprizing manner, even during the motion of the boiling Fluid, though it is driven about by it on every side. Or lastly, if you put a whole Egg into Water as hot, it will be harden'd in the same manner. Hence therefore it appears, that this coagulation does not arise from any loss of the Liquid of the White, dissipated by this Heat, but from the true action of the Fire applied in such a degree; for it happens in the middle of the Water. Nay if you put the White into a good deal of cold Water, it will harden, and separate itself from the Water, when it is towards boiling.

3. If an Egg is boil'd till it is very hard, and you then accurately separate the White from the Membranes, Treads, Yolk, and *Sacculus Colliquamenti*, and lay it in a glaz'd Bason, it begins gradually to sweat, as it were, and be resolv'd into a subtil Liquid, which appears of a watery nature, but is a most penetrating solvent, insinuating itself into the Body of Myrrh and other Substances that are dissolved with difficulty, and effecting a most beautiful solution.

U S E.

BY this Experiment then we learn how that Matter is dispos'd with regard to Heat, out of which all the animal parts without exception may be form'd in a short space of time. We see here that a certain degree of Heat dissolves it, that a greater coagulates it, and that a less again resolves it, when it is coagulated. All these things therefore are owing to determin'd degrees of Heat, without a proper regard to which nothing can be asserted that will always here hold true. Nay and it will appear still farther in *Process* 112, that a Heat exceeding 224 degrees will attenuate and dissolve the *Coagulum* caused by 212. Hence therefore let us be warn'd to pronounce more cautiously concerning the dissolving or coagulating power of Fire with regard to plastic, nutritious Humours, or what degrees of Heat will attenuate, putrefy, inspissate, or resolve them into their parts.

P R O C E S S CXI.

An Examination of the White of an Egg with Alcohol.

A P P A R A T U S.

IN this clear glass Vessel I have the White of an Egg, upon which I pour some of the purest Alcohol of Wine in such a manner that it runs very gently down the sides upon the White; and this I do very carefully for this reason, that you may evidently perceive that every part of the surface becomes coagulated

coagulated, as the Alcohol comes at it, whilst the lower part still continues liquid, and pellucid. As I shake them now gently together, the *Coagulum* still spreads with the Alcohol, and now I have, by shaking them thoroughly, mix'd them well together, the white you observe is intirely coagulated. If the Alcohol is heated before you make the Experiment, the coagulation is effected in a greater degree, as it is, too, the swifter you endeavour to mix them together; for the Heat and Motion here increase the *Coagulum*.

U S E.

HENCE again it appears, that the purest vegetable Spirits coagulate that plastic matter that is the *Basis* of nutrition; and certainly in that instant of time it becomes absolutely unfit to perform its office. This admixture, however, of Alcohol preserves the white from Putrefaction. How much then does the plastic Matter of Animals tend towards Coagulation? What unexpected Powers does the too great depuration of some Bodies produce in 'em? Wine will suffer itself to be mix'd with this White; the Alcohol produced from it becomes coagulated with the coagulated White; and yet Alcohol diluted with a pretty deal of Water will not coagulate it.

P R O C E S S CXII.

The fresh Whites of Eggs resolv'd by Distillation.

A P P A R A T U S.

I Boil'd some new-laid Eggs in clean Water till they were hard, and then nicely separated the Whites, and chopp'd 'em to pieces as clean as possible. These then I now throw into a clean glass Cucurbit, and fitting on an Alembic apply a Receiver. The whole Cucurbit I place, according to Art, in a Bath of Water, and urge it by successive degrees, till the Water in the Bath keeps constantly boiling. By this means then there does not appear any Streaks like those of Spirits, but there comes off a simple Water, discovering itself in dewy Drops, and that in such an incredible quantity, as to rise to $\frac{2}{10}$ ths of the whole weight. I patiently continue this Distillation with the heat of boiling Water, till not a drop more of this Liquor will rise. This Water then, upon examination, discovers no sign of any Oil, Salt, or Spirits in it. It is very pellucid, and insipid, except that towards the latter end it tastes a little bitterish, and is almost inodorous, an Oil only at last smelling a little empyreumatical. Nor does there appear the least sign you see of any Alkali, though I examine it by proper Experiments; nor by any Trial does it discover an Acid. I have here some pounds of this Water. In the bottom of the Cucurbit, now, pray observe what a small matter there is remaining. The pieces you see from their former magnitude are contracted into a very small Bulk, and they are of a golden Colour, especially in those parts which were in contact with the Glass, but yet they are pellucid, like stain'd Glass. As I take 'em out of the Glass now I find 'em very light, hard, and perfectly brittle so that they snap, and fly to pieces, having a slight empyreumatical Smell, and a bitterish Taste, occasion'd by the Fire, but
being

being by no means either alkaline, or acid. This is the first *Analysis* of them.

2. With these pieces that are left I fill a glass Retort one third full, apply a large Receiver, place the Retort in a Sand Furnace, carefully lute the Joint, and then distill with successive degrees of Fire to the very greatest, call'd a suppressing one. By this means then there rises a pinguious, oily Spirit, which runs down in Streaks; and at the same time a volatile Salt fixes itself to the sides of the Receiver, pretty considerable in quantity, with regard to the dried Fragments, but little in comparison of the whole Whites before the Water was drawn off. Last of all, besides a light, gold-colour'd Oil, mix'd with the former parts, there comes over a black, thick, pitchy one. And when this last Oil is forc'd out by the extreme torture of the Fire, then the Earth at the bottom of the Retort, still intimately united with its ultimate, exceeding tenacious Oil, rarefies, puffs up, and rises to the neck of the Retort, nay, if it happens to be fill'd too full, enters into the Neck, and choaks it up, and hence has sometimes caus'd the Vessels to burst in a very dangerous manner. Continue the operation till nothing more comes off. The first oily, pinguious Spirit, then, is strongly alkaline, in every character, as you see here, upon being mix'd with an Acid, it causes a very violent effervescence. By rectification it is resolved into a volatile alkaline Salt, an Oil, and a pretty inert, fetid Water. The Salt that adheres to the sides, is perfectly alkaline, very acrid, fiery, oily, and volatile; and the last Oil is acrid, caustic, and remarkably fetid. The Earth that remains at the bottom of the Retort is exceeding black, shining, light, rare, and brittle, and has a fetid Smell from the empyreumatical Oil that is united with it, and a bitter Taste from the same. If this is burnt in an open Fire it produces a little fix'd, white, insipid, inodorous Earth, from which there can scarcely be procured any Salt, it yielding only an exceeding subtle Powder.

U S E.

HENCE then it appears, that the white of an Egg contains a very great proportion of Water, but that it has nothing at all of an Alkali in it, that will rise even with 212 degrees of Heat. That matter, therefore, which by a greater degree of Heat is converted into a volatile Alkali, is not by this considerable one disposed either to be alkaline or volatile. Hence therefore I infer, that there is no volatile Salt naturally contain'd in it; for in Chemistry we call that a volatile Salt that is more so than Water, and is carried up with a much less degree of Fire. Nor do we discover any Spirit here that rises with this Heat of boiling Water; nor any Oil that suffers itself to be separated by the same; nay, nor is even the *Residuum*, after the watery part is drawn off, so alter'd by this Action of the Fire as to give any indication of its containing any Salt, and hence, the more liquid part being expell'd, it spontaneously acquires the appearance of a brittle Glass. By this experiment, therefore, we learn, that a volatile Salt may be produced from the White of an Egg, but does not naturally exist in it in that form; for after that this Salt is become volatile by its proper degree of Fire, and is separated from the other parts, it will then rise with 60 degrees of Heat, though it was not to be raised before by 300: That volatility therefore is not natural to the Salt of the White, but is communicated

municated to it by the Fire; which is true of its alkaline quality likewise. And lastly, hence too we discover, the tenacious adhesion of the Oil to the more fixed parts of the White, whilst the Water is separated from them very easily; and see here again, that an animal Coal will never part with all its Oil in a close Vessel, this adhering so obstinately to the terrestrial Elements, that no Fire, except in the open Air, can destroy the union. These then, Gentlemen, are the notions we ought to form concerning this Matter of the White of an Egg, from which all the parts of the Animal are afterwards produc'd. But how different are these from what are generally laid down concerning the chemical Principles extracted from the Matter of Animals! What idea now we shou'd form of the saline part, that is pre-existent in the White, before the Fire is applied to it, I confess I am at a loss, as it discovers itself by no mark to any of the Senses. This indeed we are certain of, that from the exceeding inert and insipid *Mucus* of the White, may presently be produc'd, by the sole action of the Fire, the most acrid, igneous, caustic Bodies, as well saline and alkaline, as oily; but then from compounding these together again, you never will make 'em recover their former nature, or softness. The natural Heat, therefore, without a progressive Putrefaction, does not generate an Alkali in the Body.

P R O C E S S CXIII.

The fresh white of an Egg will putrify.

A P P A R A T U S.

IF good Eggs, or their Whites, are kept in a Heat of 70 degrees, or more, they begin in a few days to be attenuated, grow fetid, dissolve, and putrify, and at the same time, if the Eggs are whole, they begin to grow empty about the large end, and if they are then boil'd, will not harden, but retain their Liquid form. And this change happens much sooner in those Eggs that are impregnated, than in those that are not; for in these last, the greatest part of the putrid Moisture exhales, so that at last the whole Shell almost is fill'd only with Wind or Air. If you continue to keep the Eggs or Whites in the same degree of Heat, at last all the parts grow surprizingly putrid, and alcalious, cause an effervescence with Acids, and in distillation, the first part that rises from 'em is an alkaline Spirit, and an alkaline Salt, exactly in the same manner as we observed in putrified Urine, *Process* 100. If the White is suffered to putrify in the open Air, it becomes almost totally volatile, exhaling in proportion as the putrefaction advances, and at last leaving nothing behind but a few Skins, all the rest being dissipated into the Air. In these Experiments there is never generated the least Acid.

U S E.

IF a little quantity of Egg, putrified to such a degree as to become of an alkaline Nature, is taken into the human Body, it produces very surprizing effects there, exciting a *Nausea*, *Horror*, Vomiting, vast Uneasiness, a *Diarrhœa*, and Gripings, firing the Bile, and causing Heat, Thirst, and a Fever. Nay, only

only by its putrid exhalation it brings on a *Horror*, *Nausea*, and Giddiness, and wonderfully dissolves our Humours like a pestilential Poison. This therefore we know to be the nature of that Matter, which is in the next state to being chang'd into all the parts of an animal Body. Only Rest, now, and such a degree of Heat as has been describ'd produce all these qualities in that Matter. Hence therefore we learn its spontaneous alteration and corruption. But again, than which nothing is more surprizing, if an impregnated Egg is cherish'd in a proper Stove, with a Heat of 92 degrees, the parts that are attenuated and alter'd by this Heat, it spends for the space of 21 days in nourishing, increasing, and perfecting a Chicken, in which however there does not appear any thing alcalious, fetid, or putrid. Here then the Physician may observe some very wonderful *Phænomena*; for by Rest, and such a degree of Heat as was first mention'd, a thick Matter becomes thin, a tenacious one grows liquid, an inodorous one, fetid, an insipid one, of a fracid, very acrid, abominable Taste, an exceeding soft one, caustic, a non-alcalious one, alkaline, and a very sweet, latent Oil, vastly putrid. Compare these Observations now with what *Malpighi* has wrote *de ovo incubato*, and you will find some things in this Affair that are quite astonishing. These Experiments now I have made in particular upon the Whites of Eggs, the other parts where it cou'd be done being separated from them, because the white alone is that Matter which supplies the embryo with Nourishment, all the other parts assisting only to the alteration of the white, that when it is chang'd in a proper manner, it may be applied to the *carina* of the Chicken that is to be brought to perfection by it.

P R O C E S S CXIV.

The fresh Serum of human Blood is not acid, nor alcalious.

A P P A R A T U S.

1. **I**F the Blood, drawn with a free stream from a Person in health, and fasting, is suffered to stand quiet in a clean Vessel, it spontaneously, and in a short time separates into two parts, *viz.* a concreted solid Cake, and a liquid, yellowish, thin *Serum*, which if the Mass is let alone, is continually increased by it. This last part I have separated as accurately as possible from all the red, and have disposed it into these Vessels before you. Into one portion of it then I pour some of the strongest Vinegar; into another, Spirit of Salt; into a third, Spirit of Nitre; and into a fourth, Oil of Vitriol; and you observe that neither of the Mixtures discovers the least sign of any effervescence.

2. In these two other Vessels I have some of the same *Serum* likewise, with one portion of which I mix a fixed, and with the other a volatile Alkali, and you see they are perfectly at rest, without any conflict, or appearance of ebullition.

3. But I now pour some of the same *Serum* mix'd with a fix'd Salt, upon some more mix'd with Spirit of Salt, and what a violent effervescence immediately arises? Certainly by the swift rarefaction the Bodies take up ten times as much space as they did before, and the ebullition is much stronger than ever you observe in Milk on the Fire: And this happens even in the cold.

4. This *Serum* has a soft, occult, saline Taste: It diffuses a disagreeable

Smell, but by no means an acrid or very active one: If a little of it is dropp'd warm into the Eye, it excites no painful sensation, but is one of the most speedy Demulcents in Ophthalmies, and wounds of that part. And if it is applied to the Nerves laid bare in Ulcers, or Wounds, it is scarcely perceived.

U S E.

1. **I** HAVE made frequent Observation upon the Blood of healthy Persons flowing from them upon opening a Vein, upon that springing out of the Arteries when they have been divided by Wounds, or burst in Hæmorrhages of the Nose, upon that hawk'd up from an Artery broke in the Lungs, upon that likewise discharg'd from Dogs, Oxen, Sheep, and other Animals, when they have been opened alive, or had their Throats cut, and lastly, upon that flying with violence from the Veins of Persons blooded in the most burning Fevers, *Phrenitis*, and *Pleurisy*; I say I have made a careful Observation in all these cases, and yet I cou'd never discover in the Blood, the very instant it was received into the Basin from the living Body, the least sign of any Ebullition, Effervescence, Fermentation, intestine Motion, or Rarefaction, tho' it was so rapidly agitated in the Vessels the very minute before. Upon the evidence therefore of these Observations, I many years ago quitted *Sylvius's* Opinion, which I was led into purely by the reading of chemical Authors; for I was by this means absolutely certain, that the Senses were not able to discover any such alcalious and acid Principles in the Blood, as cou'd produce any of the visible effects that arise from the mixture of such Principles, such as Ebullitions, Effervescences, Fermentations, intestine Motions, or Rarefactions. I have ventured to assert farther therefore, that there really are no such Principles in the Body, for if there were, it wou'd appear at least the very moment the Blood came out of the Vessels. If a person will still insist upon it, that there are such, but that they are so quiet, as not to be perceived, I have nothing more to add, only wou'd ask him one Question, and that is, by what Arguments then he will prove that there are? One may doubt, certainly, whether they wou'd be convincing. This however at least is certain, that if there are these opposite saline Principles of the Chemists in the Blood, they are so weak as to produce no sensible effect, and that consequently it is not safe, from a bare supposition of these, to explain any sensible Effects by them.

2. The Blood of a healthy Person left to itself ought rather to be looked upon as a Solid than a Fluid; and yet the Solid that is form'd from it will spontaneously dissolve again into a Fluid. Surprising *Phænomenon*, but certainly true! If it is the Blood of a Person fasting, it does not separate like Milk into a Cream, and Whey, but into a solid Substance, and a fluid one, the liquid part only being yellow, the concreted, of a scarlet colour where it is in contact with the Air, but black in those parts where the Air can't come at it. The red part however itself loses its Colour, and that even in the Air, and acquires a yellowish one proper to the *Serum*. Nor is there in the *Serum* or any other part, either an Alkali, or an Acid that by being mix'd with its opposite will discover any sign of Effervescence, but they are as quiet upon such Mixture, as when Water is poured upon Water.

3. But from this Process we learn particularly, that our Blood is of such a Nature,

Nature, that if any acid and alkaline Salts shou'd meet together in it, they wou'd burst in an instant into such an expansion, that the rarefied Matter wou'd take up at least ten times more space than it did before, and as soon as ever the *Impetus* of the Effervescence was over, wou'd shrink again to its former compass: But this is absolutely repugnant to the Nature, Health, and Life of the Body, and the equable state it is observed to exist in.

4. This *Serum* contains all that Matter which is propell'd through all the Vessels of the Body, the red part alone excepted. It has in it therefore every thing that comes afterwards into any of the Vessels, from the greatest to the least, and consequently contains the Matter of Nutrition, from which every thing is prepared that is necessary either for growth, or to repair those Particles that are continually wearing away. In it therefore is the Matter of the whole Body, as well the Solids as the Fluids. Hence therefore we infer the excellent use of this Experiment throughout the whole Body; and here we see the chemical Art setting to rights those errors with which it had infected both Philosophy and Medicine. This plastic *Serum* is soft and inert, perfectly like the White of an Egg; and as out of that are formed all the parts of a Chicken, so this furnishes all the parts of the human Body.

P R O C E S S CXV.

Serum of Blood, being digested, grows putrid.

A P P A R A T U S.

IF *Serum* of Blood is put into a tall open Glass, and exposed to a Heat of 70 degrees, it will grow every hour thinner and thinner, so as in the space of three or four days to be quite resolv'd and sanious. At the same time too, from being almost inodorous, it becomes fetid, and exhales a cadaverous Stench; from being insipid, it acquires a fracid, rancid, acrid, abominable Taste; and if it is kept in this degree of Heat a few days, it grows alkaline, putrid, and intolerable to our Senses, evidently discovering its alkaline Nature, by causing an Effervescence with Acids. If it is committed under these circumstances to Distillation, it yields the first time a volatile alkaline Salt, exactly as we saw in the Whites of Eggs treated in the same manner, *Process* 113.

U S E.

HENCE then we see, that *Serum* when it lies open to the observation of the Senses, by Rest, and the degree of Heat mentioned, becomes spontaneously thinner. When it stagnates therefore in the obstructed Vessels of a sick Body, by a gentle Heat, and Time, it dissolves of itself, and so often opens the Vessels it had stopp'd up. Hence in acute inflammatory Disorders, when the Body is reduc'd to a moderate Heat, in a certain number of days the obstructing Matter becomes capable of passing on in its Vessels, as in practice is every day observ'd. By the alteration now the *Serum* undergoes in this Experiment it never becomes acid, whatever the greatest Artists write to the contrary, but always grows only putrid. Nor do we ever observe here the least sign of Fermentation, use what-

ever Arts you will to raise one, but a determin'd Putrefaction only. It's true indeed, that by thus putrifying it rarifies and produces an elastic Air that flies off from it, but not a fermentative spirituous one. Nor are there fermented inflammable Spirits generated by this Putrefaction, but other putrid ones, that are volatile likewise, and then take Fire: For Excrements having been close stopp'd up in a Privy, and compress'd together, have conceiv'd a strong intestine Motion, and at the same time have exhal'd an exceeding fetid Vapour, which upon the application of a Candle, has burst out into a violent Flame. Hence it has sometimes happen'd, that a Heat and Rarefaction have been excited in a dead human Body, but only about the *Abdomen*, and then not a very great one. From what has been said then, the Physician may learn the spontaneous degeneration of the Humours, when they stagnate either in their Vessels, or in the cavities of the Body without 'em. By acid, compound, saline, and spirituous Bodies, however, the Putrefaction we have described may be prevented.

P R O C E S S CXVI.

Serum of Blood coagulates in boiling Water.

A P P A R A T U S.

IF into clean Water, boiling on the Fire, you pour *Serum* of Blood, it immediately grows white, and forms a kind of *Coagulum* in the middle of the Water. In this property therefore, again, *Serum* agrees with the White of an Egg, *Process* 116, tho' at the same time it must be observed, that the White forms a more solid Mass than the *Serum*.

U S E.

HENCE then we see the effect of Heat upon *Serum* of Blood; and how boiling Water acts upon the Humours when it is applied to, and consequently burns the parts of a living Body. It is plain, that by that means, neither the saline parts, nor the Oils of the Blood are rendered volatile.

P R O C E S S CXVII.

Serum of Blood hardens with a dry Heat.

A P P A R A T U S.

TAKE some *Serum* of Blood, put it into a clean Vessel, and gradually bring it to the Fire, and when it begins to smoke, that part that is in contact with the Vessel, will grow opake and white, and coagulate; and thus proceeding successively, the whole *Serum* will at last be hardened into a white, tenacious, opake, scissile Mass, lying in Waves, as it were, in the middle of the surface, perfectly solid, of a soft Taste like that of the White of a boil'd Egg, and having scarcely any Smell. If this Mass is kept in the open Air, it gradually
sweats

sweats out a thin watery Liquid, perfectly in the same manner, again, as the boil'd White of an Egg does. And here, if the Coagulation is made with a proper degree of Fire, that is to say, with such a one as will just effect it, and no more, it will then harden without any *Empyreuma*, without expelling any Salt, and without the least appearance of an Alkali. When it is once consolidated in this manner, there is scarcely any thing that will resolve it.

U S E.

HENCE then it appears, that in a certain degree of Heat, and that not much exceeding 100, all our Humours will be together reduc'd into Masses, that will not be able to pass through their Vessels. A Heat, therefore, of a little above 100 degrees, arising either from an internal or external cause, cannot be born in the human Body, without the circulation of the Humours being stopp'd, and the Person being destroy'd, the disorder being first visible in the Head and Lungs, from their proper action's being first disturbed. But here we observe particularly, that Heat, by coagulating the Humours, will destroy the animal long before it can render the Salts and Oils alkaline, putrid, and volatile. Of what infinite use therefore are *Fahrenheit's* mercurial Thermometers? How certainly do they point out to us the danger that arises from the Heat in acute Diseases?

P R O C E S S CXVIII.

Serum of Blood coagulates with Alcohol.

A P P A R A T U S.

I N T O some *Serum* contained in this clear Glass, I now pour some very pure cold Alcohol; and immediately in those parts that it comes at, the *Serum* begins to grow turbid, white, and opake. When I shake them together, the same thing happens throughout, and the whole becomes coagulated, tho' not so strongly as the White of an Egg, but in different Portions, cohering less firmly together. If I mix the Alcohol with it very hot, the *Coagulum* then becomes a good deal more solid. When the *Serum* is coagulated in this manner by Alcohol, it will never grow putrid, but may be kept for years without alteration.

U S E.

H E R E then we see a farther agreement betwixt our *Serum* and the White of an Egg, viz. in their Coagulation by Alcohol. That the *Serum* now is not consolidated by the Alcohol into so dense a Mass as the White is, seems to be owing to the greater solidity of the latter: For the White contains the Matter of all the Nourishment that is impended upon the Chicken so long as it continues inclosed in the Shell, is not very thin, and has nothing putrid in it; whereas the *Serum* of our Blood contains both urinous Particles, and a great deal of Water; but Alcohol, diluted with Water, will not condense the *Serum* in such a manner, nor even the White of an Egg. Hence you see the efficacy of pure Alcohol

Alcohol upon our Blood; for it condenses it like Fire, and preserves it from a spontaneous Corruption, on both which accounts it is the most ready styptic we are acquainted with, at the same time that it prevents Putrefaction, producing a very thin, indeed, but solid Eschar. For if a Teint dipp'd in the purest Alcohol made scalding hot, is applied to a bleeding Wound, press'd on pretty strongly, cover'd with a piece of Hog's Bladder soften'd with Oil, and then secured with a proper Bandage, the Hæmorrhage will be immediately stopp'd, and the whole dressing may be kept on for the space of three days, in which time the Vessels generally grow together, being wonderfully contracted and consolidated by the Alcohol. Thus then does Alcohol coagulate all our thicker Fluids, contract the fibrous parts into a hard dry Coalition, and defend both of them from the Putrefaction they are naturally disposed to. A famous instance of this we have given us by that excellent Physician *Samuel Cabelliau*, in a Leg that was perfectly sphacelated, which by the help of Spirit of Turpentine, and alcoholifated Spirits of Juniper, was preserved from Extirpation for the space of six months, without any farther Putrefaction. *Eph. Germ. Dec. III. An. 5. and 6. p. 495.* But those parts of the Body that are made up of exceeding fine Vessels, soon grow hard in Alcohol, together with their contained Humours. No wonder, therefore, that those poor Wretches who use this Alcohol, tho' somewhat diluted too freely, should be obnoxious to such terrible disorders of the Nerves, and Polypus's in the Blood.

PROCESS CXIX.

The Analysis of Blood by Distillation.

APPARATUS.

1. TAKE the Blood of healthy Persons drawn from 'em only to prevent a *Pletthora*, fill with it a clean glass Cucurbit one third full, fix on an Alembic, and securing it with a proper Lute, place the Cucurbit in a Bath of Water, and carefully lute on a Receiver. Then raise such a Fire, that the Water in the Bath may have 150 degrees of Heat, and there will rise a Vapour into the Alembic, appearing, just like pure Water, in form of scattered dewy drops, without the least indication of any pinguious Spirits. Keep up this degree of Fire as long as any moisture comes off pretty readily, and then remove the Receiver, and keep this first part by itself, which is of the same weight, colour, and fluidity as Water; has scarce any Smell or Taste; excites no Effervescence with any Acid, or Alkali, but mixes as quietly as possible with both of them; gives no indication of any thing saline, or oily, by any trial whatever; causes no painful Sensation if it is dropp'd into the Eye; and if it is thrown upon Flame, extinguishes it: It approaches very nearly therefore to elementary Water.

2. This being remov'd, and another Receiver applied, increase your Fire 'till the Water in the Bath boils, and you will then have such another volatile, watery Fluid. Proceed to distill as before, till nothing more will come away with this degree of Heat, which requires a pretty deal of patience, for at last, when the Mass begins to grow dry, it is separated from it with difficulty. This Liquor then is in every Property perfectly like the former, all that I asserted

and demonstrated to you by Experiments concerning that, holding true of this likewise, without any difference at all; which deserves your particular notice and remembrance. These two watery Liquors now make up almost $\frac{2}{3}$ ths of the Blood made use of in this Operation.

3. The Cucurbit being broke, and the hard Mass that remains being taken out, it does not by any kind of trial discover any thing alkaline, acid, or acrid; but it is inert, having something of an empyreumatical Smell and Taste. In a dry place too, it may be preserv'd for a long while in a Box not painted, or it may be reduced to Powder, and kept in that form, as the Apothecaries experience in Goat's Blood.

4. This Mass, being divided into small pieces, I put into a glass Retort, whose Neck is cut off so low that the Mouth may be very large, and I leave one third part empty. I then gradually urge it in a Sand Furnace, and there comes off a subpinguious, oily, bitter, sub-alkaline Liquor, and then a white, solid, volatile Salt, which fixes to the sides of the Receiver, and the Mouth of the Retort. The Fire being then raised by degrees to the greatest, you will have a golden Oil likewise, and a Salt with it to the very end. These being all remov'd, and a fresh Receiver applied, let the remaining Matter be tortur'd with the strongest suppressing Fire, and there will appear some white Fumes, which perhaps will never cease, continue your Operation ever so long, and together with these a thick black Oil; and then the Mass being melted in the bottom of the Retort, will rarify, puff up, and rise into the Neck, which if it stops quite up, it will in an instant burst the Vessels to pieces with a prodigious Noise and *Impetus*, as I once experienced myself, whilst I was urging it to the Extremity. This however may be prevented by taking a Retort with a large Neck, and cutting it so low that the Mouth shall be very wide. By this means then, you have an alkaline oily Spirit; a volatile, alkaline, oily Salt; a Salt somewhat more fix'd, and more oily; a yellow Oil; and a pitchy black one; in all which there is contained an Alkali, just in the same manner as we found before in the Distillation of the Whites of Eggs, *Process* 112: Nor indeed is there any such considerable difference observed here, that a Person may easily take notice of it.

5. The *Residuum* in the bottom of the Retort is very black, shining, brittle, rare and light, fetid, empyreumatical, and exceeding bitter, but scarcely salt. This I urg'd in close Vessels till the Retort was ready to melt, and yet even then it did not leave off fuming, nor did it lose its black Colour. This therefore is a true Coal of Blood. If this is exposed to an open Fire, it flames, the blackness is consumed, and there remains a white Earth, in which there could never be discovered any acid, or fix'd alkaline Salt. The Sea-Salt, indeed, that we take in with our Food, and which suffers no alteration from the vital Powers, is frequently contained in it; and hence if this is afterwards distill'd with the Earth, it may yield somewhat of an Acid. All these *Phænomena* therefore, considered together, make it appear, that the White of an Egg, and the *Serum* of Blood, are very nearly of the same nature; but the former continues at rest in the Shell, whilst the latter is carried swiftly through the Vessels of the animal Body. Those Persons now, who assert that Phosphorus may be produc'd from this last Matter, are perhaps in the right: I am apt to doubt, however, whether ever they have tried it, as there remains so little of these *Fæces* from the Blood. Reasoning from Analogy is easy; that from Experiments is much more laborious.

U S E.

HENCE therefore it evidently appears, that Water, and a fetidish Spirit, are the most volatile parts of the vital Humours, and that this Water constitutes much the greatest part of them. But by this Operation we learn likewise, that the natural Salt of our Blood can never be rendered volatile in the Body; for we see it is not disposed to rise with a Heat that is $2\frac{7}{13}$ ths greater than that of a Person in health, nay scarcely with one that is 3 times greater; but a Heat exceeding the natural one of the Body by $\frac{1}{10}$ th only, soon proves fatal. But it here appears farther too, that in a degree of Heat 3 times greater than the natural, there does not rise any thing of a volatile, alkaline Salt, and consequently that there is none in the Blood. And at the same time we see likewise, that there is here too a pitchy Oil very intimately united with an Earth: That the Blood, when it is depriv'd of its Water, does not discover any saline Principles: That these therefore do not act there at that time as such, nor undergo any alteration, but will lie conceal'd there for years, thus involv'd and unactive, tho' they may be extricated thence by the assistance of Fire: That Blood will be inspissated by Fire, from 100 degrees to that which is necessary to render the Salt of the Blood volatile and alkaline: That when it is inspissated by such a Degree of Heat, the greatest part of it will again be converted into a volatile Liquid by a greater degree, and then all the parts that are drawn off, except a small quantity of Earth, will continue for the future, volatile, and fluid: That the Blood contains no fermented Spirits: That the Salts of the Blood, which at first will not rise with 276 degrees of Heat, when they are once rendered volatile, can scarcely be retain'd from spontaneously flying off with one of 32: That the animal Salts, by the action of a strong Fire upon them, from not being volatile, are rendered volatile, and from non-alkaline, alkaline, and then continue so afterwards: And lastly, that by mixing together the different parts drawn off from the Blood, the same can by no means be produc'd again, but a Compound as different from it as possible. Hence therefore we perceive the wonderful difference there is in the effects of Fire upon Blood, according to the different degree in which it is applied. Through all the degrees from 50 to 100, it attenuates it, and renders it putrid; from 100 to 276, it inspissates it; and from this degree again, it attenuates it, and renders many of its parts volatile, acrid, and alkaline. Hence our Aliments, Chyle, Milk, Serum, and its productions are understood in their original Species, and Effects. All these things, now, I have found to hold true in the Blood of many Brutes likewise.

P R O C E S S CXX.

The Analysis of Horses Hoofs by Distillation.

A P P A R A T U S.

1. TAKE a sufficient quantity of the Parings of Horses Hoofs kept at Grass, macerate 'em in Water, clean 'em very carefully, and dry 'em again, and then put as much of 'em into a glass Retort, as will fill it almost to the lower

lower part of the Neck where it begins to be bent. Place the Retort in a Sand Furnace, lute on a very large Receiver with a Lute made of Linseed Flower, and distill with a gentle Fire at first, increasing it by slow degrees. By this means then, there will first come off a limpid, watery Liquor, appearing in form of dewy drops. Keep up the same degree of Heat as long as this continues to distill, and then remove the Receiver, and pour it into a clean Vessel by itself, and apply the Receiver again. Proceed to increase your Fire till you perceive white Clouds begin to rise, and then together with them you will immediately have an oily Spirit, which will run down in oily streaks. Carry on your Distillation with the same Fire, whilst any thing will rise with it, and there will begin here and there to appear somewhat of a Salt. Raise it still higher, and, with a more pinguious Spirit, there will rise a volatile, alkaline Salt, that will form itself into little Globules, together with an Oil. This being persisted in till scarcely any thing more will come over, proceed to urge the *Residuum* with the strongest suppressing Fire, and there will still ascend a volatile Salt, but somewhat more fix'd, and with it a very red, thick Oil. At the same time too, the *Residuum* will melt, run into one Mass, puff up, and rise to the Neck of the Retort. Then desist from the Operation, and remove the Receiver before the Retort is grown quite cold, for otherwise great part of the volatile Salt will re-ascend into it. When you have taken out the Bodies in the Receiver, keep 'em in a Vessel very nicely stopp'd, for they are extremely volatile. The *Fæces* that then remain in the Retort, are exceeding acrid, very light, rare, fetid, and bitter, and if they are burnt in an open Fire, they yield a small quantity of a white Earth, that is very insipid, and considerably pure.

2. If you take the oldest, driest Hartshorn, break it into pretty large pieces, put it into an iron Pot fitted in a Furnace, and fix on a very large earthen Alembic with two Beaks, and to each of these apply a large Receiver; then if you carefully distill with successive degrees of Fire, there will come off very nearly the same principles as in the Distillation of these Hoofs, *viz.* alkaline, oily, pinguious Spirits; a volatile Salt; a light Oil; a Salt a little more fix'd; and another thick, tenacious, pitchy Oil. But when the Operation is over, there will remain at the bottom a black solid Coal, which will not so easily melt with the Fire, but remains brittle, and being reduc'd to Powder, and given fasting, is an excellent Remedy for the Worms.

3. The fresh Bones of Animals, clean'd as much as possible from their Fat, being treated in the same manner, produce the same parts, setting aside that from the great abundance of a very fetid, putrid Oil, the whole is rendered exceeding impure. The same may be drawn too from Horns, Claws, Hair, and Silk.

U S E.

AS there is a greater or less quantity of Water, therefore, drawn from all these Bodies, let 'em be ever so dry, hence it appears how intimately this adheres to the other Elements of Animals, and is consolidated with them into an exceeding hard, dry form, which remains fix'd and durable for a great number of years, till it is at length resolved by Fire. This now appears particularly, when you free the liquid Spirit from its volatile Salt and Oil, for then you

have a fetid Water in considerable quantity. But hence we learn farther, that Bodies that are perfectly inodorous, by the sole action of the Fire, acquire a manifold and very various fetid Smell; for every one of these different parts has a particular kind of fetidness, which it is scarcely credible, how long they will retain. From the most insipid Body, likewise, we here see a Production of various Tastes, for neither the Water, Spirits, Salts, or Oils, have the same. But from a solid Body, how many Fluids have we here too, that will not, without vast difficulty, become concreted again? And from a fix'd Body, how many volatile ones? Certainly of the whole large Mass there is but a small quantity of Earth that remains fix'd. And as the very same Principles are drawn both from the fluid and solid parts of the Body, with this difference only, that after the Distillation of the firmer parts, there remains more Earth, hence we easily see, that they have one common Nature, and that the Solids are made up of the Fluids. If the larger Bones, however, are calcined with a very pure and intense Fire to a perfect whiteness, not only on their surface, but to the very inmost part of their substance, tho' they will retain their proper form and size, yet upon being exposed to the action of the Fire in a close Vessel, they will not yield any Water, Salt, Spirit, or Oil, but they are easily reduced to Powder; tho' even then, if they are immersed in Water or Oil, they will acquire a considerable degree of cohesion. And again, if Horns, Bones, or the like parts are boil'd strongly, and for a long while in Water, often shifting the Decoction, and putting on fresh, and this is continued till the last Water, after boiling some time, is as pure as when it was put on, then all these Decoctions being mixed together, and inspissated, will form a thick Jelly, which when it is cold, acquires such a consistence, as to stand against the Knife. And if you then take such a Mass prepared from Hartshorn, Ivory, Bones, or Flesh, and distill it in the manner describ'd, it will yield the very same parts as before; and the horny or bony Substance that remains after such a thorough Decoction, will give out in Distillation so much less Salt, Oil, and Spirit, as there was Jelly boil'd from it. Hence therefore it appears, that all that saline, spirituous, and oily Matter, proceeds only from the Fluids, and that the ultimate solid parts are mere simple Earth, cohering but slightly together, in which, after it has suffered the utmost torture of the Fire, there is not discovered the least sign of a fix'd Salt, nothing then remaining but white Ashes, which are exceeding fit for making the assaying Tests with. And if you boil Bones in this manner in *Papin's* Digester, as I have formerly frequently done, when the Decoction has been repeated sufficiently, they will be found almost purely earthy. These things therefore being all laid together, have inform'd me, that there is scarce any discernible difference in the principles produced by Distillation from any animal Substance, except only with regard to the Oil, which is in greater plenty in some parts than others. But the Oil in Distillation becomes intolerably empyreumatical, and infects all the other parts with a most abominable and indelible Smell and Taste. Hence it comes to pass, that a solid part, when it is distilled, becomes proportionably more offensive, as it contains more Oil, for which reason, the Bodies which lean Hartshorn yields in Distillation, are in this respect different from what you procure from an Ox's Bone that is full of Marrow. But setting aside this one consideration, in other respects there is hardly any difference; for the Spirits and Salts being freed from their Oil, become very nearly the same.

Nor

Nor could I ever discover any considerable variety in the Chemical Productions from different Animals; for Horses Hoofs, Bullocks and Harts Horns, Ivory, Tortoise-shell, Hair, and Silk, yield the same Principles. And hence again it signifies little from which they are procured, setting aside the regard to the Oil already explained. Thus in the Spirit of human Blood, Hartshorn, Horses Hoofs, and raw Silk, I never could find any disagreement, but in their Oil. I know indeed, that *Van Helmont* extolls the saline Spirit of human Blood above all others, on account of its curing the Epilepsy; and that the *English* prefer *Goddart's* drops made from Silk, to any of the like kind; but I have been long satisfied, that such a difference in their effects is seldom observed in Practice with sufficient certainty. This however, in the mean time, we are sure of, that by boiling the Solids of Animals with Water, all that Matter may be nearly extracted, which in Distillation yields those parts we have been describing, the Body that remains after the Decoction yielding very little: That hence in these insipidish, and scarcely odorous Decoctions, all that Matter lies concealed, which in Distillation gives out the Salts, Spirits, and Oils: And that the animal Salts, therefore, by such long and repeated boiling, cannot be rendered alkaline and volatile. But it is farther certain too, that Air, Water, and Salt, will in time absolutely deprive Bones of all that animal Matter, which in Distillation would yield Water, Spirits, Salts, and Oils; and that old Bones by this means rendered perfectly white, upon being committed to Distillation, afford nothing of this, but exhibit only a very simple Earth, all the other parts being carried off by the previous Putrefaction. And lastly, which is a pretty Experiment, if you take the Muscle of an Animal, a Bullock's Heart for instance, and boil it in fresh Waters till you can boil nothing more out of it, and then take it, and softly press out the Water, and squeeze it gently betwixt your Hands, and then boil it again in more Water, and so proceed, taking off the external fine Membrane, that the melted Fat may easily discharge itself; I say, if you treat it carefully in this manner, you will at last have a dry solid Muscle, which will not corrupt, and is exceeding fit for the examination of its Fibres, especially if you first inject warm Water into the coronary Vessels till you have thoroughly washed both the Arteries and Veins from their Blood, for by this means you will obtain a Skeleton of the Muscles.

PROCESS CXXI.

The Depuration, and Separation of the Bodies produced by Distillation, from alcalescent Vegetables (Process 33.) or from vegetable Soot (86) or putrefied Vegetables (88), or Animals (95, 101, 112, 119, 120); with their Vertues when thus purified.

APPARATUS.

1. **I** Here, as you see, take all the Bodies procured by Distillation in the *Processes* cited, and mixing them together, put them into a pretty large glass Cucurbit, which I then set apart for this Work. To this I apply a large Head, whose Beak I cut off in such a manner as to have the Mouth pretty wide, that the Salt may readily pass into the Receiver, which would otherwise be easily stop-

ed there, and closing up the Orifice, might cause the Head to fly off with a great deal of violence. This being done, I place the *Apparatus in Balneo Mariae*, and with a Heat of 150 degrees, kept up just to the same height, I draw off whatever will rise with that degree. By this means then I have a pinguious alkaline Spirit, that is perfectly volatile, and with it a white, solid, volatile Salt. When nothing more comes off with this Fire, the Receiver must be removed, and this Spirit must be kept by itself, together with this volatile Salt. And if then, upon shaking 'em together, the Salt will be no farther dissolv'd by its Spirit, it is a sign that the Spirit is as generous and strong as it can be prepared by any Art. Let this therefore be poured off, and be kept stopt as close as possible for its proper uses, under the Title of true Spirit of Hartshorn, Human Blood, &c. The Salt likewise, which would not be dissolved in this Spirit, may be kept in another Vessel, under the Title of a volatile, oily Salt of Hartshorn, &c.

2. Let the *Residuum* be then urg'd with the heat of boiling Water, and you will have another Spirit that will rise slower than the former, together with a light Oil swimming upon it, and a small quantity of a volatile Salt. Proceed to distill with this degree of Heat as long as any thing comes off, and keep this aqueous, oily, and saline Liquor by itself. This being done, at the bottom of the Cucurbit there will remain a thick fetid Oil.

3. Hence then you have from these Bodies, first, a Water that is neither oily nor saline; then an alkaline oily Spirit; next a volatile oily Salt; fourthly, a volatile Oil, with an oily Alkali, a little less volatile, together with a fetid Water; and lastly, an Oil so fix'd, that it won't rise with 213 degrees of Heat.

4. If the first Spirit is sublim'd in a fresh Vessel with a Heat of only 100 degrees, you will then have a purer Salt almost in a solid form; and if you proceed so long till the sublim'd Salt begins to be dissolv'd by the following Liquor, then at the bottom there will be left a watery Liquid, together with an Oil swimming at top. Hence, therefore, these Spirits consist of a very light Water, Oil, and Salt, combin'd together, and hence they are capable of being resolved into these three again. These Spirits therefore are a volatile, saponacious *Lixivium*. And the residuary Water and Oil may, by a new Distillation, be so separated, that an insipid, but fetid Water, and an Oil, may be obtained distinct, all the Salt being carried off by the most volatile Oil. Hence then we understand the nature of these Spirits. This Salt, however, thus produc'd by Sublimation from its Spirit, is always oily, tho' less so indeed than it was before, and hence it is whiter; for in every repetition it leaves a yellow, and sometimes a red Oil behind it, from which it had its Colour. But when the Spirits of *Process* 106, that are not oily, but merely aqueous and alkaline, are treated in this manner, then a volatile alkaline Salt rises alone in a dry form, and there remains a proportionably less saturated alkaline Water at the bottom. Hence, therefore, we learn, that when by Putrefaction the admixture of a fix'd Alkali, or the action of the Fire, the Salt of Animals is once render'd alkaline and volatile, by this very means it becomes and continues more volatile than pure Water, and the most volatile Oil; and hence the Water that is left behind, discovers the Oil that lay concealed before; for whilst this was united with its Alkali, it was of a saponacious nature, and so wou'd dissolve in the Water, but its Alkali being now separated from it, it no longer retains this
soapy

soapy quality, but like true Oil disengages itself from the Water, and appears in a distinct Body.

5. Let the Oil that is separated from the other parts, in the rectification of the Spirits, be mix'd with that which remain'd at the bottom of the Cucurbit No. 2. Upon these pour some clean warm Water, and shake 'em together, in order to dissolve any Salt that may adhere to the Oil, by which means the caustic acrimony of the Oil will be in a great measure destroy'd, and it will become milder. Decant this saline Water, and set it by, that the Salt may by sublimation be separated from it. Put the Oils into a Cucurbit, and with 213 degrees of Heat free 'em from their Water, keeping up this Heat till nothing more can be drawn off, and then distill them with a clean Retort into a pretty large Receiver, beginning with a moderate degree of Fire, and gradually increasing it, till you can't force out any thing farther with the strongest Sand Heat. By this means then the Oil will become thinner, more limpid, and less fetid, and there will be a black Earth left in the Retort. And if you repeat the distillation a second time upon these black *Fæces*, the Oil will become still more limpid, purer, thinner, and less fetid, and you will again have more Earth left behind, so that every time the quantity of Earth will be increas'd, whilst that of the Oil is diminish'd, which continually advances in limpidity, purity, and subtlety. And indeed of this there is scarce any end, as I once had an opportunity of observing, whilst, according to *Van Helmont's* direction, I attempted, with the utmost Patience, to prepare the oily diaphoretic which he mentions in his *Aurora Medicinæ*; for he there orders the Oils to be distill'd till they will no longer leave behind 'em any earthy *Fæces*. I took therefore some pounds of Oil of Hartshorn, distill'd it in the manner describ'd, and cohobated it a great number of times, but there was always some feculent Matter left behind, so that at last I had lost the greatest part of my Oil, obtaining only in the room of it a good deal of useless Earth, of which I found there was some left at the bottom of the Retort the very last Distillation. By this means, however, I procur'd a very penetrating Oil, that was not unpleasant. Hence therefore I was ready to believe that *Van Helmont* had never brought this Experiment to a conclusion himself, which he recommends to others; and was satisfied that the Great *Boyle* tells us upon better authority in his Treatise *Of the Mutability of Principles*, that by an obstinate cohobation almost all these Oils are converted into Earth, and that then the Acrimony is taken away that remain'd in the Oils after the Salt was wash'd out of them. Any Person however will find it worth his while to cohobate these Oils fifteen times, for by this means he will obtain an Oil that is almost as thin as a Spirit, is pellucid, exceeding penetrating, volatile, of a grateful Smell and Taste, that penetrates wonderfully through all the passages of the Body, is an anodyne, paregoric, resolvent, and febrifuge, is greatly beneficial to the Nerves, and being rubb'd upon the Spine of the Back before the Fit, proves serviceable in Intermittents: The Dose from 20 drops to 30. See *Dippelius de Morb. H.* and the famous *Hoffman Ob. Ch. Phys. C. I.* Hence therefore we see, that these Oils are convertible into a very large proportion of Earth, and a very small one of true Oil. But when they have undergone such a management, then they all become of the same Nature, and scarcely to be distinguish'd from one another, so that distill'd animal Oil, when it is perfectly freed from every thing else, seems from all Animals to be intirely the same.

6. Lastly,

6. Lastly, the volatile Salts of Animals are depurated after various methods in order to procure them simple, and free from the admixture of any other Body; and these are as follow.

1. I take this large Bolthead that has a very long large Neck, which I cut off in that part where it is widest. Into this I put some volatile Salts that are not very pure, and fitting on a Head that has a large Beak, and applying a Receiver, I gently urge them with a soft Sand Heat: By this means the Salt ascends to the top of the Alembic, and the Neck of the Bolthead. I continue this Operation till nothing more rises, and then take out the pure Salt, and keep it in a close Vessel, there remaining at the bottom of the Bolthead an Oil and fetid Water. In this method however there is always some Oil ascends with the Salt, though by a second sublimation, great part of this will be again left behind, and the Salt will rise more pure. And here the Salt procur'd from Urine, Whites of Eggs, Blood, Horns, and Bones, when it is rectified in this manner, becomes at last perfectly the same; for by a repetition of this Operation I have at length brought them to such a likeness that I cou'd not distinguish them from one another, and always the less, the oftner the sublimation had been repeated. Hence then it appears, that all the difference observed betwixt volatile alkaline Salts is owing only to the empyreumatical Oil that adheres to 'em, which being carefully and intirely remov'd, the remaining depurated Salts become perfectly alike: Though it is very white however just after the Operation, yet in time it grows yellowish, a latent Oil discovering itself a-new. This those Chemists find greatly inconvenient who prepare Salt of Hartshorn for sale, and therefore want to give it an agreeable whiteness that will last a good while.
2. This second method therefore I have found to succeed very well. Take the Salt once purified by sublimation in the manner describ'd, put it into a tall glass Cucurbit, and immediately throw upon it 4 times as much of the purest, driest, hot Chalk, reduced to a very fine Powder, which must be done in such a manner that the Salt may be well cover'd with it. Fit on, as soon and as close as you can, a clean, dry Alembic, which will be so much the properer for this Operation, as it is bigger and has a Beak with a wider Mouth. Then lute on a Receiver, and distill with only a gentle Warmth, which will be best directed by the warm Bath. By this means then all the Salt will be sublim'd white, pure, alkaline, and volatile, whilst almost all the Oil will be retain'd in the dry bibulous Chalk. At the same time too the Chalk, by its admixture, will make no alteration at all in the nature of the Salt, inviscating only the Oil, and by this means rendering the Salt more simple and pure. And indeed the Salts prepar'd in this manner will continue for a great length of time without any alteration, especially if they are accurately rubb'd with the Chalk before they are sublim'd: But then it's true a good deal of the volatile part exhales during the rubbing, and the Salt grows very soon moist with the Air, and dissolves.
3. Lastly therefore, if upon the Salt thus depurated by Chalk you pour as much pure Spirit of Sea-Salt as is necessary to a perfect saturation, then dissolve the *Sal-Ammoniac* thus produced in Water, filter the Liquor till you have reduc'd it to the greatest purity, inspissate it to a Salt, and then distill

this Salt with a fix'd Alkali, according to *Process* 106, you will by this means have a very white, pure alkaline Salt, perfectly simple, and intirely freed from all its Oil. See the *Phil. Transf. abr.* Vol. III. p. 335, where you have this elegant Invention very well describ'd. After the volatile, alkaline, oily Salts now, mentioned in the title of this *Process*, are by these three methods brought to their greatest simplicity, there is then no sensible difference to be observed in them, and that whether they naturally reside in the Bodies, or are produced by Putrefaction, or Fire. And, exactly in the same manner, may the same be procured from Birds, terrestrial, and amphibious Animals, Fish, Reptiles, and those Creatures that live in the Earth, as likewise from alcalescent Vegetables, Soot, &c. So that all these, when they are freed from their Spirit and Oil with Spirit of Sea-Salt, produce the very same kind of *Sal-Ammoniac*, which being again resolv'd by fix'd Alkali's yields the alkaline Salt and Spirit of *Process* 106. Hence therefore, in the whole compass of Nature, there is but one volatile Alkali that we are at present acquainted with, that is to say, when it is perfectly freed from every thing else. The difference therefore that is observ'd in it, when it is not so pure, depends always upon the admixture of some other Principle, particularly upon an Oil that adheres to it, which in various Bodies is more different in its Nature; though even this Difference that appears in the Oils is principally owing to a small quantity of Spirit, and so ultimately this diversity in the Salts will arise chiefly from the Spirit that resides in the Oil. Hence therefore we see that the Water, Earth, and Salt of Animals, when, by the methods laid down, they are reduc'd to their ultimate simplicity, are perfectly the same without any difference at all. The distinguishing quality therefore of every one of them resides chiefly in the Oil alone, which itself too, is distinguished by its Spirit, so that this being intirely remov'd, even the Oils themselves become wonderfully like one another: In Animals therefore the *Spiritus Rector* again causes the principal difference, as we have already made appear it does in Vegetables. These then are the ultimate and very simple effects of this chemical *Analysis*: If the Artist endeavours to prosecute his labours any farther, he almost loses the fugitive corpuscles, which when they are alone don't considerably cohere together, but being properly united with one another, form infinite numbers of compound Bodies. It's likely now, you may desire that I shou'd chemically explain to you the properties of this pure, volatile, alkaline Salt, and therefore I'll give you the chief of them, which are as follow.

1. It causes, in the same manner that a fix'd Alkali does, a pretty strong Effervescence with every known Acid, which continues too a considerable while. At the same time too it unites itself strongly with the Acid, retains it powerfully, and with it constitutes a compound Salt, the kind of which is determined by the attracted Acid: And by this means, in a perfect saturation, it is increased $\frac{3}{8}$ ths of its weight. Hence then we learn the proportion betwixt the Alkali and Acid that is necessary to bring them to an *Equilibrium*, and how much of each of them may be expected again in the resolution of these compound Salts. As soon as ever now this point of Saturation is obtain'd, the action of the Salt thus produced must not be

be judg'd of from the Acid or Alkali that enter into the composition, but from the particular nature of this new Salt. Hence therefore the error many Persons have fallen into is easily refuted, who imagine compound Salts have the same Vertues, which they observe in the simple Salts into which they may be resolved.

2. This Salt, being put into action by the Heat of a healthy Body, very soon inflames, burns, converts into a gangrenous Eschar, and hence perfectly destroys every part to which it is applied in such a manner that the Motion excited by this Heat shall be kept determin'd upon it: For if a scruple of pure volatile Salt of Hartshorn is laid upon the Skin, and presently secur'd with a Pitch Plaister, within half a quarter of an hour there will be rais'd a surprizing black Carbuncle, in the same manner as if it had been burnt with a red-hot Iron. The Colour, Pain, Heat, and shrivelling up the Skin too, is always exactly the same. And as for the Humours it resolves them, and renders them thin, and sanious.
3. It is wonderfully mobile, and volatile, in this particular, even exceeding all the Bodies we are acquainted with; for in mobility it goes beyond Alcohol and every thing else. If Water, Alcohol, and this Salt are mix'd together in a tall Bolthead, and you fix on an Alembic and apply the least degree of Fire, the Salt will rise alone into the Alembic long before the Alcohol, which will ascend next, the Water rising last of all, and that not without difficulty. And in the same manner this Salt flies off from every heating point. Thus if you lay it open upon your hot Hand, it presently flies off without giving it any pain, for it does not react a great deal upon the heating Body, but quitting it immediately leaves it unaffected; in which particular it differs greatly from a fix'd alkaline Salt, which by its weight remains unmov'd. In the mean time however, when these volatile Alkali's have enter'd into our Vessels, and are there agitated by the vital Heat, and the *Impetus* of the circulating Fluids, they then, by their acrid, corrosive, stimulating quality act very powerfully upon the sensible *Fibrillæ* in particular of the nervous System, which they excite into a greater degree of motion, and at the same time dissolve the Humours, and thus promote Perspiration, Sweat, Urine, and a discharge by the salival Glands. If its volatile Fume too mix'd with the Air, is drawn in, and applied to the *Membrana Pituitaria* of the Nose, Mouth, *Fauces*, and Lungs, by the irritation it causes, it resolves the *Pituita* when it begins to grow viscid there, and thus has often beautiful effects, when it is made use of with Judgment.
4. In watery, acid, austere Disorders, therefore, of the Humours, in a *Langor* of the nervous System, and in those cases, where from a too easy mobility of the *Sensorium Commune*, the *Impetus* of the animal Spirits is irregular, and they rush into particular Muscles without the direction of the Will, this Salt is greatly suitable, and is of excellent service. And hence in hypochondriacal and hysterical Affections, Epilepsies, and Convulsions, it proves a successful Remedy. If it is diluted with Water, and received into the *Vagina* in form of Vapour, it is look'd upon as one of the most expeditious Emmenagogues, when it is prudently administred, and the constitution of the Body requires such an Evacuation. In an alcalious, putrid,

and broken state of the Humours, and in those Bodies which are too much in motion already, it proves a desperate Poison. It may be applied outwardly too as a Caustic for burning small Issues, and extirpating Warts, and the grandinous Tubercles of the Eye-lids. In these cases you take a little Pellet of Lint, and wetting it with a solution of this Salt, apply it to the place to be corroded, covering it with a little Plaister of *Diachylon cum gummi*, and then leaving it till you think it has perform'd its Office.

P R O C E S S CXXII.

A Soap made with a pure volatile alkaline Salt, and Alcohol.

A P P A R A T U S.

I TAKE an alkaline Spirit of *Sal-Ammoniac*, so strong that a good deal of its Salt remains undissolv'd at the bottom, and put such a quantity of it into a very clear, clean, dry, cold, cylindrical Glass with a narrow Mouth, as will fill it near half full. Upon this I then very gently pour as much choice cold Alcohol as will fill the Vessel, taking care that it don't directly fall upon the Spirit, but run softly down the sides. This then being done, you see there is a white *Coagulum* form'd on the surface of the alkaline Spirit, upon which the Alcohol, which is lighter, disposes itself. I now therefore turn up the Vessel, and you see wherever the Alcohol and alkaline Spirit come into contact there immediately appears a white opake *Coagulum*; and when by shaking 'em, as I do at present, they are thoroughly mix'd together, the whole Compound becomes white, opake, and of a solid consistence, and that to such a degree, that upon turning the Vessel upside down there does not one drop run out. If you stop the Vessel nicely, however, and set it by, you will in a short time find it dissolve again into a Liquid swimming at top, and a denser, saline Substance collected at bottom, so that in a year's time there will be an almost solid Salt at the bottom with a Liquor above it. If the whole Mass produced in this manner is committed to distillation with a gentle Fire, from the Alcohol, and dry Salt, there will be sublim'd a solid alkaline Salt that is balsamic, and oily. The colder now the Weather and Place is, in which this Experiment is made, the more successful will be the event.

U S E.

THIS is one of the most difficult amongst the chemical Experiments, as both these Liquors are required so perfect, and so many circumstances must be observ'd, one of which being neglected, it will never succeed, though it constantly will if they are all rightly attended to. Here then you learn, that a pure volatile alkaline Salt attracts into it the most subtil Oil we are acquainted with, *viz.* Alcohol. And hence it comes to pass, that the Soap thus produc'd is the most subtil and penetrating of all, as it consists of the most subtil and volatile Alkali and Oil, surprizingly combin'd together in an instant. Hence this Medicine being diluted with Honey and Water, and taken

fasting, makes its way into almost all the Vessels of the Body, resolves Obstructions, frees the Vessels, and at the same time incites the vital Powers, by which means, when the Disorder arises from such a Matter as is disposed to submit to these kind of helps, it very happily cures many Diseases, and those bad ones too. As it is of an exceeding volatile nature however, and its vertue soon goes off, it is not capable of subduing the more stubborn. In the Jaundice it is greatly extoll'd, where there is no considerable inflammation. It will not dissolve the human *Calculus*, nor prevent its concretion and increase. It seems to be of the same nature with Salt of Tartar render'd volatile. In a gentle Heat it becomes fluid; in the Cold it comes nearer to the form of a Solid. If the purest Alcohol is mix'd in the same manner, in a glass Vessel, with one third as much of a very dry volatile Alkali, you have a Soap that is a good deal solidier, for then there is no Water in it, whereas in the strongest alkaline Spirit, there is always twice as much Water as Salt. *Van Helmont* was afraid that this wou'd quickly generate a *Calculus*; but certainly without reason; for this Soap, quite different from a human *Calculus*, dissolves with Heat, may be diluted with Water, and being spontaneously volatile, all flies off: They have nothing therefore common to them both, nor is there any resemblance between them. *Van Helmont* was not the Author of this Experiment, but *Raymond Lully*, a long time before him: This Compound however is call'd the *Offa Helmontiana*. Nor did the Author of that *English Treatise Of the Liquor Alcabest*, supposed to be Dr. *George Starkey*, sufficiently consider the matter, when he supposed this Soap, reduced to a Liquor by repeated distillation, to be the *Alcabest* of *Helmont*.

PROCESS CXXIII.

A simple aromatic volatile Salt of Angelica.

APPARATUS.

1. TAKE of the fresh small Roots of Angelica, dug up in February, 2 ounces, cut 'em to pieces, put 'em into a Retort, pour upon 'em 12 times as much Spirit of Wine once rectified, and then add 1 ounce of pounded *Sal-Ammoniac*, and 3 drachms of Salt of Tartar. This being done, immediately lute on a Receiver, and distill with a gentle Heat, not exceeding 150 degrees. By this means, then, there will come over into the Receiver a white, alkaline, alcoholifated Salt. When this ceases to rise, increase your Fire a little, and the Spirit of Wine will come off, and appear in very oily streaks. Proceed as long as you have any of these Spirits, and when the Salt begins to be dissolv'd by the watery part that ascends last, desist from the Operation, and put the Liquor thus prepared into a Vessel, which must be stopp'd very close. What remains after the Distillation throw away.

2. Take an ounce more of the same Roots, cut very small, put 'em into a Retort, pour upon 'em the Liquor drawn off before, and distill till the Salt, which will come off first, begins to be dissolv'd. Shake the Salt and Spirit, till they are thoroughly mix'd together, and stop 'em in a Vessel as close as possible, under the Title mention'd.

U S E.

THE Alkali of the Tartar, absorbing the Acid of the *Sal-Ammoniac* (*Process* 106.) sets its pure Alkali free, and so renders it volatile, which being united with the pure distill'd Spirits of Wine, makes with these the volatile Salt of the preceding Process; and with this again, from the natural disposition of the Alcohol, the *Spiritus Rector* of the Angelica unites itself, which resides in its balsamic oily part, and is very volatile. Hence the nature of the Alcohol, which equally unites with all these kinds of Spirits, is here determin'd by the particular Spirit of Angelica, so that now we have a Spirit of Angelica according to *Process* 69. In the mean time too, the volatile and fix'd alkaline Salts, and the acid Spirit of the Sea-Salt, help to open the Body of the Angelica during the Distillation, and thus cause it to give out its Oils and Spirits more successfully. The Liquor thus produc'd, on account of its fragrance, grateful taste, penetrability, mobility, and saponaceous, anti-acid, and anti-austere virtue, furnishes us with a Medicine, which, in the Hand of a skilful Physician, may be used with great success: For it is of service in all watery, pituitous, cold, acid, and austere Diseases, in cases where the Bile don't perform its office, and in almost every Disorder, where there is a *Languor* without any Inflammation and Putrefaction, particularly, when at the same time, an irregular mobility of the Nerves and Spirits, causes such troublesome hypochondriacal and hysterical Paroxysms; and in *Flatus's* that arise hence, it proves an excellent Remedy. It is a noble cardiac, stomachic, calefacient, sudorific, diuretic, diaphoretic, antiparalytic, antispasmodic, and antepileptic Medicine, where the Disorders are owing to the causes abovementioned. The Credit of this is particularly owing to *Basil Valentine*, and *Franciscus Sylvius*, who first introduc'd this noble kind of Medicine into Physick. The Followers of *Sylvius*, however, by an unseasonable use of it, have frequently brought it into disgrace. This instance that we have given you now, will serve for every thing of this kind; for by substituting any other aromatic, as Flowers of Lavender, or the like, you will always have a new and excellent Medicine.

P R O C E S S CXXIV.

A compound aromatic (Sal-Volatile) volatile Salt.

A P P A R A T U S.

TAKE of the compound Spirit described *Process* 72, 24 ounces, put it into a clean Retort, and then add 6 drachms of Salt of Tartar, and 2 ounces of *Sal-Ammoniac* reduc'd to Powder, and mix and distill as in the preceding Process. By this means then, there will rise a white, alkaline, spirituous, oily Salt, which must be kept for use.

U S E.

YOU have here another, and indeed better method than the former, of preparing aromatic, oily, volatile Salts, for medicinal purposes. This is easily understood from what has been said *Proc.* 69, 70, 71, 72, 106, 123: For from the conspiring Vertues of these Spirits, are prepared noble Medicines when they are used with judgment, which at pleasure may be varied an infinite number of ways.

P R O C E S S CXXV.

A particular Preparation of an aromatic (Sal-Volatile Oleosum) oily, volatile Salt.

A P P A R A T U S.

THE Title of this *Process* promises a Medicine that by its singular Vertue, shall answer some particular physical intention. Thus if you want a volatile Salt, to help the exclusion of the *Fætus*, or provoke the *Lochia*, or *Menses*, take of the distill'd Oil of Juniper, Rue, Savine, and *Arbor Vitæ*, of each 2 drachms, dissolve them in 20 ounces of alcalifated Alcohol, so as to prepare a Quintessence according to *Process* 67, to which add 2 ounces of a pure, dry, volatile, alkaline Salt, and thoroughly shake 'em together. By this means then they will be sufficiently united, if your Salt is but dry, and you will have such a *Sal-Volatile* as you want.

U S E.

HERE again you have a third, and pretty good method of preparing an oily, spirituous, alkaline Salt. If from Botany and Physick, therefore, we knew the particular Vertues of Plants, as we are sure from Chemistry that their singular Powers reside in their Oils, then by this method we might prepare these Salts to answer the ends proposed. Thus from Oil of Lavender, Rosemary, and Sweet-marjoram, we have a cephalic *Sal-Volatile*; from the Peel of Oranges, Citrons and Lemons, Bawm, Cinnamon, and Nutmegs, a Cordial, &c.

P R O C E S S CXXVI.

An extemporaneous Sal Volatile Oleosum.

A P P A R A T U S.

1. TAKE of Salt of Tartar, p. 1. of *Sal-Ammoniac*, p. 111. of Aromatics reduced to Powder p. 12. of rectified Spirit of Wine p. 36. mix 'em in a Bolthead, and shake 'em together for a considerable time. By this means, the alkaline Salt, discharg'd from the *Sal-Ammoniac*, will go into the Alcohol,

Alcohol, which will swim at top, its Water being attracted into the other Salts. At the same time too, the Salts and Spirits will extract the Oil from the Aromatics. The Liquor then, that immediately swims at top is the *Sal Volatile* desired; as was observed by the famous *Le Mort*.

2. Take of a distill'd aromatic Oil, p. 1. put it into a Cucurbit, add Salt of Tartar p. 3. *Sal Ammoniac* p. 9. and with a Fire that is but just sufficient to make the Salt rise, sublime into a large Head. Keep up this degree of Fire as long as any of the Salt continues to ascend, then take off the Head, and scraping off the Salt with a crooked Knife upon a Paper, or glaz'd Plate, bruise it a little, and immediately put it into a clean, dry, cold Vessel that has a Stopper ground to fit it as nicely as possible, and in this manner let it be kept. Thus you have a volatile, oily, saponaceous Salt, whose nature will be determined by that of the Oil you made use of. At present this is of great note in *England* in hysterical Disorders, &c.

U S E.

THUS then you have a Chemical History of these volatile, oily Salts, prepar'd indeed after different manners, but pretty nearly of the same efficacy, depending upon this volatile *Sapo*, which arises from the union of the Spirits of the Alcohol with the *Spiritus Rectior*. These now, after the famous *Franciscus Sylvius* had published his *Praxis Medica*, An. 1671. *Otto Tachenius* his Treatise *De Morborum Principe*, and *Bontekoe* his Works, were all over *Europe* esteem'd of vast consequence in the Practice of Physick. In inflammatory Disorders, however, in alcalious Scurvies, in a putrid broken *Crafs* of the Humours, and in consumptive Habits, where the Body is ready, as it were, to dissolve, they have done great, and often irreparable mischief. And let the Physician be here seriously cautioned, not to suffer their Male Patients of a softer make, but their Female ones more particularly, to smell so frequently to these Salts, for hence the olfactory Nerves in the *Membrana Schneideriana*, and others, are destroy'd, and the tender Arteries of the Nose and Lungs are disposed to bring on Hæmorrhages, that are always dangerous, and frequently fatal.

These things then being dispatch'd, I think I have sufficiently demonstrated to you the chemical *Analysis* of animal Substances; and have shewn you at the same time, various Methods of compounding again their separated parts, for chemical and medicinal Purposes. And from what has been said, it appears, that by Putrefaction, and Distillation both of putrified and crude animal Bodies, may be procured, 1. A certain, fetidish, volatile, fine Spirit, that is mixed with Water, and can scarcely be separated from it. 2. A Water, which in purity comes pretty near to elementary Water, except that it will hardly ever quite part with that Spirit. 3. A volatile alkaline Salt. 4. A fine volatile Oil. 5. A thicker Oil. 6. An Earth, which is always found to be the same. 7. A Phosphorus, and in that, perhaps, a heavy Acid. And 8. a Sea-Salt, when that is used in the Food of the Animal, otherwise not. It is evident now, that these Productions, let 'em be depurated and separated ever so nicely, and advanced to their greatest perfection, will not, by being compounded by any Art whatsoever, be restored to their original form and vertues, but will compose new Bodies, which have scarce any thing like 'em in the whole compass of Nature. What wonder is it therefore,

fore, that all the parts of Animals should by Putrefaction become volatile and fly off into the Air, or should insinuate themselves into the Earth, and that those Particles that were carried aloft, should mix with Rain, Fogs, Dew, Hail and Snow, and with them descend again to the Earth, and sink into its Bosom? And hence why should it seem strange, that from these again should arise the Elements of Vegetables, mutable by their seminal Power into their former Nature; and that thus the exhausted strength of the Earth should be recruited, and it should be rendered capable of producing new Food for Animals, to be converted by their natural Powers into the constituent parts of their Bodies? Certainly, whatever the Earth spends in the nutrition of Animals and Vegetables, it receives just as much from them again, when they come to be destroyed, and putrified.

P R O C E S S CXXVII.

The Phænomena of Blood, and its Serum, with Air, Water, Fire, Salts, acid, alcalious, and saline, Spirits, Oils, and Soaps.

A P P A R A T U S.

1. **I**N an Air that has any degree of Heat in it, betwixt 32 and 94, good Blood becomes concreted into a solid Cake, separates into *Serum* and a red Mass, and at length totally resolves, becomes liquid, putrifies, grows volatile, and at last flies all off into the Air, except a small fixed part of it. In any degree of cold in the Air, from 32 to 1, and lower, the same Blood forms itself into a Cake sooner, freezes, and by freezing has its Water separated from the other Elements, and frozen into a distinct Mass. And whilst it continues in this frozen state, the Water is continually and surprisngly lessened, and is in a short time dissipated into the Air, whilst the other part, when it comes to thaw, soon dissolves into a sanious Liquor, putrifies, becomes very volatile, and quickly flies off likewise. In an Air that is something more than 120 degrees hot, nothing like which ever happens in our Atmosphere, it begins to be coagulated into a solid Mass, and so on quite to 214: But if the Heat is increased farther, it is again dissolv'd. It admits a certain quantity of Air, divided into its Elements, and disposed betwixt its Particles and no more. If you endeavour by shaking to mix more Air with it than what it thus spontaneously admits, you lose your labour; for it either repels it, or by inviscating it, forms it into Bubbles, and so retains it separately, without admitting it equally through its Substance.

2. In Water from 32 to 94 degrees warm, Blood is at first diluted, but at last becomes concreted together; as it does in boiling Water immediately. Hence therefore it cannot be retained fluid by Water, unless assisted at the same time by the Attrition it receives from Circulation; for a brisk motion of it, even in Water, out of the vital Vessels, can neither preserve its fluidity, nor render it fluid again when it is once coagulated, as has long appeared by a curious Experiment of the famous *Ruyfch.* If it is put into Water, however, and exposed to the Air, it will by degrees grow putrid. It is not true, therefore, that either cold or warm Water will of itself dilute Blood: But Well-water seems to coagulate it more than Rain.

3. Fire

3. Fire, from 33 degrees to 100, makes Blood putrify, resolves it, separates it, and renders it volatile: A greater degree, quite to 220, coagulates it: A still greater resolves it again, and renders it putrid immediately.

4. The Acid of *Mosel* and *Rhenish* Wine, common Vinegar, and distill'd Vinegar, dilutes Blood, scarcely alters its Colour, and in some measure preserves it from Coagulation. The Acid of Sea-Salt coagulates it in an instant, and changes it to a greyish Colour inclining to black. Spirit of Vitriol and Sulphur in the same manner harden it into a Mass, which is for the most part whitish. A volatile Alkali scarce coagulates it, and preserves the red Colour. A fix'd Alkali rather dissolves than condenses it. A volatile oily Salt, in some measure coagulates it. *Sal-Ammoniac*, Nitre, *Sal-Gem*, Fountain, and Sea-Salt, and Borax, preserve and exalt the redness, and somewhat prevent a Coagulation: As do likewise the common Soaps, and the *Sapones Philosophorum*. The Spirits of Alcohol coagulate it. Oils inviscate it. In none of these Cases, now, is there any appearance of an Effervescence or Ebullition, but the Colour and Consistence are the chief Articles in which we observe any alteration. Regenerated Tartar made well, and poured upon Blood, preserves or exalts its Colour, and beautifully secures its fluidity; and of course the Liquor of tartarified Tartar does the same; as *Venice* Soap does nearly likewise. But *Helmont's* Tincture of Salt of Tartar, in regard to its Alcohol, which is here exceeding strong, rather coagulates it; tho' at the same time, in respect of its other part, it prevents the Coagulation's being so speedy. The best *Sal Volatile Oleosum*, being mix'd with Blood, without being diluted, on account of its Alcohol, somewhat inspissates it rather than attenuates it. A Liquor compounded of Spirit of Vinegar, and a volatile alkaline Salt (*Process* 108.) excellently attenuates, dilutes it, and preserves its natural Colour.

5. If Metals corroded by Acids, and by this means reduced to a compound Salt, are dissolv'd in Water till it is perfectly saturated, upon being mix'd with Blood, they often immediately make a surprising alteration in its Colour and Consistence. Vitriol of Iron, prepared in this manner, turns it almost black, and coagulates it. Sugar of Lead, made with Vinegar, or Spirit of Nitre, does the same; as corrosive sublimate of Mercury does nearly likewise. But Oil of Mercury, which I prepare with the crude Body, and the strongest Oil of Vitriol, does the same most powerfully, and soonest of all. And yet these Mercurials given in a small Dose, most certainly, and most expeditiously dissolve the whole Mass of Blood into a thin cadaverous Fluid, which soon penetrates and sweats through all the Emunctories of the Body.

U S E.

HENCE then we learn in some measure the sensible effect that the Bodies mentioned will have upon our Blood, by being simply mix'd with it. The injecting these into the Veins, has likewise, by their sole admixture, produced the very same Effects in living Animals. The same Bodies, however, taken into the Stomach by the Mouth, have often operated in a vastly different manner. There are others likewise, which, by the communication of but an infinitely small part of 'em, induce prodigious alterations in the human Body without any sensible change of the humours; as we see particularly in Poisons. We must
not

not infer, therefore, that because certain Substances, upon being mix'd with the Blood out of the Vessels, have such and such effects, that hence they will have the same, if they are taken into the Body, and mixed with it in the course of Circulation. But again, from what has been said, we see that soft Bodies, by being mixed with them, dilute and dissolve our Humours, rather than acrid ones; and that there can by no means happen any Effervescences in the vital Blood, whilst it is contained in its Vessels; certainly none such as can excite so great a force as is necessary to overcome such great obstacles, and give the circulating Fluids such a degree of velocity. *Paracelsus*, therefore, *Van Helmont*, *Des Cartes*, *Sylvius*, and others, have without foundation assumed this to explain those things that happen in the Body. Nor does the fatal error of those Physicians hence less evidently appear, who unreasonably condemn'd Acids, under a false notion of their coagulating the Blood, because they saw that this happen'd in Milk. *Hippocrates* certainly was more in the right, who from a strict observance of Nature, judg'd Vinegar to be of service in inflammatory Diseases; and yet here the Blood is condens'd. We cannot, however, upon this head, pretend to determine safely concerning the efficacy of an Acid upon the Blood, except we first settle the particular kind we dispute about. The use of fossil Acids is dangerous, that of Vegetable ones more safe: Nay, and those which are look'd upon as Solvents, often prove Coagulents.



CHEMICAL OPERATIONS,

P A R T III.

Upon F O S S I L S.

I. Upon S A L T S.

P R O C E S S CXXVIII.

An Examination of Nitre.

A P P A R A T U S.

1. **I**N our Operations upon Fossils, it is proper we should first begin with Salts, as these are almost always necessary in the Preparations of the others. And as amongst all the Fossil Salts, Nitre, by its origin, comes nearest to Animals and Vegetables, hence we shall treat of that first; for it belongs as it were to all the three Kingdoms. And indeed as it is produced from putrified Animals that take in no Sea-Salt with their Food, an Alkali, and Lime, to what class can one refer it? But of this I treated sufficiently, Vol. I. p. 28. This however does not seem to be the Nitre, or *Nitron* of the Ancients.

2. If Nitre is put into a clean Crucible, and exposed to a gentle Fire, it will all melt, without any crackling, and will stand like pure Water in the Crucible. And by this means it is not chang'd in its Nature, exhales scarcely any thing, but insinuates itself through the Crucible, does not become alkalious, nor acrid, being poured out hardens into solid Masses, but never flames when it is thus melted, or is ignited, and hence is falsely call'd an inflammable Salt. If you throw a red hot Coal into it, indeed, whilst it is in this state, it will burst into Flames immediately with a very great noise and agitation, and on this account it has been said to be inflammable. Being taken however into the human Body, it cools it more than any other Salt whatever.

3. In all these Vessels I have some very pure Nitre dissolved in a sufficient quantity of clean Water, and filtered. Into these different Portions of it now, I pour various Acids, and the Liquors do not discover any Ebullition, Effervescence, or Agitation, nor grow opake or turbid. To another Portion of this Solution of Nitre, therefore, contained in this Vessel, I add some very pure Oil of Tartar *per Deliquium*, and it immediately, as you see, becomes opake and turbid, and presently forms some *Fæces*, which precipitate to the

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bottom,

bottom, from which, if you pour off the Liquor that swims at top, it will not afterwards grow turbid by the affusion of a fresh Alkali. The same happens in some measure too upon pouring in a volatile Alkali. This then is the nature of Nitre.

U S E.

HENCE it appears, that Nitre is neither an Alkali nor an Acid, nor of itself inflammable; and that of all Salts it melts in the Fire most readily.

P R O C E S S CXXIX.

The Purification and ChrySTALLIZATION of Nitre.

A P P A R A T U S.

1. TAKE the common Nitre of the Shops, dissolve it in 6 times its weight of boiling Water, filter the *Lixivium* whilst it is boiling hot, put it into a clean cylindrical Vessel, evaporate it with a clear Fire till a Pellicle appears on the surface, and then set it by in a cold place, and lay some clean Sticks in it, upon which there will be soon form'd some long, pellucid, hexagonal Prisms. Collect these together, put 'em upon a clean earthen Plate, full of Holes that the Water may drain off, and let the Nitre dry of itself in the Air.

2. Dissolve Nitre in 8 times its weight of boiling Water, whilst it continues boiling hot run it through a filtering Bag, soon after drop into it some of the purest Oil of Tartar *per Deliquium*, mix 'em well together, drop in some more, mix 'em again, and so proceed till it is no longer disturb'd by the affusion of the Alkali. Boil the *Lixivium* for a moment, filter it boiling hot till it becomes exceeding limpid, inspissate it to the formation of a Pellicle, and set it by with Sticks in it as before, in a clean cylindrical Vessel, and in a cold place. By this means, then, you will obtain the same sort of prismatical Crystals as the former. Nor does it appear by any Experiment, that there is the least Alkali adhering to these Glebes of Nitre. This Nitre is very pure, nor do I know any method by which it can be rendered more so.

3. Take the nitrous *Lixivium* that remains after the first Crystallization, No. 2. dilute it with an equal quantity of clean Water, boil it up once in a clean Vessel, filter it boiling hot, evaporate to a Pellicle, set it by in a cold place, and it will shoot into more good Crystals, which must be dry'd in the manner directed, and will give you a pure Nitre. If after you have separated these, you treat the remaining *Lixivium* in the same manner, the event will be again the same, and so on, till at last the remaining pinguious Liquor will refuse to be form'd into Crystals any longer, nor will be dried without great difficulty. And this is not only the case with the *Lixivium* of Nitre that has an Alkali mix'd with it in order to purify it, but with that likewise, where there is only Nitre dissolv'd, without any such addition. This last is a very singular saline Liquid, remaining a good while fix'd in the Fire.

U S E.

U S E.

1. **B**Y this method then, we have an exceeding good medicated Nitre, which is very light, and of a particular bitterish Taste, and which being taken into the human Body, wonderfully cools and attenuates the Blood, checks venereal inclinations, and gives the Blood a scarlet Colour. But it is chang'd too itself in the Body, not remaining immutable there like Sea-Salt, but being converted into such an animal Salt as we have already examin'd. Both the fluid and solid parts of Animals being pickled with this Salt, are intirely preserv'd from Putrefaction, and become exceeding red. In every inflammatory Disease therefore, where there is phlogistic density of the Blood, this Salt is the most excellent attenuant, and at the same time is no ways injurious, either by its too great Weight or Acrimony; nor does it cause any considerable degree of thirst, but very happily prevents the alcalescence of the human Salt, and the Putrefaction of its Oil. On this account, therefore, Nitre truly deserves the name of an antiphlogistic Salt.

2. In this Process you have an instance of the CrySTALLIZATION of Salts, which is the collection of saline Elements of the same kind into compact Glebes, which in every sort are of a constant and singular figure. And this depuration depends upon that Law of Nature, by which, when different Salts are dissolv'd in Water, and that is reduced to a certain proportion in respect of 'em, they begin to acquire a power of uniting together their own proper saline Particles, and so repel both the Water, and the other Salts. And for this reason, if various Salts are mix'd together in Water, and this is by any means drawn off, that always begins to shoot first that requires the greatest quantity of Water to keep it dissolv'd, for the Particles of this first begin to associate together, and repel those that will remain diluted in a less quantity of Water. If any Salts therefore whatever should require exactly the same quantity of Water to dissolve them, it would be exceeding difficult, when they were once blended together, to separate them from one another, which is done now with a great deal of ease and certainty, as we see by the Method describ'd, the Nitre is perfectly separated from its Sea-Salt, No. 1. and from the Salt of Tartar, No. 2: For if you take Nitre that is perfectly purified from its Sea-Salt by CrySTALLIZATION, and distill it, you will have an acid Spirit that will dissolve Silver, but will not touch Gold; whereas if a very small portion of Sea-Salt had remain'd mix'd with it, it would have yielded an *Aqua Regia*, and not an *Aqua Fortis*. And again, the same Nitre dissolv'd in Water, and purified by means of a fix'd alkaline Salt, by CrySTALLIZATION alone expells all the Alkali; for in Distillation it is converted into such an Acid, as would not have been produc'd, had the fix'd Alkali still remain'd united with it. Here therefore we see a wonderful attracting and repelling power, in the action of Salts.

3. These Crystals, if they are well prepared, are always pellucid, and exactly of one particular figure. And whilst they continue in this form, they always consist of Water and Salt united together by a certain Law, and in a certain Proportion. This is evident, for if you put these Crystals into a clean glass Vessel, and cover it with an Alembic, and expose them to the action of the Fire, they constantly give out a pure Water; but then at the same time they

they grow white and opaque, and losing their figure moulder into an irregular Powder. If this Powder, however, is dissolv'd again in Water, inspissated, and crySTALLIZ'd, both the figure and pellucidity will be again restored. This therefore they shou'd consider, who talk about the figure of a saline Element. Nitre now, that is purified in this manner, remains dry in the Air, nor will easily dissolve with its Moisture.

P R O C E S S CXXX.

Nitre and Tartar produce an Alkali in the Fire.

A P P A R A T U S.

I Have here of the purest, driest Nitre, reduc'd to a very fine Powder, 6 ounces; and of the purest, driest Cream of Tartar powdered likewise, the same quantity: These I have taken care to have thoroughly mix'd together, by rubbing them in a clean Mortar, and then had the Powder well dried. An ounce of this Powder then I now put into a very clean, dry, hot brass Mortar, and apply to it a little bit of a live Coal, upon which it immediately catches into a Flame, with a great noise, throwing out Sparks, and diffusing a very strong Smell, and in a short time leaving a white Mass that is here and there a little upon the green. As soon as ever the Deflagration is over, and whilst the Mass continues very hot, I sling in half an ounce more of the same Mixture, which deflagrates in a moment, as before, but quicker, as every thing is now become hotter. I proceed then in this manner, till all the Powder is deflagrated, and has produc'd a white Matter a little greenish, which is homogeneous, except that there are a few Particles dispersed up and down, which have not sufficiently undergone the action of the Fire: These therefore must be carefully separated from the other part; and on this account it is better to throw in but a little quantity at once, for then the Fire acts upon the whole more equably.

U S E.

HENCE we see, that Nitre, which of itself is not inflammable (*Process* 128.) when it is mix'd with Tartar, which is oily (*Process* 55.) upon the application of Fire to it, immediately, like Gun-powder, takes Fire with a great noise and agitation. And here we learn, that the compound Salt of the Nitre and Tartar, which is evidently acid, by the sudden action of the flaming Fire, is converted in an instant into an Alkali, which the moment before did not by any indication whatever discover itself, either in the Nitre or the Tartar. Nor indeed, is there any other Method known, by which from a Mixture of Salts not alkaline, but distinguishing themselves by a remarkable acidity, a strong fixed Alkali can be so soon produc'd; for the Salt that is left after this Deflagration is an acrid, strong, fix'd Alkali in every quality, and in every chemical, medicinal, and physical Effect. It must be confess'd indeed, that there is some little difference betwixt this and other fix'd Alkali's, as upon pouring Oil of Vitriol upon it, there rises a Spirit which is still Acid, and has evidently the Smell

Smell of Spirit of Nitre, and so demonstrates, that there is still some true Nitre remaining in this Alkali, as will appear farther *Process* 134: But there is but little of it. This therefore is the best method of preparing a fix'd Alkali when you want it in haste. This conversion, however, of Nitre into a fix'd Alkali will not appear so strange to a Person that is appriz'd, that there is no Nitre produc'd in *Europe*, into which there does not originally enter some fix'd Salt of Wood-ashes. The Salt prepar'd in this manner dissolves in the Air immediately.

P R O C E S S CXXXI.

An Alkali from Nitre with live Coals of Wood.

A P P A R A T U S.

TAKE a large strong Crucible, fill it with very dry Powder of Nitre thrown loosely in, and place it where it may stand sufficiently firm. Round it at a distance lay a circle of live Coals, which gradually bring nearer and nearer, that thus the Crucible, with the contained Powder, may by degrees be equably heated quite through, for fear, otherwise, the Crucible shou'd fly: When they are grown thoroughly hot, place as much Fire round 'em as is sufficient to melt the Nitre intirely, and keep it standing in the Crucible in the form of Water. Then take a little bit of Wood-Coal perfectly red quite thro', and gently lay it upon the Nitre in fusion, and at rest; and the very moment this is done, the Coal will burst into a Flame, will make a Noise, and run about the Surface of the melted Nitre, and will be pretty soon consum'd, the Flame then going out, and the Nitre growing quiet again as it was before. As soon as ever all is at rest, throw in such another bit of Coal, and you will have all the same *Phænomena* over again. Proceed then in this manner gently, and with care, till the Nitre in the same degree of Fire loses its fluidity, and becomes fix'd, nor will any longer make the Coal flame that is thrown into it, which at length always happens. And when you are near the end of your Work, as the Nitre begins to lose its fluidity, it will fly about violently, and the Coal that is thrown in will often leap out of the Crucible. When this is the case, proceed very patiently, and make your Fire a little stronger. When thus at length the Coal will be lighted no longer, let the Fire gradually sink, and you will have a Mass in the Crucible, which will have a hollow at the top where the last Coal burnt. This Mass then will be solid, heavy, whitish, greenish, alkaline, and igneous, and will spontaneously and immediately dissolve in the Air, for which reason you must break the Crucible, and take it out whilst it still continues very hot, and then put it up into a clean glass Vessel, and stop it very close.

U S E.

1. **H**ERE the Eye perceives that the Nitre is not set on fire by the Coal, but that betwixt the inflammable Matter of this, and the melted Nitre, there arises a prodigious expulsive and repulsive Motion; for as soon as ever the little

little Coal is consum'd, the Nitre appears without any visible agitation, nor is there any Flame excited again, till upon another bit of Coal's being thrown in the same Motion is renewed. Hence the consumption of the inflammable Matter of the Coal, seems to be accelerated by the melted Nitre, whereas it wou'd otherwise have been consumed much more slowly. And this accelerated action of the Fire upon the combustible Matter seems to increase the force of its burning; and hence the effect of the Nitre upon combustible Bodies, when it is assisted by Fire, seems to be only this violent repulsive Motion with which the Matter thrown in, if it is not too small, is driven from the Nitre with an explosive *Impetus*, after which the whole Body of Nitre soon becomes perfectly quiet.

2. The Ashes of the burnt Vegetable remaining after the deflagration is over, are by that very Motion converted into a fix'd Alkali, and that a pretty pure one, and which of all soonest dissolves in the Air. But the Alkali produced here in so great a quantity does not arise only from the burnt Vegetable's leaving a fix'd Salt in its Ashes, but from the Nitre too which is chang'd at the same time. This then is a second Method by which Nitre is converted into an Alkali. And this Alkali is in its nature vastly attractive of Moisture, and hence immediately dissolves in the Air, and then runs into a very strong, alkaline, igneous Liquid, and leaves a considerable quantity of Ashes. And if this Salt, as soon as ever it is made, is dissolved in pure rain Water, and filter'd, and the *Fæces* that remain in the Bag are wash'd with such a quantity of Water, that they retain no Salt at all, and are afterwards dried; then if all the *Lixiviums* are inspissated to the thickness of Oil of Tartar *per Deliquium*, you will have such a Liquor as the former: And if you then weigh the dry Ashes, you will hence see how much Earth remained after the Operation, and consequently how much Salt from the burnt Vegetable cou'd concur towards producing this fix'd Alkali; by which means too you will discover how much the Nitre contributed to it likewise. This generally goes by the name of *Nitrum Alcalisatum*, or *Nitrum Fixatum*, Alcalisated, or Fix'd Nitre.

P R O C E S S CXXXII.

Sal Prunellæ from Nitre.

A P P A R A T U S.

1. **M**ELT the pure Nitre of *Process* 129 in a clean Crucible, and as soon as ever it is in fusion pour it out in little thin Cakes upon a clean Marble, and keep these, which are of excellent medicinal vertues, under the Title mention'd.

2. Take some Flowers of red Poppies, infuse them in hot Rain-water till it is well colour'd, then strain it, and dissolve in it the same Nitre. Inspissate, and crystallize according to Art, and dry the Crystals, and you have another *Lapis Prunellæ*, call'd Crystal Mineral, which was formerly kept as a great secret for a certain Antiphlogistic.

3. To 4 ounces of the purest Nitre in fusion in a clean Crucible add 1 scruple of the best Flowers of Sulphur; upon which there will in an instant break out a violent Flame of the colour of Lightning, which as soon as the Sulphur

is consum'd will immediately go out. Repeat this three or four times, and then let the Nitre be pour'd out into little Cakes, for medicinal uses, under the title of *Sal Prunellæ*.

U S E.

NITRE prepar'd in this manner, agrees perfectly in its Vertues with that of *Process 129*: Nay I prefer that before it, so that I think so much trouble is by no means necessary, purified Nitre answering the end intirely. Here we see, however, that Nitre, when it is in fusion, and at rest in the Fire, has the very same effect upon inflammable Sulphur thrown into it as it has upon a live Coal, that is to say, it makes it burn away sooner, and more fiercely. This gave rise to the Invention of Gun-powder, which consists of Sulphur, Nitre, and Charcoal. This name now of *Sal Prunellæ*, was given it by the *Germans*, on account of its very happily curing an epidemical Camp-Fever, attended with a threatening blackish *Angina*, which therefore they call'd *die Bräune*. And as they found the *Symphytum petræum* of *Lobellius* us'd with success in the same case, they gave that Herb the name of *Prunella* likewise. The Salt prepar'd in this manner is by no means alcalious.

P R O C E S S CXXXIIL.

Sal Polychrest.

A P P A R A T U S.

1. **U**PON pure Nitre flowing in a Crucible in the Fire, throw in a little of the purest Sulphur, not above a scruple at a time, which will deflagrate as we took notice in the preceding Process. When the deflagration is over, throw in some more, and so proceed till the quantity of Sulphur equals that of the Nitre. When you come towards the end, the Sulphur that's thrown on will deflagrate, but not with that *Impetus* and Brightness like Lightning, which appear'd at first, but with a sulphureous Flame. Keep the Matter red hot in the Fire for the space of an hour, and then the Salt will be here and there reddish, but otherwise greyish, or of an Ash-colour. If you take out the Salt, however, immediately after the deflagration is thus perform'd with an equal quantity of Sulphur, without exposing it to any farther Fire, it appears to me, I confess, to be exactly of the same efficacy.

2. Or take of pure dry Nitre, and the best Flowers of Sulphur, of each equal parts, rub them together into a fine Powder, heat this cautiously, and throw 2 scruples of it into a Crucible standing in the Fire and red hot, upon which a deflagration will be excited with a vast *Impetus*. When this is over, throw in the same quantity again, and so proceed, till you have us'd all your Powder. By this means then you will have a Salt at the bottom of the Crucible exactly like the former.

3. Dissolve the Salt thus prepared in five times as much Water, boiling hot, and in a glass Vessel. Filter it whilst it continues thus hot, and evaporate till you have got your Salt pure. It will then be of a withish Colour, a bitterish, sulphureous

sulphureous hot Taste, and of such a Nature as one sometimes finds a Salt of in natural Baths. It is by no means acid, nor is it alkaline, but is compounded of the Nitre, and some part of the Sulphur, which has suffered an alteration from the Fire.

U S E.

THE Sulphur therefore, which consists of the Acid of Vitriol, and an Oil combined together, has here the greatest part of its Oil consum'd with the Nitre, whilst the acid part of its substance, though perhaps chang'd by the Fire, together with part of its Oil, becomes intimately united with the Nitre, which is alter'd by the deflagration likewise; so that you have a third neutral fossil Salt here prepar'd by the Fire. Hence you see that the Nitre, which, when it was deflagrated with the vegetable Coal, was converted into an Alkali, is here with the Sulphur chang'd into a fix'd Salt that is not alkaline, though the deflagration with the Sulphur is so long and so fierce. The Physicians, of *Paris* in particular, having had abundant Experience of the Vertues of this Salt in the human Body have call'd it (*Sal Polychrestum*) Salt of many Vertues, as it is so greatly useful, and does good in so many different Distempers. If a Person in health takes 2 drachms of this fasting, diluted in 20 times as much Water, and walks gently after it, drinking 4 or 6 ounces of common Whey, fresh made, it sometimes gently provokes to vomit, but oftener moves by Stool, and always by Urine: It promotes Sweat too, if it is assisted and determined that way by Heat, Motion, and the Admixture of Sudorifics. It attenuates a cold mucous *Pituita*; as it does likewise a condensed inflammatory one. It opens Obstructions, corrects a putrifying Bile, incites where the vital Powers are too languid, and stimulates gently and safely. Hence if it is administered with Judgment it is of service both in acute and chronical Disorders. A perfect Tertian it almost certainly cures without danger of a return, and without any obstruction of the *Viscera*. Quartans too it cures very safely, by gradually resolving the stubborn Matter of them, and hence, with sufficient reason, it is greatly esteemed. If upon simple Nitre in fusion you throw a little *Sal Ammoniac*, it takes Fire likewise: And if you repeat this to a saturation, it produces a wonderful Salt, which on account of its singular nature deserves examination.

P R O C E S S CXXXIV.

Glauber's Spirit of Nitre.

A P P A R A T U S.

UPON 18 ounces of the purest and driest Nitre reduc'd to an impalpable Powder, and put into a clean glass Retort, pour 6 ounces of the strongest Oil of Vitriol, perfectly freed from its Water. Place the Retort immediately in a Sand Furnace, cover it well over, and apply a very large Receiver, which lute on with a Mixture of Lime, Clay, and a little Sand. Upon this there will presently arise a Heat, and a red Fume. Raise a moderate Fire, and the Receiver will be fill'd with red Fumes, and a Liquor will distill

in drops. Gradually increase your Fire to the very strongest Sand Heat, and then let it spontaneously abate. When the Heat in the neck of the Retort is gone off, remove the Receiver, taking care at the same time to have by you a dry strong glass Bottle with a Funnel standing in it. Pour the Liquor out of the Receiver into the Funnel under the Chimney, using all possible caution, that the red Fumes don't come at your Lungs; for they are acrid, igneous, and exceeding volatile, and diffuse themselves about surprizingly. As soon as ever the Spirit is in the Vessel, stop it close with a glass Stopple ground nicely to the Neck. The Receiver may be likewise secured with a glass Stopple, and set by for the same use, and you will find it for some Weeks continue fill'd with a red Vapour that is never at rest. And as for the Liquor in the Bottle, which is of a golden Colour, that too fills the upper empty part with a red Vapour, even for years, as I have myself experienced; and whenever you open it, there immediately issues out a large quantity of a red, volatile Fume. This Operation is best perform'd in the coldest Winter season, and the prepar'd Liquor shou'd be kept in a cold place. When the distillation is over, at the bottom of the Retort there remains an exceeding white Salt, that is not acid.

U S E.

THE Oil of Vitriol scarce touches the Nitre, but there is immediately produced an exceeding acrid, igneous Spirit, that is vastly volatile, and perfectly nitrous, and has always the very same effect as *Aqua Stygia*, or *Aqua Fortis*, as it is commonly called, and with a fix'd Alkali is recover'd again to true Nitre. And here it is impossible to procure any more of that Spirit from the Nitre, whether you make use of more or less Oil of Vitriol, and then urge with ever so great a Sand Heat. All the Nitre, therefore, is not here chang'd from a very fix'd Salt to an exceeding volatile one, from a solid to a very fluid one, from a mild to a very acrid one, from a white to a red one, from a neutral to an exceeding acid one, and from an inactive one, to one that is vastly mobile, nay never at rest. That the Liquor now thus produced is a true Spirit of Nitre, appears evident from its Smell, Taste, Colour, Effect, and red Fumes, and its being capable of being recover'd to Nitre again; nor does it contain any thing at all of the Oil of Vitriol that is made use of, as is certain from undoubted Experiments. The other part of the Nitre, therefore, which by this Operation is not render'd volatile, unites with the Oil of Vitriol, and both of 'em become fix'd, and are converted into a white fix'd Salt, that is neither acid, nor alkaline, but a new neutral one, in some measure resembling vitriolated Tartar. From these considerations therefore the most famous of the Chemists have been induc'd to believe, that Nitre in its first original was produc'd from a pure, fix'd, alkaline Salt thoroughly saturated with the true proper Spirit of Nitre, such a one as is drawn off here. When the Oil of Vitriol therefore, which is a stronger Acid than Spirit of Nitre, comes to be mix'd with the Nitre, then they imagine, that the fix'd alkaline part of the Nitre attracts the very acid Oil of Vitriol, and that this is reciprocally attracted by the Oil, so that these two become combin'd into one Salt consisting of the Alkali of the Nitre and the Oil of Vitriol, whilst the pure Acid of the Nitre being expell'd from its proper Alkali by the superior

power of the Oil of Vitriol, is now set at liberty, and appears in its original form of a pure, red, volatile Acid. Hence they impute the whole Effect, observ'd here, to a pure separation of parts that actually existed before, and not to a production of any thing new by the action of the Fire. And this plausible Explanation of the Affair seems to be farther confirm'd by other Experiments, especially by *Process* 136, 137, 143, 145, 146, 147. If we consider, however, the production of Nitre from Animals and fix'd alkaline Salts, it seems difficult to find any Principle in these that in any form bears the least resemblance to the acid Spirit that we here prepare. And this Opinion seems still the more improbable, as the most curious Naturalists cou'd never discover any perfect Nitre that is spontaneously produc'd; nor did there ever appear, in the whole compass of Nature, such an Acid as is prepared by this method. It is safer therefore to proceed more slowly in our Conclusions from Theory, and submit to the Evidence of Experiments. In the mean time there is no contrivance, that we are at present acquainted with, by which a stronger and purer Spirit of Nitre can be procur'd than this. This sort therefore is what we always make use of when we want it most perfect for Chemical Uses. The Honour of this valuable Discovery is due to *John Rudolphus Glauber*, who, as it was a perfect secret, made a considerable advantage of it, and at length reveal'd it. Hence you see, Gentlemen, what beautiful and useful things are found out by applying Bodies to one another, and then exposing them to the action of Fire: Certainly among all the Experiments that have ever been made in the Chemical Art, this is one of the principal.

P R O C E S S CXXXV.

Glauber's sweet Spirit of Nitre.

A P P A R A T U S.

1. **T**AKE 8 parts of Spirit of Wine, reduc'd to the purest Alcohol without the addition of any Alkali, put it into a tall Bolthead, pour on it a few drops of *Glauber's* Spirit of Nitre, wait a little, and shake the Vessel, that they may be perfectly mix'd together. When every thing is quiet drop in a little more, and so proceed till you have added 1 part of Spirit of Nitre with respect to the Alcohol, always taking care to shake them well together after every instillation. Digest the Liquor for some time in the Bolthead, and then distill two or three times in a Retort, and by this means you will have a true Spirit of Nitre. *Hoffm. Phys. Chem.* p. 128.

2. If you mix in this manner common Spirit of Nitre and Spirit of Wine that is not reduc'd to Alcohol, then as both of 'em are diluted with a good deal of Water, they will not yield so generous and truly balsamic a Spirit, nor can one expect such valuable effects from it.

3. But here let me caution you, that I have often experienc'd, myself, and demonstrated to others, the very great danger of mixing the purest Alcohol, and the strongest Spirit of Nitre in great quantities: For if you put 2 drachms of *Glauber's* strongest Spirit of Nitre into a tall Bolthead, and pour upon it 6 or 7 drachms of the choicest Alcohol, there will arise a very great Heat, Ebullition, and copious Vapour, and almost all the Liquid will soon fly off with a very rapid Motion, even out of the tallest Bolthead; and if it then happens to be

receiv'd into the Lungs, it will bring a Person into eminent danger of present suffocation. In this manner I have lost the whole myself. See the famous Dr. Stare. *Phil. Tran. Abr.* Vol. III. p. 358.

U S E.

WHILST the Alcohol and Spirit of Nitre are here uniting together, there is immediately diffused a fragrant pleasant Smell, like that of Southernwood. And at the same time there appears a most violent effervescence, nay one that is ready to burst into Flame, betwixt the very acid volatile Spirit, and the pure subtil Oil, tho' it does not contain the least Alkali. If a Candle is applied to the agitated Vapour, it takes Fire immediately, fills the whole Bolt-head with Flame, and in an instant sets every thing on Fire in the most dangerous manner. The oftner now the united Liquors are digested and distill'd, the more accurately they become combin'd together, and yield a more perfect, oily, acid Salt, which possesses a truly antiseptic, balsamic, detergent, dissolving quality, and resists the putrefaction of the Bile. If it is prudently used, well diluted, and in small quantity, it very soon gives the Teeth an exquisite whiteness, but destroys them if us'd too freely. It restores an appetite, when the loss of it is occasion'd by a mucous *pituita*, a corrupted Bile, or the proper tone of the Stomach's being weaken'd. Among all the Remedies for *Flatus's* it stands the first. It is said to prevent the Stone, and even to dissolve the *Calculus* after it is form'd. This was the *Lithontriptic* of the famous *Sylvius*, which was formerly so much in esteem, and sold so dear. It provokes Sweat too and Urine, quenches Thirst, mends a stinking Breath, and is remarkably efficacious in curing the Scurvy. It is taken best on an empty Stomach, in Wine, Mead, or Ale, to the quantity of 30 drops at a time, and three or four times a day.

P R O C E S S CXXXVI.

The Regeneration of Nitre from Proceſs 130, 131, and 134.

A P P A R A T U S.

1. **T**AKE an ounce of Nitre reduc'd to a dry Alkali, according to *Proceſs* 130, 131, dissolve it in eight times its weight of clean Water, and by letting it stand quiet, and filtering it, make the *Lixivium* as clear as possible. Put this Liquor whilst it continues hot into a very clean large glass Vessel, with a narrow Neck, and then drop into it successively a few drops of *Glauber's* Spirit of Nitre. By this means then, upon the falling in of every drop, there will be excited a prodigious effervescence, during which keep the Vessel shaking about. When this is over, add a few drops more, and proceed in this manner till the Effervescence begins to grow weaker, and then drop only 1 drop at a time into the hot Liquor, and shake the Vessel about very well, and repeat this till upon the instillation of the last drop there is excited no farther effervescence. The point of saturation then being perfectly obtain'd, you will have a pellucid Liquor, in which there will begin to be formed some long *Striæ*, which are truly nitrous. This Liquor has no Smell at all, but its Taste is bitterish, and exactly like

like that of Nitre. Dilute this with Water a little more, boil it for a moment, filter it boiling hot, inspissate it to a Pellicle, and you will see it shoot into oblong, octogonal, prismatical, pellucid Crystals, which appear to be Nitre by every chemical and physical mark. Filter the *Residuum* again, inspissate as before, and let it shoot into Crystals. By this means then you will recover and collect together a true Nitre, which melts easily in the Fire, and deflagrates with any inflammable Matter that is thrown into it whilst it is in fusion, and evinces its perfect nitrous nature by every quality.

2. If any other pure fix'd Alkali, as that from Tartar or Pot-ashes, is made use of in this Experiment instead of the Alkali from Nitre, the event is always the same in every respect; so that in the Nitre regenerated there is not the least sensible difference.

U S E.

THE great *Boyle* look'd upon this Experiment as of so much consequence, that he thought it worth while to write a whole Treatise about it. And certainly it is one of the most remarkable in the chemical Art: For hence we learn, that from the most acrid, caustic Alkali, and Acid, only simply mix'd together in a just proportion, there is produc'd a neutral Salt, that is mild, cooling, and by no means corrosive; and that an exceeding odorous and volatile acid Spirit, by being attracted into a fix'd Salt, in a moment loses all its Smell and Volatility, so that now it will bear a melting Fire without becoming volatile; whence we easily conceive the vast attractive power there is betwixt the Acid and the Alkali. But at the very instant that this conflict arises betwixt them, there is an elastic and wonderfully expansive Air rushes forth, which is generated no longer than whilst this attraction is carrying on, so that it seems by the collision to be struck out of the very Body of the Acid, and the Alkali. We impute this therefore to an attraction, and strong tendency towards each other, not to any repulsion or disagreement between them; and suppose this prodigious sudden motion to arise from the Air's being violently expell'd whilst the Acid and Alkali powerfully attract one another into the most intimate union. But from this Operation we see farther, that a subtil acid Liquor regenerates in an alkaline Body a firm solid Salt: That an Alkali, which before spontaneously dissolv'd in the Air, and an Acid of Nitre which cou'd scarcely by any Art be consolidated, now they are combin'd together compose a Salt, which may be easily kept dry in the Air, and which even in Water forms itself into solid Crystals: That the Alkali is determin'd by the Acid into that sort of compound regenerated Salt, from which the Acid was originally extracted: That hence the Alkali is indifferent towards every Acid, and may be united with them all, but under this Law, that every Acid will regenerate the Mother-Salt from which it was produc'd: That the Alkali, therefore, is of itself empty, unfruitful, and feminine, whilst the Acid is masculine, impregnates it, generates an offspring of its own kind, and fixes the indetermin'd nature of the former: And lastly, that the ultimate Elements of Nitre may consist of any fix'd Alkali whatever, perfectly saturated with Spirit of Nitre, and that, consequently, its figure and all its other properties may be produc'd by these two united together. But whether now all the Nitre in the World was originally produc'd from this Acid, and fix'd Alkali, first existing

isting separately, and afterwards combin'd together, I don't pretend to know, but I very much doubt it. That Nitre however may be prepar'd in the manner describ'd, as likewise from an Earth that is full of putrified animal Substances, and the saline Ashes of Vegetables, or Lime, I am very sure of: And this is to me sufficient.

P R O C E S S CXXXVII.

A Regenerated Nitre that is not fix'd.

A P P A R A T U S.

1. **T**AKE 3 ounces of a pure, volatile, alkaline Salt prepar'd according to *Process* 106, put it into a large, clean, glass Vessel with a narrow Neck, dilute it with six times its weight of Water, and then drop into it some of the purest Spirit of Nitre. Upon this there will be excited an effervescence, exactly in the same manner as in the preceding *Process*. Proceed therefore intirely according to the directions there laid down, till you have accurately obtain'd the point of saturation, and you will then perceive, that there will presently be form'd some oblong, prismatical, octogonal, saline *Spicula*, exactly resembling Nitre.

2. Dilute this compound Liquor with twice its weight of Water, filter, inspissate to a Pellicle with a gentle Fire, set it by in a cold place, and it will shoot into nitrous Crystals. Proceed in this manner till, according to Art, you have reduc'd the whole into saline Masses, which will be Crystals of Nitre, having no Smell, but that bitterish cold Taste which is proper to true Nitre. These melt easily in the Fire, but then do not remain fix'd, but fly off. They deflagrate in the Fire too like Nitre with all inflammable Substances; and yield a Spirit of Nitre with Oil of Vitriol. Hence therefore they furnish us with a true Nitre, but a semi-volatile one.

U S E.

THIS beautiful Experiment likewise teaches us all those things which we took notice of in the preceding *Process*. But here we learn farther, that from a volatile alkaline Salt, and a volatile acid Spirit, which of all perhaps of the same kind are the most odorous, is produc'd a Salt that has no Smell at all: That from caustic Bodies arise a Salt that is very mild, and exceeding cold: That from the most volatile ones is generated a Salt that continues of itself at rest, nor becomes volatile, except in a considerable degree of Heat: That a volatile Alkali which is naturally indifferent to all Acids, is determin'd by the nature of the saturating Acid, and made to regenerate that Salt from which the Acid was produc'd: That the volatility of this regenerated Salt depends upon the disposition of the concurring Alkali, which being fix'd, the new Salt is fix'd, whereas if it is volatile, that is semi-volatile likewise: That the nature of this Salt, however, is determin'd by the Acid made use of: And lastly, that we have hence a method of preparing a volatile Nitre, about the discovery of which the Chemists in all Ages have been so greatly solicitous. The Vertues now of

this semi-volatile Nitre, as far as I have been able to judge, are nearly the same with those of the common fix'd Nitre, or the fix'd regenerated one, but something milder; the difference betwixt them being pretty much the same as that betwixt Sea-Salt and *Sal-Ammoniac*.

P R O C E S S CXXXVIII.

Glauber's Alcahest.

A P P A R A T U S.

TAKE the alkaline Salt of *Process* 131, lay it on a glass Plate, and expose it to the open Air in a low cold place, that is not dusty. By this means then it will begin spontaneously to dissolve, and run into a Liquor, which must be carefully pour'd off into a clean glass Vessel. Set the *Residuum* again in the same place, separate the liquid part as it melts, and so proceed till all the Salt is become fluid. There will then remain a good deal of Ashes, and you will have a Liquor, which being filter'd becomes limpid, alkaline, thickish, and exceeding like Oil of Tartar *per deliquium*.

U S E.

THIS is that very famous chemical Liquor, which was kept such a secret, and was so boasted of by its Author *Glauber*, that he did not scruple to sell it for the true *Alcahest*. But we have often seen, that when these *Arcana* come to be known, they lose all their reputation. And why mayn't we say the same thing here? For my own part I confess, though I have taken a good deal of pains about it, I never cou'd discover any thing particular in it, or that was not in Oil of Tartar *per Deliquium*, in what manner soever I made trial of it. But it is more troublesome to make, you have less of it, and it costs more money; and hence it is valued.

P R O C E S S CXXXIX.

Nitrated Nitre.

A P P A R A T U S.

TAKE of a *Lixivium* of the purest Nitre 8 ounces, drop into it of the best Spirit of Nitre 30 drops, inspissate to a pellicle, and reduce to Crystals according to Art. These then will be perfectly nitrous in every respect, but of an acid Taste, and go by the name of *Nitrum Nitratum*.

U S E.

THIS Process serves only to shew the method by which some complete Salts may be united with the Acid drawn from them into the form of a compound Salt. This now, by adding a greater or less quantity of the Spirit, will be more
or

or less acid. And the acider it is, the more difficult it is to dry, and the harder to keep dry, almost always dissolving spontaneously. Nitre acidulated in the manner describ'd is of excellent use in burning Fevers, where the tongue is dry and foul, and the patient is thirsty.

PROCESS CXL.

Vegetating Nitre.

APPARATUS.

IF in the preparation of *Glauber's Spirit of Nitre Process 134*, you take 4 parts of Nitre, and 1 of Oil of Vitriol, and after all the Spirit is perfectly drawn off, leave the white dry Salt, that remains at the bottom of the Retort, in the open Air, in a short time its whole surface will be covered with a very thick and pretty long Down, which makes it look as if it vegetated, and which I don't remember to have seen in other Salts. But when the same residuary Salt is dissolved in Water, filter'd, inspissated to a dryness, put into a cylindrical Glass, and so left in the Air, its surface often seems to sprout out into the perfect resemblance of little Plants full of Branches. These all however dissolve, and fall again, upon the application of Heat to 'em, and the surface becomes plain, though upon setting the Vessel again in the free Air they shoot out again as before; so that these Plants seem to be reviv'd again from their own Ashes, concerning which some of the Chemical Tribe have given such extraordinary accounts, the foundation of which I am apt to suspect lay in this Art.

USE.

FROM this elegant Experiment, then, we see, that the very easy Crystallization of Nitre gives us an opportunity of representing as it were a kind of Vegetation. Some of the more credulous of the Artists indeed have talk'd of a true one, under the Title of a *Palingenesia Vegetabilis*, but I am of opinion, they never were able to make it appear.

PROCESS CXLI.

Spirit of Nitre with Bole.

APPARATUS.

1. **T**AKE of pure Nitre reduced to Powder ~~th~~is, of common red Bole ~~th~~ivfs, mix them accurately together, and put them into two such earthen long Necks as are describ'd, *Vol. I. p. 503*, taking care that when they lie horizontally in the Furnace described, *p. 513, 514*, and with the *Apparatus* there sufficiently explained, nothing of the Matter shall fall into the Necks. The cylindrical Segments and Receivers being luted on, apply a little Fire that they may gradually warm, and then every quarter of an Hour add a little more, till by this gradual increase they are perfectly hot quite through. When this is the

the case, a humid Vapour will begin to come over into the Receiver, upon which gradually increase the Fire for two hours, till the Vapour changes its Colour from white to reddish. Raise your Fire still higher by degrees, till the Vapour comes off quite red, and keep it up for the space of three hours. And lastly, increase your Fire so long, till the Vessels are perfectly red hot, and you can see the Matter red hot in the long Neck through the glass Receiver, and continue it in this strength for two hours longer. Then shut the Furnace, and let the whole cool gradually, and as soon as ever the earthen Cylinder that is placed betwixt the long Neck and Receiver is grown cold, very cautiously remove the Receiver, keeping as clear as possible from the Fumes, and through a glass Funnel pour the distill'd Liquor into a glass Bottle, which must be nicely secured with a glass Stopple, and set in a cold place. Thus then you have a very acid, acrid, caustic Spirit of Nitre, that exhales very red Fumes, and is exactly like *Glauber's* Spirit of Nitre, *Process* 134, but never so strong. When the Distillation has proceeded most successfully, I have had, with regard to the Nitre made use of, $\frac{9}{16}$ or $\frac{1}{2}$ and $\frac{1}{16}$ of such a Spirit.

2. The Bole that then remains at the bottom with the *Residuum* of the Nitre, still retains a nitrous Taste. All this I have boiled in a large quantity of Water, filter'd the Liquor that swam at top whilst it was boiling hot, and then proceeded to boil the *Residuum* with fresh Water, and so on, till the Water at last would fetch out nothing more. All these *Lixiviums* I then filtered till they became a limpid Liquor of a nitrous Taste. This I inspissated, till I reduced it to a small quantity of about the thickness of Milk, which had a Taste that was not very acrid, but lixivious however, and in some measure alcalescent. This Liquor I examin'd, by pouring into it various Acids, and I found it chang'd from the nature of Nitre, and in some degree alcalious, but yet not a true Alkali.

3. In this Operation it is necessary to take care, that the Turf or other Fuel you throw in during the Distillation, is first made very hot, for otherwise its coldness will make the long Necks fly: For this reason too, when you open the Door of the Furnace, you must see that the cold Air don't rush in too suddenly, for that too will crack the Vessels. And at the same time take care likewise, that upon opening the Door, the Flame don't burst out violently upon you, and burn you, or with the Air be received into your Lungs.

U S E.

1. IF pure Nitre is put into a glass Retort, and plac'd in a sand Furnace, it melts long before the Glass; and when it is heated to such a degree as to flow, it will not grow any hotter, tho' you increase the Fire; nor if you keep it there in Fusion for a long time, will it give out any acid Spirit, but will remain fix'd, exhaling very little. If you treat it too in the same manner in a Retort, made of *Hessian* Earth, and urge it with a very intense Fire, there will no acid Spirit come over into the Receiver, but it will insinuate itself through the Pores of the Retort, and be almost all lost.

2. If you intimately mix Nitre with 3 times its weight of Bole, Clay, or Tobacco-pipe Earth, reduc'd to Powder, and then put 'em into a Crucible, and set 'em in the Fire, the Nitre will not melt, but will fume and exhale an acid Vapour, and by this be almost all pretty soon dissipated into the Air.

3. Hence

3. Hence then it appears, that the Fire acts in a very different manner upon Nitre, when it is prevented from flowing by the interposition of 3 times as much of some other Matter that will not melt, and is able to heat it to a much greater degree, than when it is in Fusion by itself, and then suffers no farther alteration from the Fire. And the change that is by this means effected, consists in the rendering a fix'd Body volatile, a mild one acrid, a solid one fluid, and a neutral one very acid, all which is purely owing to the Nitre's being prevented from melting: The same alteration now we saw before produc'd by the help of Oil of Vitriol, and a sand Heat, *Process* 134. That these things happen in this manner is past dispute; but whether now in the Spirit thus prepared, there is contained any Liquor produced from the Bole itself, has been much inquired into, especially as it is asserted, that when the Bole has been once used for this Operation, it won't answer the same end again, as you can't then by the help of it draw this Spirit of Nitre. But certainly, the Spirit of Nitre made with Oil of Vitriol *Process* 134, that prepared with the *Calx* of Vitriol, under the Title of *Aqua Fortis*, and that drawn with calcin'd Alum, are absolutely like this, without almost any difference at all; and yet in the Preparation of these, there is no admixture of Bole. Let the Experiments therefore on both sides be carefully observed and consider'd, and 'tis likely time will discover which is in the right. *Dabit dies quod hora negat.*

4. But again, some of the modern Chemists, and those of the first rank too, will have it, that Nitre consists of an Alkali, and the proper Acid of Nitre, as we have already taken notice *Process* 134, 136, 137; and the incomparable *Homborg*, by a subtil, and very laborious Experiment, has inferr'd the proportion of the Alkali to the Acid, to be as 480 is to 183. But by this Distillation, however, the acid Spirit drawn off is but $\frac{2}{18}$ ths of the Nitre made use of, and from the *Residuum* you can scarcely procure any thing alcalious, whence it is evident that this Spirit is produced from the Nitre, actually altered by the Fire, and does not arise purely from a separation of an Acid and Alkali that existed before in the Compound. The wonderful action of the Fire, therefore, has the same effect here, as we saw Oil of Vitriol had before. As never therefore any true Nitre spontaneously appeared in Nature, nor ever any of its Spirit has been discovered but what was first produced from Nitre by the help of Oil of Vitriol, or the action of an intense Fire, assisted by somewhat to keep the Nitre from melting, hence we are induced to believe, that an acid Spirit of Nitre did never exist in the World, before the method of making Nitre, and the Art of drawing a Spirit from it were discovered: This at least is as much as we can deduce from Chemical Experiments. Nor cou'd Gunpowder possibly be produc'd either by Art or Nature, before this invention of Nitre, even supposing, that setting aside this one thing we had been acquainted with all Nature besides.

5. If with Nitre you mix the red Colcothar of Vitriol strongly calcin'd, or calcin'd Alum, in a certain proportion, by this means too the Nitre will be kept from melting in the Fire, and hence will be capable of acquiring a greater degree of Heat, and will yield an acid Spirit in considerable quantity with very red Fumes, and will exactly resemble the true Spirit of Nitre of this *Process* in every character. But besides the Colcothar's, and the calcin'd Alum's preventing the Nitre's melting by the interposition of their parts, we must here consider

likewise, that in both of them, notwithstanding their Calcination, there still lies concealed a very strong Acid, and that in great quantity, call'd Oil of Vitriol, or Alum. This therefore, when it comes to be agitated by the action of the Fire, enters into the Nitre, dislodges its Spirit, takes possession of its place, and when the Spirit is expell'd, produces some *Fæces*, in which the Salt, call'd the *Panacea Duplicata*, pretty much resembles that generated in the Preparation of Glauber's Spirit of Nitre, *Process* 134. Hence therefore arise all *Aque Fortes*, the production of which depends intirely upon the principles laid down in the *Process* cited. And certainly the Operation of the *Metempsychosis* of these saline Spirits is very surprizing, whilst they thus expell one another from their former Seats, and take possession of them themselves, and hence produce a great variety of *Phænomena*, intirely unexpected. But on this Head, see *Vol. I. p. 480. & seq.* So far, however, as we have hitherto been able to discover, Oil of Sulphur *per Campanam*, Oil of Vitriol, and Oil of Alum, are one and the same Acid, which has this property, that it will expel all other known Acids from the Body that retains them, will render them intirely volatile, occupy their place, and after the former acid Spirits are separated, the *Residuum* forms a Body of its own nature, that is to say, of the genius of this very strong Acid. *Aqua Fortis*, then, is a mere Spirit of Nitre; for Colcothar, by no action of the Fire, continue it ever so long, can be quite freed from its Acid, and hence this remaining in the *Caput Mortuum* of the Vitriol and Alum, is attracted into that part of the Nitre which is not convertible into an Acid, is united with it by the Fire, forms with it a new kind of Salt, and entirely expells all the other acid Spirits in the form of *Aqua Fortis*. As for those Chemists, therefore, who say they can, by a chemical Distillation, convert the whole Body of Nitre into a Spirit of Nitre, so as from a pound of Nitre to procure the same quantity of Spirit by a true Transmutation of the whole, I confess they seem to me to assert somewhat impossible, and absolutely repugnant to the Chemical Art. This, after a great deal of pains taken upon this Head to come at the truth, I cannot help thinking.

6. The Spirit of Nitre of this *Process*, Glauber's Spirit of the Nitre, and common *Aqua Fortis* rightly prepared, constitute a nitrous Acid, which by its red Fumes, and singular Smell, distinguishes itself from every other. This Spirit, with a fix'd Alkali regenerates true Nitre, and it dissolves Silver, and the other Bodies treated of already, *Vol. I. p. 468.*

PROCESS CXLII.

The Purification and ChrySTALLIZATION of Sea-Salt.

APPARATUS.

TAKE the best Sea-Salt of the Shops, dissolve it in 6 times its weight of the purest Rain-water, and filter the Brine boiling hot through a linen Bag made of thick Cloth till it becomes exceeding limpid. Evaporate $\frac{2}{3}$ th part of the Water in a clean glass Vessel, and let the remaining *Lixivium* stand cool and quiet for the space of three days, the Vessel being covered that no Dust may fall into it. If it deposits any *Fæces* during this time, let the Liquor

Liquor be gently pour'd off from them ; if not, it is fit for Chryftallization. Evaporate then this Brine to a Pellicle, and let it ftand quiet in a cold place for eight and forty Hours, and it will fhoot into cubical Cryftals. Carefully pour off the remaining Brine from the Salt, and let that be dried with a clean Heat, and kept by itfelf; for this is what I chufe for chemical ufes. Let the Brine that is left be inſpiſſated again, till a Pellicle appears, and you will in the ſame manner have new Cryftals. And if you repeat this Operation ſufficiently, you will at laſt have a thick, pinguious, rough Liquid, that is not dried without difficulty, and can ſcarcely be reduced to a farther Cryftallization. If the Salt thus obtain'd is calcin'd by decrepitation, and then melted with a ſtrong Fire, and pour'd out upon a very dry ſmooth Stone, it will diſſolve in the Air, and depoſite terreſtrial *Fæces*. And if the liquid part is again ſeparated from theſe, and is inſpiſſated, calcin'd, pour'd out, and then diſſolved in the Air, as before, and you repeat this a ſufficient number of times, it will at laſt all fly off into the Atmosphere, and diſappear, as a very ancient Chemical Writer obſerved very juſtly.

U S E.

WHAT was ſaid before of Nitre *Proceſs* 129, is confirm'd again by this new Experiment, *viz.* that cryſtallization is the only method by which Salts are procur'd pure and ſimple, an innate vertue, when they are diluted in a certain quantity of Water, uniting together the ſimilar Elements, and ſeparating them from all others ; and that the Water's being attracted more by the Elements of one Salt than thoſe of another, is the reaſon that upon inſpiſſation ſome of 'em extricate themſelves, and ſhoot ſooner, others later. Unleſs now Salts are firſt purified in this manner, you will in vain expect to draw ſuch pure Spirits from them as are abſolutely neceſſary for ſome particular purpoſes. Thus for inſtance in the Diſtillation of Nitre, if there happens to be any portion of Sea-Salt among it, you will have an *Aqua Regia* and not an *Aqua Fortis*. And the ſame thing is true, when Nitre happens to be mix'd with Sea-Salt. The Salt thus prepar'd is ſo properly the ſolvent of Gold, that without the aſſiſtance of it in ſome degree Gold can never be diſſolved, except by Metals in fuſion. This Salt is a wonderful Baſam, by means of which all animal and vegetable Subſtances are preſerv'd from putrefaction.

P R O C E S S CXLIII.

Glauber's Spirit of Salt.

A P P A R A T U S.

1. **U**PON 3 parts of Sea-Salt prepar'd according to the preceding *Proceſs*, and put into a Retort, pour 1 of the beſt Oil of Vitriol. The very moment then they are mix'd together, there riſes from them a volatile, white Vapour, of which take all poſſible care, for it is ſuffocating, and at once may injure the Lungs beyond remedy. Preſently fix on a large cold clean Receiver, and lute the Joint. Upon the application then of the very leaſt Fire, you

will for a good while see a sylvestrian Spirit fly about with such a violence, that it will perspire through the Lute with a strong Blast, or else wou'd burst the Vessels. This therefore very gently expel for the space of three or four hours, and then raise your Fire a little, and there will come off a Liquor that is not so volatile. After eight hours is spent in the Distillation, urge it to that degree as to make the iron Pot red-hot, and keep up the Fire till the Liquor ceases to come over. Let the whole then spontaneously cool, and when the Neck of the Retort continues hot no longer, remove the Receiver. The distill'd Liquor will then send out a Fume, of which beware. Pour this into a Bottle, stop it very close with a glass Stopple, and set it in a cold place, for otherwise the Vessel is often burst by the force of the Vapours. Nay if you open the Bottle after years, there will immediately issue out a suffocating white Vapour. If you put this Spirit into a Cucurbit under the Chimney, and with a gentle Fire draw it off into a Receiver, there will come off a volatile Spirit, and there will remain a Liquor at the bottom of the Cucurbit, of a yellowish Colour inclining to green, that will exhale nothing, but will be more fix'd and quiet, whilst the acid Liquor in the Receiver will be vastly suffocating and volatile. This therefore may be kept very close by itself.

2. With 3 parts of the purest dry Sea-Salt mix in a Retort 2 parts of clean Water, and then add 1 part of the choicest Oil of Vitriol, taking care to drop it in gently, lest from the sudden Heat that wou'd arise from mixing it in too great a quantity at once, the Vessel shou'd be broke. Upon doing this the whole will grow warm. Place your Retort then in a Sand Furnace, apply a large Receiver, and for the first four hours distil very gently, that the Water that was added may be leisurely drawn off, for if this rises very fast it always cracks the Receiver. This being done, gradually increase your Fire, and there will ascend a Spirit of Sea-Salt, which will discover itself by streaks in the Receiver uniting together and running down in various convolutions. Then raise your Fire freely, urging it till at last the iron Pot becomes red hot, and nothing more will come over into the Receiver. The Spirit then will emit no Fumes. When the whole is grown cool, take off the Receiver, and pour out the Spirit, which neither fumes, nor is suffocating. If you distil this Spirit in a clean Cucurbit with a gentle Fire you will have a Water that is very gratefully acid, and being mix'd with Juleps, is of excellent service in those Distempers where it is proper; and there will then remain at the bottom a choice pinguious Spirit of a golden greenish Colour.

3. In both these cases there is left at the bottom of the Retort an exceeding white Salt, that is very fix'd, and will not melt without a very strong Fire: But this we shall consider nicely when we come to *Process* 145.

U S E.

IT is pretty surprizing here, that Oil of Vitriol shou'd cause so volatile a Spirit to rise from such a very fix'd Salt as Sea-Salt, when it is mix'd with it alone, and yet that this Spirit shou'd be immediately fixed by being mix'd with pure Water after it is drawn, and should not be generated when you mix Oil of Vitriol with a strong Brine of Sea-Salt for this Operation, or when you dilute your Oil of Vitriol with Water, before you mix it with the Salt; for by these three methods

thods this wonderful volatile Spirit becomes fix'd, and the fatal suffocating quality of it is prevented. When the Spirit is thus fixed, and render'd salutary, if you expose it to a Heat of 100 degrees, it lets go its Water, and at the bottom of the Vessel there remains a strong, very pinguious, thick, gratefully acid, and fragrant Spirit of a green Colour, which is as good a Spirit of Salt as it is possible to make by any Art whatever. But as we observed before of the Nitre, so here again, there is only a certain portion of the Sea-Salt converted into an acid Spirit, the other part always remaining fix'd with the Oil of Vitriol: And indeed I have scarce been able to procure more than one third pure Spirit, free from Water. This Spirit now has the common properties of Acids, and some singular ones. It is particularly grateful to the Stomach, creates an Appetite, attenuates any mucous Viscidities there, promotes Digestion, resists Putrefaction, and corrects the Bile, when it grows acrid and putrid, or exceeds in quantity. It is of excellent Service too in extirpating a Gangrene of the Gums, Mouth, and Tongue. According to *Van-Helmont*, it prevents the generation of the Stone in the human Body, and dissolves it when it is form'd. And it eases the Strangury that is apt to happen to Persons in Years. If this Spirit now, when it is very strong is mix'd with three times as much of the choicest Alcohol, and they are accurately combin'd by two or three Distillations, you then have an oily, acid, balsamic, volatile Salt, that is exceeding fragrant, and of incomparable Vertues. And lastly, when this Spirit is drawn some number of times from Sea-Salt, and render'd very strong and generous, it dissolves Gold. All things consider'd therefore, I may venture to say, that this Liquor of Sea-Salt cannot be sufficiently extoll'd. And for this very useful Experiment too we are indebted to the industrious *Glauber*.

P R O C E S S CXLIV.

Spirit of Sea-Salt with Bole.

A P P A R A T U S.

1. TAKE of the best dry Sea-Salt 6 pound, put it into two earthen Long-necks that hold exactly 3 pounds a piece, set them in the Fire, cover them with Tiles that nothing may fall into them, and then surround them with Fire first at a distance, and then gradually nearer and nearer, till at last it touches them on every side, and lies upon them. By this means then, the Salt will decrepitate strongly, and for a considerable time; but when the Long-necks with the Salt are grown red hot, the crackling will cease. When the Fire is mouldered away, you will have an exceeding white Salt, divided into very small Particles, which will decrepitate in the Fire no longer. In this Decrepitation, now, the Salt loses nearly one quarter part of its weight, but setting aside its not crackling as before, it remains without any alteration, tho' it will melt very easily. By this method the Salt is render'd fit for Distillation, but if you go to distill it before it is decrepitated, when it comes to grow hot, it flies about the Vessels, and gets into the Receiver, and thus disturbs the Operation, and sometimes too breaks the Vessels. This *Sylvestrian* crackling Spirit, however, being expell'd by such a Calcination, it will bear the action of the Fire very quietly.

2. Take

2. Take of this Salt, as soon as ever it is decrepitated, 3 pounds, powder it immediately in a hot Mortar, and as soon as possible mix with it in a large Bason 10 Pounds of common red Bole, rubbing them well betwixt your Hands for a considerable time. Divide the mixture into two equal parts, and put it into two such Long-necks as are described *Vol. I. Pl. X.* taking care that when these are disposed horizontally in the Furnace, the Matter shall not fall into their Necks. Place the Long-necks in the Furnace, and make up the Cavity round them with Bricks and Mortar, so that it shall be quite close, and the Mouths of the Vessels shall come out beyond the Furnace Wall. Apply to these cylindrical Segments and large Receivers, exactly in the same manner as was directed in the Distillation of Spirit of Nitre, *Process 141.* This being done, raise a gentle Fire, and keep it up for the space of four and twenty hours, that the whole may grow thoroughly hot; then give a pretty strong Fire, and there will rise a Vapour which will cover the Receiver with a white Cloud, and render it opake, and at the same time will appear upon it in form of dewy drops. Continue the Fire in this degree for the space of two or three hours, and then increase it, upon which the Receiver generally grows clear again, and discovers some pinguious streaks running down upon it. As soon as these appear, you may raise your Fire to the highest degree, and keep it up for the space of six or eight hours more, that the Vessels may be perfectly red hot. When you see no streaks of Spirits run any longer with this intense Heat, desist, and leave the whole till it spontaneously begins to cool. Then carefully remove the Receivers, and pour out the pure Liquor that is collected in them. This then is of an acid Taste, a grateful fragrant Smell, and a green Colour, and is obtain'd to about the value of 3 ounces, from every 8 ounces of Salt. The Operation being finished, there remains at the bottom of the Long-necks a salt Bole. This I have boiled in Water, filter'd the *Lixivium* till it was perfectly limpid, and then inspissated it, and by this means, have procured a considerable quantity of a yellow Salt that was not alcalious, but saline and styptic, and that seem'd to be a new kind of Salt. And this I have almost always found to be the case, and therefore can't help being surpriz'd at *Beguinus*, and others, who have asserted, that they cou'd convert the whole substance of the Salt into a very choice Spirit. For my own part, I confess, tho' I have used the utmost care, and urged it with the greatest degree of Fire kept up for a long time, I never cou'd draw off half so much Spirit as I put in Salt, unless there was some Moisture either in the Bole or Salt before the Operation. This Distillation of Sea-Salt requires a more intense Fire than that of Nitre.

U S E.

THE quantity of this Spirit, again, makes it evident, that there is but a certain part of the Salt converted into Spirits, and not the whole. In this Distillation, there is always towards the end a white Matter inclining to the yellow, that fixes itself to the upper part of the Receiver, and has a sweetish, saline, styptic Taste. And this I observed to be collected in greater quantity when I mix'd the Salt with Clay instead of Bole. This seems to me to be produc'd from a pinguious Earth and Salt mix'd together. The Salt procur'd from the *Caput Mortuum* is vastly extoll'd by *Van Helmont* for the Preparation

of *Butler's Stone*. The Spirit has the same Character and Vertues that are mentioned *Process* 143, and therefore we shall not trouble you with a particular account of them, but refer you thither.

PROCESS CXLV.

Glauber's Sal Mirabilis.

APPARATUS.

BREAK the Retort you make use of for the Preparation of *Glauber's Spirit* of Salt, take out the white fixed Salt that remains at the bottom, pound it, put it in a Crucible, and keep it in the Fire till it flows, taking care that none of the Coals fall into it; and then dilute it with hot Water: Or dissolve the Salt in the Retort, by pouring hot Water upon it. Filter the *Lixivium* almost boiling hot, inspissate it to a Pellicle, and set it by in a cold place, and by this means it generally hardens into an icy Mass. Or if it should happen still to continue fluid, it will grow solid by pouring it out into another Vessel. But if that Salt is dissolved in 6 times as much hot Water, and is then inspissated a little, and set by in a large glass Vessel, it will shoot into exceeding beautiful Crystals, which are pretty large and durable, nor afterwards melt in the Air.

USE.

THE Author of this noble Discovery, with a great deal of reason called this a *Sal Mirabilis*, not only as it was an intirely new one, but on account likewise of its wonderful Effects. I know indeed, some of the systematical Chemists assert, that this is nothing more than a true vitriolated Tartar, which was known long before *Glauber's* time. But certainly, the same Properties are never found in vitriolated Tartar, as one sees here, whether you consider the Figure, Taste, or Effects: For if this Salt rightly prepared, is reduc'd to Powder, and mixed with 3 times its weight of Vinegar, Ale, Wine, or Water, and set by, it makes them freeze. If whilst it is in Fusion in a Crucible, you throw into it, by pieces, one quarter part of Antimony, it surprisngly dissolves it, and has many other Effects, concerning which it is worth your while to consult *Glauber*, *Boyle*, *Becher*, and *Stahl*, Gentlemen of uncommon penetration in the more abstruse Mysteries of the Chemical Art; with whom likewise we must join the great *Homberg*. In Surgery it is of excellent service against Putrefaction and a Gangrene. And internally it produces happy effects, gently stimulating, resolving, and promoting a discharge both by Stool and Urine.

PROCESS CXLVI.

The Regeneration of Sea-Salt.

APPARATUS.

DILUTE 4 ounces of Oil of Tartar *per Deliquium*, with 3 times as much clean Water, pour the Solution into a tall large Cucurbit that has a small Mouth,

Mouth, make it pretty hot, and then drop in either some of *Glauber's Spirit of Salt*, or that prepared with *Bole*. Upon this there will be excited a prodigious Effervescence, which being over, shake the Vessel that they may be well mixed together. Then drop in some more, and so proceed till the Alkali is perfectly saturated with the Acid. The point of Saturation being obtain'd, let them stand quiet, and when the Liquor has deposited its *Faces*, and is grown clear, gently pour it off, filter it, and when it is limpid, inspissate to a Pellicle, and set it by in a cold quiet place, and it will shoot into Crystals, which manifestly discover themselves to be Sea-Salt by their Taste, and every other Property. This therefore we may assert is true Sea-Salt. What remains after this first Crystallization, inspissate to a Pellicle again, and set by as before, and you will have more Salt like the former. This Salt is intirely fix'd in the Fire likenative Sea-Salt.

U S E.

THE vegetable Alkali here, which of itself is equally disposed to receive any Acid, is, by being saturated with the acid Spirit of Sea-Salt, determined into the particular nature of that Salt alone. Compare this with the issue of the Experiment made with Nitre, *Process* 136, and it seems greatly to confirm the Doctrine of an Acid, Alkali, and compound Salt. Consult every thing too that we have mentioned there upon this head, for it all holds good here likewise.

P R O C E S S CXLVII.

The Regeneration of Sal-Ammoniac.

A P P A R A T U S.

TAKE of the alkaline Spirit of *Sal-Ammoniac* 4 ounces, dilute it with twice as much clean cold Water in a tall large Cucurbit with a narrow Mouth, and through a Funnel drop into it a little Spirit of Sea-Salt prepar'd in either manner, taking care that it falls directly upon the Liquor without touching the sides of the Cucurbit. Upon this there will arise a very great effervescence, which being over, proceed cautiously according to the directions frequently given, till you have most exactly obtained the point of Saturation. And here there is more than ordinary care required, because if you add more Acid than is necessary to saturate the Alkali, it will remain united with the regenerated Salt; whereas in the preceding *Process*, if the Acid was predominant in the fix'd Salt, it might be separated from it by the Fire: Here if you endeavour to do the same, both the acid and the regenerated Salt, inasmuch as it is not fix'd, will exhale together. The Saturation then being nicely obtain'd, the Liquor will be exceeding limpid, inodorous, of the singular Taste of *Sal-Ammoniac*, and though you boil it, will not give out any saline Vapour. Filter this Liquor, inspissate it to a Pellicle, set it by, and there will be form'd in it very fine saline Elements, somewhat like Down, and exactly resembling those that are generated in a *Lixivium* of *Sal-Ammoniac*, treated in the same manner.

If you inspissate the Liquor, according to Art, till a dry Mass remains at the bottom, you will have a white Salt that is truly ammoniacal in every respect, and with a proper Fire may be sublim'd into true Flowers of *Sal-Ammoniac*.

U S E.

THE volatile alcali of Animals and Vegetables, which of itself is equally disposed for the reception of all Acids, is here determined by the Acid of Sea-Salt, into a Sea-Salt, but a semi-volatile one. Compare this with *Process* 137, and the Rule observed before seems to be confirmed, that the Acid determines the Alcali into a Salt of its own nature, whilst the Alcali is the cause of its fixity or volatility. As a volatile Alcali therefore is continually produc'd in great abundance from putrified Animals and Vegetables, hence if there was a Spirit of Sea-Salt dispersed throughout the world, then wherever these two met together they would produce a *Sal-Ammoniac*, whilst the same Spirit meeting with a fixed Salt in the Ashes of Vegetables, would immediately generate a true fix'd Sea-Salt. But tho' it is easy enough to demonstrate such an Alcali by Experiment, it is vastly difficult to make it appear, that there is any such Acid naturally existing, unless one was acquainted with that *Arcanum* of Mr. Boyle, who tells us, that by a secret long continued Digestion, Sea-Salt may be disposed to part with its Acid by a gentle Heat, before any Water ascends, and that without mixing any thing else with it. *Mech. Qual.* 234.

P R O C E S S CXLVIII.

Vitriolated Tartar.

A P P A R A T U S.

I. TAKE of the purest Oil of Vitriol 3 ounces, dilute it with 3 times the quantity of clean hot Water in a large tall Cucurbit with a narrow Mouth, and pour into it, by drops, Oil of Tartar *per Deliquium* till the Saturation is exactly complete; for otherwise, in this case there will remain a very prejudicial alkaline, or acid Acrimony. Upon every Instillation of the Oil of Tartar, there will be excited a very violent Effervescence, and a white Salt will be generated long before the Acid is saturated, and will fall to the bottom of the Vessel. When you have found the point of Saturation, shake the Liquor about for a good while, and then if it tastes neither acid nor alkaline, take a little of it out, heat it, and divide it into two parts, into one of which drop one drop of Oil of Vitriol, into the other a drop of Oil of Tartar *per Deliquium*, and if there then appears no Effervescence in either, the Saturation is nicely obtained, which is very necessary here for medicinal Purposes. But if upon dropping in the Acid an Effervescence is excited, it is a proof that the Alcali abounds; and the contrary. The *Equilibrium* being obtained, dilute the Liquor with a good deal of Water boiling hot, that all the Salt may be perfectly dissolved. Whilst it continues thus hot, filter it, and then inspissate it, and reduce it to Crystals, according to Art, and you will have a white Salt of a middle Taste, that requires a large quantity of Water to dissolve it intirely. When you have obtained all

the Crystals you can, there will remain a Liquor at the bottom, which will not shoot any longer, as happens in Nitre, Sea-Salt, and almost every other sort.

2. Some famous Chemists, and among the rest *Tachenius*, have been of opinion, that the Oil of Vitriol, by being exposed to so intense a Fire in the preparing it, carries up along with it somewhat metaline, and thus gives this acid Salt a noxious quality that it is not easy to free it from afterwards: They contrived therefore to procure the native simple Acid from the Vitriol, before it had suffered any thing from the Fire, and then united it with the fix'd Salt of Tartar. To this purpose therefore they dissolve the Vitriol in Water, so as to obtain a thin Liquor, which being filtered till it becomes pure, they drop into it some Oil of Tartar *per Deliquium*, upon which it grows turbid, and the Iron precipitates to the bottom in form of a yellow Ochre. In this manner they proceed, till at last, upon dropping in of the Alkali, there is caused no farther Precipitation. This point they observe very nicely. This being done, the Mixture is set by till all the metallic *Fæces* are subsided, and then the clear Liquor at top is filtered, inspissated, and crystallized as before. By this means then you obtain a vitriolated Tartar without Fire, and, as they imagine, without any suspicion of an acid corroding quality. And indeed, if there is no appearance of a blue or green Colour in the Liquor and the Salt prepared from it, this is sufficiently pure, but otherwise retains something of Copper in it, and therefore is of a hurtful nature.

3. If you treat any pure volatile Alkali in the same manner, either with Oil of Vitriol, or Vitriol dissolved in Water, you will have the same kind of Salt, but more penetrating, and semi-volatile, whereas the other was surprisingly fix'd. And this Salt, prepare it in what manner you will, is considerably heavy and solid, and yet at the same time is sufficiently soft, and aperient.

U S E.

THIS Salt, if it is taken, diluted in Broth or Whey, upon an empty Stomach, is wonderfully aperient, especially if it is assisted with moderate exercise; for then, by attenuating, resisting putrefaction, and stimulating, it so powerfully frees the obstructed *Viscera*, that it has obtained the name of the *Universal Digester*: *Tachenius* called it *Vitriolum non-metallicum*. From the 136th, 137th, 146th, 147th, and 148th *Proteffes* now, it is evident, that those Bodies that are most acrid and corrosive when they are alone, *viz.* these Alkali's and Acids, upon being mix'd together become perfectly mild. Hence therefore we see, that two Liquors that wou'd prove Poisons were they taken separately, may be drank together without any inconvenience; nay that the ill effects of one of them might be prevented by drinking the other presently after it. We learn farther too from what has been said, that Water lies wonderfully concealed in Salts, and at last may be extirpated from them: For the acid Spirit of Nitre contains 60 parts of Water, to 19 of true Acid; Spirit of Salt 52 to 13; and Oil of Vitriol 60 to 37; that is to say, supposing these Acids to be as strong as they can possibly be made. In the second case, therefore, the Water must have lain concealed in the decrepitated Sea-Salt in so considerable a quantity. From the whole then we see, that there are but very few simple fossil Acids: For that of Alum, Sulphur, and Vitriol, is the same; *Aqua Fortis*, and Spirit of Nitre,

Nitre, differ very little; and the Spirit of Sea-Salt, *Sal-Gem*, and Fountain-Salt, are perfectly alike.

II. Upon S U L P H U R S.

P R O C E S S CXLIX.

The examination of Sulphur.

A P P A R A T U S.

PERFECT Sulphur is found in the Mines in very various forms. Sometimes it is smooth and yellow; sometimes yellow, and almost clear like Amber; at others of a gold Colour, approaching to a Ruby, and nearly pellucid; but more frequently of a grey Colour, and opaque. If any of these sorts are put into a Crucible, and exposed to the Fire, they easily melt, and whilst they are in Fusion appear red and pellucid, but become opaque as soon as ever they are cold. As soon as ever it melts, if it has a communication with the external Air, it very readily takes fire, burns with a blue Flame, and emits a Vapour, which being received into the Lungs suffocates all kind of Animals, and thus it intirely consumes, leaving hardly any *Fæces* behind it. If it is melted, but not set on fire, it sends forth a strong, and as it were, sub-aromatic Vapour, but not a suffocating one. As soon as ever it is in Fusion, part of it flies off into the Air, and if it is kept a good while in this condition without taking fire, it by degrees becomes totally volatile, and disappears. When it is cold, it is very brittle; when it is melted it hangs together like Pitch: In both forms it refuses to be mix'd with Water. When it is pure and unmixed, it will by no means dissolve in Alcohol. If the Powder of it is mix'd with any kind of Acid or Alkali whatever, it does not discover the least sign of an Ebullition or Effervescence; so that in this respect, it does not produce the effects either of an Alkali or Acid. If it is taken crude into the human Body, in a small Dose, but frequently repeated, it wonderfully purges the first passages, and at last pretty strongly, and then efficaciously cures some cutaneous Diseases, as well as Disorders arising from Worms, and Mercury. All these things now, except the last, I here demonstrate to you by Examples, and they always succeed in the same manner.

U S E.

THUS then we in some measure understand the nature of Sulphur, as it spontaneously offers itself to our examination. And hence we see why the Chemists have call'd it the Refin of the Earth, as it comes near to a Refin in its other properties, though it will not dissolve either in Spirit of Wine or Alcohol.

P R O C E S S C L.

Flowers of Sulphur.

A P P A R A T U S.

1. **T**AKE of the common Sulphur of the Shops 6 ounces, put it into a Cucurbit made of *Hessian* Earth, fit a large glass Head to it, lute the Joints with a Lute made of equal parts of Ashes and Clay work'd together with Water, place the Cucurbit in a Sand Furnace, taking care that the Sand reaches to the Rim of the Head, and that the Beak of the Head, and the Cucurbit lean forwards a little, that the Moisture may distill into the Receiver. This being done, gradually raise your Fire till the Head begins to be clouded with the yellowness of the ascending Sulphur; and there will come over a little Water into the Receiver. Keep up this degree of Heat very nicely, so that the Flowers in the Head may not be melted, and yet the Sulphur in the Cucurbit may be sublim'd. Proceed in this manner for the space of eight hours, at last increasing your Fire to that degree, that if the lower Limb of the Head was but a little hotter, the Flowers in it wou'd melt. By this means then the Sulphur will be sublim'd into a very fine, soft, yellow Matter, almost like Wool, which goes by the name of Flowers of Sulphur.

2. This demonstration is sufficient for our purpose. But these Sublimations are commonly made with Furnaces contrived on purpose for this work, which have two distinct parts, one which contains the Sulphur to be sublim'd, and under which the Fire is made; the other, which communicates with the former by holes, and is kept cold. Both these are very nicely stop'd up, so that no Air shall come into either of them. The Sulphur then being acted upon by the Fire in the first Partition, is rendered volatile, and propell'd into the second cold one, and is there collected. When the Operation is over, and all is grown cold, the Furnace is open'd, and the Flowers are taken out of one part, whilst the other is charg'd again with fresh Sulphur. And by this means, as they can sublime a great quantity at a time, and with little trouble or expence, the common Flowers of Sulphur come very little dearer than the Sulphur itself.

U S E.

BY this Operation the Sulphur is attenuated and purified, but in other respects suffers no alteration. Hence it becomes exceeding fit for internal medicinal uses, as by being thus divided it exerts itself in the Body more efficaciously. It by this means becomes better likewise for external applications in Surgery, especially when it is to be mix'd up with Balsams, Liniments, or Ointments. Thus then we learn the wonderful Nature of Sulphur; for sublime it ever so often, it always remains the same, being neither altered, nor becoming fix'd. It can never, therefore, be converted into a Metal, nor ever enter into the composition of one; and hence it is not the *Sulphur Philosophorum*: Nor can that ever be made from it, as this is nothing but an Oil combined with an Acid. So long as the open Air is kept from it whilst it is in Fusion, it suffers no alteration from the Fire, but as soon as ever that has access to it, it very readily takes

takes fire, flames, is altered and separated into different parts. *Paracelsus* orders these Flowers to be sublimed from the red *Calx* of Vitriol, and commends the Flowers thus produced in Ulcers of the Lungs. This therefore I tried, but could not find that they were so much better than the common Flowers as he would make them.

P R O C E S S C L I.

The acid Spirit of Sulphur.

A P P A R A T U S.

1. **I**N cool moist Weather, when there is no Wind, melt some of the best Flowers of Sulphur in a Gally-pot that is 3 inches deep, and as many broad. When the Sulphur is quite melted, but not on fire, place the Vessel upon the Hearth under a Chimney that don't smoke at all, and then light the Sulphur, covering it immediately with a glass Bell, so that the Flame shall be just in the middle of the Glass. And here you must observe to hold the Bell over the Vapour of hot Water before you use it, that its internal surface may be a little moistened; and it must be set upon three Bricks disposed in a triangular manner, so that it shall but just suffer the Flame to burn, for the nearer it comes to the Flame without putting it out, the better. When the Flame is almost extinguished, remove the Gally-pot, and have another ready with melted Sulphur, which set on fire, and place in its room. And in this manner proceed the whole day. In the Bell then there will be collected, at night in particular as it grows cooler, a heavy acid Vapour, that exhales from the Flame of the burning Sulphur. To this let there be applied a wide mouth'd Glass for a Receiver, and let the Bell be plac'd leaning in such a manner, that the Liquor may run into it. By this means then, with a good deal of trouble, and some number of Bells, you will procure a Liquor that is gratefully acid, heavy, and sometimes red, and that is wonderfully fix'd in the Fire, requiring as great a degree of Heat to raise it, as Oil of Vitriol. It attracts Water too very powerfully, and hence if it stands in an open Vessel, it gradually increases in weight. If all the cautions mention'd are observed, the Operation always succeeds in this manner.

2. Monsieur *Homburg* however, being tir'd with this tedious method, contriv'd one much easier and better, by which may be obtain'd 5 ounces of this Liquor in four and twenty hours. This you have in the *Mem. de l'Ac. Roy. des Sc.* 1703. p. 31. & seq. and is as follows. Take the biggest Receiver you can get made, in which cut a circular hole in the bottom, of 8 or 10 inches wide. In order to do this, with a Thread let down a Bullet from the middle of the Mouth, and on the outside mark the point with a Diamond where the Bullet rests at the bottom. Upon this point, as a center, with a pair of Compasses, describe a circle with Ink of 10 inches diameter, and when the Ink is dry, with a Diamond cut the circle as deep as you can conveniently, the deeper the better. When this is done, take an iron Ring exactly of the same size with the circle, which make red hot, and apply to it, and the piece will fly out, and leave the bottom open. With a proper Glue then, round the Neck glue on a piece of Canvas, that has loops to it through which you may pass some lines to keep the Bell equally

bly suspended. Then take a Gally-pot 6 inches wide, fill this with pure Sulphur, melt it, set it on Fire, place it upon a glaz'd earthen Stool standing in a large glaz'd Dish that rises in the middle, and then hang the Bell exactly over the middle of the Flame, and so near it, that it shall just suffer it to burn and no more. Keep the Sulphur constantly burning equably, by continually adding fresh, and removing the Crust with an iron Rod, if any is form'd whilst it is burning, that by this means the Distillation may not be interrupted. The same cautions too about chusing a cold, damp, quiet Air, moistening the Bell, and the Chimney's not smoking, are necessary here likewise.

U S E.

SULPHUR, when it is sublimed into Flowers, contains neither Earth nor Metal. Being set on Fire, when it is in Fusion, it burns only in its upper surface, and then its blue Flame consists of Fire, the oily inflammable part of the Sulphur agitated in that Fire, and the caustic fossil Acid that makes up the other part of the Sulphur, agitated and attenuated likewise, and render'd volatile by the violent action of the Flame. And thus the oily combustible part is consum'd by the Fire, and the heavy acid part is dissipated into the Air, which presently however unites together again by its weight, as soon as it gets beyond the power of the Flame. On this account it is that this Vapour proves so fatal; for the acid, which is extremely so, and in a very rapid motion, being applied to the Nerves which move the Muscles that connect together the Interstices of the cartilaginous Segments of the *Aspera Arteria*, *Bronchia*, and *Vesiculæ Pulmonales* renders them convuls'd in such a manner, that the Lungs are thrown into a short Cough which by no means relieves them, and become perfectly contracted, so that they won't suffer themselves to be expanded by the weight of the Atmosphere, tho' the *Thorax* is dilated with the most laborious inspiration. If this Vapour is shut up with any fermentable Matter, it prevents Fermentation. In every thing that easily putrifies, too, it hinders Putrefaction, if it is but sufficiently applied to it: Hence this Vapour proves a security against pestilential *Effluvia*, when they are either dispers'd through the Air, or lie conceal'd in infected Goods. And for this reason it is, that the Flame of Sulphur set on fire with Nitre, but particularly the Smoke of Gun-powder is so very serviceable in the time of a Plague; for the acid Vapour of the Nitre and Sulphur corrects the whole Air. The same being shut up in a close place destroys all Animals, even Insects themselves. This Spirit of Sulphur call'd Oil of Sulphur *per Campanam*, is the very Oil of Vitriol, which before resided in the vitriolic Pyrites, and being combin'd with Oil of Coals, constituted the Sulphur. This appears to be the case by every kind of examination. In Oil of Vitriol however there is supposed to be a metalline Taint, from which the Spirit of Sulphur, prepar'd from the Flowers, is free. After a great deal of pains, the famous *Homborg* very subtilly computes, that the Acid makes up nearly one tenth part of the Sulphur, *Mem. de l'Ac. Roy. des Sc.* 1703. p. 31. & seq. Hence therefore perhaps we see the reason why Alcohol won't affect this Sulphur? Because its Oil is saturated with an Acid. Why the mixing an Alkali with it by Fire in the proportion of 1 to 10 will dispose it to be dissolv'd by Alcohol? Because the fixing Acid is absorb'd by the Alkali, and the Oil being
set

set at liberty, comes then within the efficacy of the Alcohol. Why Sulphur resists Acids, nor is dissolv'd by them? Because it is already saturated with an Acid, and therefore will admit no more. Why Metals when they are fus'd or calcin'd with Sulphur are corroded by it? Because the Acid of the Sulphur leaving its proper Oil, is attracted more strongly into the Metals, corrodes them, and converts them into a kind of Vitriol. Hence therefore let those Dabblers in Chemistry think better of it, who give themselves a great deal of trouble to find out a method to fix Sulphur; for it is nothing but this fossil Acid united with a combustible Oil. Let them pretend no longer by the help of this to fix the Mercury of Metals: Such heterogeneous Bodies can't enter so intimately into one another, nor can they give the weight and durability so necessary here, nor indeed the malleability or simplicity. If this Spirit of Sulphur, when it is render'd pure by standing quiet, is mix'd in such quantity with Juleps, as to render them gratefully acid, it is vastly serviceable in every inflammatory Disorder, where there is great Heat, Drought, and a tendency to Putrefaction. *Van Helmont* says it will prolong Life to a great Age.

P R O C E S S CLII.

The solution of Sulphur in a fix'd Alkali.

A P P A R A T U S.

TAKE of the purest Flowers of Sulphur 9 drachms, melt them in a Crucible, and throw into them of a very dry fix'd Alkali finely powder'd 2 drachms. By this means the Sulphur will immediately acquire a new and particular Smell, and a very red Colour. Stir the Mixture with a Tobacco-pipe, and when it is well melted, and thoroughly mix'd, pour it out upon a cold Marble. The Mass then will be red, and very brittle, and will dissolve in Water, and soon run in the Air, though the Sulphur resisted the action both of Water and Air so powerfully before.

U S E.

THE fix'd Alkali being render'd active by the Fire, and intimately mix'd with the Sulphur in fusion, extracts the acid part out of it, and unites it with itself, and the Sulphur presently becomes resolv'd into its two distinct principles. The Oil however does not remain separate, but is closely combined with the alkaline Salt, and the Acid, and thus gives rise to a wonderful kind of Soap, consisting of an Oil, an Alkali, and an Acid. The combination therefore of the fossil Acid with the vegetable Oil, in the composition of Sulphur, changes the Oil indeed from its original nature, but the Acid lies conceal'd in it almost without any alteration, and therefore, in the resolution of it, appears again in its proper form. Hence then we see the efficacy of a fix'd Alkali in Metallurgy. Sulphur is often mix'd with Metals, and by this admixture produces a brittle Mass: If to this in a melting Fire you add an Alkali, it immediately lays hold on the Sulphur, and separates it from the metalline Glebe, and a lighter *Sapo* presently swims at top, whilst the Metal now it is freed from its

its Sulphur, falls by its proper weight to the bottom of the Crucible, the Alkali having no power upon, nor being able to penetrate into it. And hence, when it is doubtful whether any fossil Glebe contains Sulphur or not, only rub it with an Alkali, and then melt them together, and the Alkali will discover the melted Sulphur, both by its Colour and Smell.

P R O C E S S C L I I I .

The solution of Sulphur in a volatile Alkali.

A P P A R A T U S .

WITH the purest Flowers of Sulphur mix the strongest alkaline Spirit of *Sal-Ammoniac*, Hartshorn, Blood, Urine, or any thing of the like nature, distill, and cohobate, and the Sulphur will be dissolv'd. Or if you keep them a considerable time in a close Vessel, and frequently shake them well together, by this means too you will at length extract a golden Tincture.

U S E .

THIS Operation serves to demonstrate the power of a volatile Alkali upon the Acid of Sulphur, and to shew us the alteration that is hence effected. But whether or no this Preparation possesses such medicinal Vertues, especially in Disorders of the Breast, as a very great Chemist imagin'd, is much to be doubted.

P R O C E S S C L I V .

The solution of Sulphur in Alcohol of Wine.

A P P A R A T U S .

UPON Sulphur open'd by a fix'd Alkali, according to *Process* 152, and reduced to a very fine Powder in a hot dry Mortar as soon as it came hot and dry from the Fire, and then stopt up in a dry clean Glass, I here pour as much of the purest Alcohol as will cover it to the height of five Fingers. And you observe now, that by the sole contact the Alcohol intirely dissolves the Sulphur, thus prepar'd, into a pinguious thick Liquor of a deep gold Colour, which upon shaking becomes still much more saturated. When the Liquor has deposited its *Fæces*, and grown pure by standing, let it be poured off, and fresh Alcohol be added, which will be ting'd likewise, and so proceed till the Alcohol at last is not colour'd at all. Mix all the Tinctures together and you will have a Liquor of a very particular, and not disagreeable Smell, and of a warm, penetrating, and very aromatic Taste, and hence of medicinal Vertues answerable to these Qualities. The *Fæces* that remain at last are grey, saline, and earthy.

U S E .

U S E.

NATIVE Sulphur is not affected by Alcohol, though you digest them together for a great length of Time; and yet when it is once opened by an Alkali it is so greedily dissolved by it that I don't know any solution that happens quicker. Hence then we see how efficacious an alkaline Salt is in procuring an entrance for Alcohol into Sulphurs. As Sulphur therefore lies conceal'd in a great number of fossil Glebes, and in metalline ones in particular, but still retains its proper nature, hence it has often happen'd, that this simple Tincture of Sulphur has been sold to Persons of the greatest distinction for a profound metalline Tincture. Thus I remember a pretended Tincture of Gold sold at a great price for potable Gold. And the preparation of it was this: Gold was mix'd with crude Antimony, to this Mixture was added in the Fire the Alkali of Tartar, or the *Alcabeft* of *Glauber*, and then the Compound was pounded and rubb'd well together, which, upon pouring Alcohol upon it, in an hermetical Glafs yielded a golden Tincture. But this I say is nothing more than a simple Tincture of Sulphur; for the Gold remains without any alteration, but the Antimony abounding with Sulphur, the Alkali, whilst the Antimony is in fusion, attracts this Sulphur, separates it from the metalline Glebe, and opens it, and hence, when the Matter is well rubb'd, and the Alcohol is pour'd upon it, that attracts only the sulphureous part thus open'd by the Alkali, and leaves both the Gold and metalline part of the Antimony intirely unaffected. And this Observation now is of infinite use in the examination of many other fictitious Tinctures; for as soon as ever it is known that Sulphur is necessary for the preparing them, the skilful Artist will presently perceive that they arise purely from the Sulphur, as the metalline, or, as the Chemists call it, the mercurial part, is never affected by a vegetable Alkali. This sulphureous Tincture furnishes us with a wonderfully warming Medicine, which breaks the Wind, corrects Acidities, and incites and attenuates any pituitous Matter, if a few drops of it are taken fasting in Mead, *Spanish* Wine, or any proper Syrup; but then it turns whitish, and goes by the name of *Lac Sulphuris*. But as for its having any salutary antiphthifical Vertue, and being the grand Relief in an Abscess of the Lungs, I cou'd never yet discover it, though I have observed carefully, and heartily wish'd for it. With proper regard therefore to the authority of the famous *Willis*, I think it convenient to give you this caution, as in my opinion he has extoll'd it in this Distemper greatly beyond what it deserves.

P R O C E S S CLV.

Syrup of Sulphur.

A P P A R A T U S.

IF you take a drachm of Sulphur open'd by an Alkali, dilute it with three times the quantity of simple Water, and then add twice or three times as much Sugar a little boil'd, you will have a sulphurated Syrup which will contain the true Vertues of the open'd Sulphur, and may in this form be conveniently

applied to medicinal uses. Or shorter, simply mix it with Syrup of Liquorice, or any such Syrup in the proportion of 1 to 6.

U S E.

WHAT opinion we ought to have of this Mixture in Physic, I have already observ'd in the Tincture. This Syrup heats, dries, and stimulates, which kind of Medicines seldom are proper to People afflicted with a Cough, or those in a Consumption, the *Crafsis* of whose Blood is quite broken, and who are hence dispos'd to continual Sweats. But here we learn how surprizingly the Vertues of Fossils may lie conceal'd in almost every kind of Body; for if a fossil Glebe, abounding with Metals and Sulphur, is gently torrified, ground, and then calcin'd with a fix'd Alkali, the alkaline and sulphureous part will easily dissolve in Water, Syrups, Wine, Alcohol, and other Liquids, and communicate to 'em some particular secret Vertue, but which ought to be examin'd with a great deal of caution, before it is us'd as a Medicine.

P R O C E S S CLVI.

The solution of Sulphur in an express'd vegetable Oil.

A P P A R A T U S.

TAKE any express'd vegetable Oil, put it into a glaz'd earthen Pan, set it over the Fire, and add to it one fourth part of Flowers of Sulphur. When the Oil is heated to that degree as is necessary to melt the Sulphur, that will dissolve, and fall to the bottom of the Oil, in form of a very red shining Liquor, and in this degree of Heat they will continue unmix'd for a long while. Increase your Fire then, but very cautiously lest the Matter shou'd take fire, and at last, when the Oil comes to fume, it will become intimately mix'd with the Sulphur, and both of 'em will become opake, and together form a new Body that is perfectly homogeneous. If to this Mixture, whilst it continues thus to emit Fumes, and is ready to boil, you add more Sulphur, that will readily dissolve likewise, and thus a very large quantity of Sulphur may be dissolved in such a manner, in a very small one of Oil, as to lose intirely its former nature.

U S E.

THIS is that very famous Balsam of Sulphur of *Helmont*, *Ruland*, and *Boyle*, concerning which you may consult those Authors. Externally to warm, soften, and discuss, they extoll it above any thing; and commend its internal use against Putrefaction, and Suppurations, particularly of the Lungs and Kidneys. Nay, in this they seek the secret and only sufficient help for a pulmonary Consumption, and assert they have found it. For my own part however, I can't think but that, by its pinguious, acrid, indigestible, hot Qualities, it must do harm to those Lungs, Stomachs, and *Viscera* that are weak, as well as pall the Appetite, increase the Drought, and burn up the Bodies of consumptive

sumptive People, which by their Distemper are too much dried already. Nor do I say this without proper examination of the matter, and therefore wou'd advise a very moderate use of it, with a careful observation of its effect: Certainly it is not without a caustic rancidity. Its curing pale, cold, watery, mucous and sanious external Ulcers with considerable success, has, I imagine, given occasion to its being asserted, that it will do the same thing internally; but this perhaps is done a little too precipitately, as the internal use of it raises and keeps up a Fever. In a chemical view now we learn from this Experiment, that Sulphur which remains unaffected in Alcohol, which is the subtlest of all Oils, pretty soon and almost intirely dissolves in one that is very thick and inert, but is capable at the same time of admitting a very great degree of Heat. And this in the Doctrine of *Menstruums* is a remarkable instance, to prove, that the most subtle and penetrating Body is not capable of effecting what is sometimes soon brought about by another that is thick and inactive. The Chemists are apt to wonder, that a great many Fossils will not yield at all to the sharpest acid Liquors, and yet dissolve successfully in a soft inert Oil; But this is not surprising, if we consider, that Sulphur is capable of resisting all acid *Menstruums*, as it already contains as strong an Acid as any in nature. Hence, therefore, when by boiling a fossil Glebe in Oil you obtain such a sulphureous Balsam, this is owing to the Oil's having dissolv'd the sulphureous part of the Glebe, and the Lead too, if there was any in it, for this Oil is capable of dissolving and reducing to a Balsam likewise, as will appear, *Process 177.*

P R O C E S S CLVII.

The solution of Sulphur in a distill'd vegetable Oil.

A P P A R A T U S.

TAKE of Flowers of Sulphur 1 ounce, put them into a tall Bolthead, pour upon them 6 ounces of æthereal Oil of Turpentine, and boil them together in our wooden Furnace, and the Sulphur at first will be melted at the bottom, then part of it will be dissolved by the Oil with a crackling Noise, and at last the whole will appear thoroughly mixed. Let it cool then gradually, and great part of the Sulphur will be found concreted at the bottom in form of yellow *Spicula*, with a fluid Balsam at top of it, so that the Sulphur appears precipitated in the Balsam with a true Crystallization. Nicely pour off all the liquid part from the gold-colour'd sulphureous Crystals, and upon the *Residuum* put fresh Oil, and boil as before, and the whole Sulphur will be again dissolv'd, but then, too, when it comes to be cold you will have more sulphureous Crystals. The Balsam being separated, add again more Oil, and so proceed till at last the Sulphur will shoot into Crystals no longer, and then you will find that it will have taken up about sixteen times its quantity of Oil. Mix together all the Balsams, thus prepar'd, and keep them under the title mention'd. This Operation ought to be perform'd with a great deal of caution, as it is a very dangerous one; for if a Person shou'd happen to stop the Mouth of the Bolthead, the boiling Matter wou'd burst the Vessel to pieces with such a violence as can

scarcely be equall'd; a terrible instance of which we have given us by the famous *Frederic Hoffman*.

U S E.

HENCE therefore it appears, that this thinner, more penetrating, and more pungent distill'd Oil, is not capable of dissolving Sulphur with so much ease as the soft, thick, inert one did in the preceding *Process*; so that it looks as if Oils were unfit for this solution, in proportion to their greater subtlety; as we see particularly in Alcohol. And here we observe likewise, that Sulphur is dissolved in distill'd Oils, as Salt is in Water; that is to say, to a determin'd saturation, and that it is then discharg'd in form of Crystals. The explosive force of this Balsam of Sulphur is the greatest that we are acquainted with. It consists of the Oil of the Sulphur, the dissolving Oil of Turpentine, the true Acid of Sulphur *per Campanam*, and simple unchangeable Earth. *Mem. de l'Ac. Roy. des Sc.* 1709. p. 46. Externally this Balsam proves an Anodyne to the Nerves, when they are hurt, and is an excellent Remedy for sanious, sinuous, moist, watery, fistulous Ulcers. Internally it is a Diuretic, and Sudorific. It is said to cleanse and heal internal Ulcers, and hence it is commended in Consumptions, and Ulcers of the Kidneys, but far more than it deserves. Some Persons recommend it too for forcing away Stones; nay and tell us, it is able to dissolve them. But prudent Physicians are best pleas'd with those Medicines that work gently, and are cautious about those that are rough. It must be confess'd however, that a little of this Balsam taken inwardly will quickly give the Urine a violent Smell. On account of the Sulphur that is in them, Tinctures have been drawn from Fossils by distill'd Oils, as we mention'd before of express'd ones, and then have been unjustly sold for Tinctures of Metals. This goes by the name of *Balsamus Sulphuris Terebinthinatus*. Other distill'd Oils now may be mix'd with Sulphur in the same manner, and then the Balsam is distinguish'd by the name of the Oil made use of. Thus if you use Oil of Aniseed, it is call'd *Balsamus Sulphuris Anisatus*, and so *Succinatus*, *Juniperinus*, &c.

P R O C E S S CLVIII.

A Soap with Balsam of Sulphur.

A P P A R A T U S.

1. **T**AKE the Balsam of Sulphur of *Process* 156, dilute it with twice or three times as much of the Oil it was made with, and then with this Mixture make a Soap exactly in the same manner as was directed *Process* 73. This is what Dr. *Starkey*, after *Van Helmont*, extolls so extravagantly in his *Pyrotechny*.
2. Or take the Balsam of Sulphur of *Process* 157, and with that, instead of simple Oil, make a terebinthinous Soap in the same way you saw it done *Process* 74; and then you have the *Sapo Sulphureus Philosoporum*.

U S E.

U S E.

FROM this *Process* then, we learn the Methods by which both simple native Sulphurs, and those that are closely combin'd with semi-metals, as Antimony, and others, may be brought into union with fix'd alkaline Salts, and with these constitute a Body which is miscible with almost every Fluid, and is capable of insinuating itself into the Vessels of the human Body, of mingling with its Humours, and there exercising its proper Powers. From these Medicines the Followers of *Van Helmont* promise very singular and surprising effects, which they imagine can scarcely be expected from any thing else; for in these opened Sulphurs, they think there is a most efficacious dissolving Vertue, discovering itself by the Smell, (which certainly is a disagreeable one) and a very penetrating warm Taste. But I can't help thinking, we have as good Medicines in the Soaps describ'd *Process* 73, 74, and without the fetid smell and rancidity that we find in these. In a chemical view, however, they have their use.

P R O C E S S C L I X.

Balsam, or Soap, of Sulphur, united with Alcohol.

A P P A R A T U S.

1. WITH the terebinthinous Balsam of Sulphur of *Process* 157, mix 6 times as much of the purest Alcohol in a Bolthead, and it will dissolve it; but when they have stood quiet some time, the Sulphur will be partly precipitated into sulphureous Crystals, and partly continue dissolv'd, and give you an alcoholisated Balsam of Sulphur.

2. Or digest the terebinthinous Soap of Sulphur of *Process* 158. No. 2. with pure Alcohol, and the Solution will be of an exceeding penetrating Smell and Taste.

U S E.

THIS finishes our *Processes* upon Sulphur. But before I quit this subject, it is necessary I should observe to you, that when Sulphur is dissolv'd in Alkali's, upon being mix'd with an Acid, it precipitates, grows white, sends forth a most noisome stink like that of putrified Excrements, and immediately exhibits very surprising *Phænomena*, which we observe in other Fossils too, treated in the same manner, and which may hence be understood. Thus, for instance, if into the Golden Tincture of Sulphur of *Process* 154, you drop Vinegar, you have presently a stercoraceous Smell from the precipitated Sulphur. And if you mix Antimony with an Alkali in the Fire, and then draw a Tincture from it with Alcohol, Vinegar dropp'd into this, will have the very same effect. This, therefore, will help us to understand what we shall sometimes meet with in the *Processes* upon sulphureous Semi-metals.

PROCESS CLX.

An artificial Sulphur from an Oil and an Acid.

APPARATUS.

TAKE of the purest rectified Oil of Turpentine 4 ounces, put this into a clean Retort, and pour upon it of the best Oil of Vitriol perfectly dephlegmated 1 ounce, shaking them about after every instillation that they may be thoroughly mix'd together. By this means then, the Mixture will grow hot, emit Fumes, become red, and diffuse various kinds of Smells. After they are thus mix'd together, digest them for the space of eight days, and then apply a large Receiver, lute the joint well, and distill with a sand Heat. Upon this there will come off a very singular oily Liquor, and the Matter at the bottom of the Retort will appear at first like a liquid *Bitumen*, but will gradually grow thicker and thicker, and at length become of a pitchy bituminous nature. The Liquor that rises at the same time has a suffocating sulphureous stench, vastly prejudicial to the Lungs. If you cautiously distill with successive degrees of Heat, there will a true Sulphur ascend into the Neck of the Retort, which is evidently such, both from its look, and the *Phænomena* it exhibits upon being set on fire.

USE.

HENCE then we see the artificial Method of preparing *Bitumen* and Sulphur, and that the fix'd Acid of Vitriol, Alum, or Sulphur *per Campanam*, is the *Basis* of them, and is incombustible, whilst the other part may be any very pure combustible Oil. When these two are intimately united together, they constitute a Sulphur, and when this Compound is set on fire, the oily part yields a Flame without any Smoke, whilst the Acid part being distill'd in the Flame of the former, produces a caustic, suffocating, anti-alkaline, antiseptic, heavy, acid Vapour, which does not rise high, and may be collected again by the sides of a glass Bell into the very same Oil of Vitriol. An exceeding pure inflammable Oil, therefore, nay such a one as is scarce any where else to be met with, seems to enter into the composition of Sulphur, whilst every thing else that is thick, not inflammable, earthy, or saline is rejected. And of all the different Acids with which we are furnish'd, either by Nature or Art, the Acid of Vitriol alone is capable with an Oil of producing Sulphur, and that, wherever it is, let it lie ever so much concealed, will, with any inflammable Oil, produce it. Thus vitriolated Tartar, *Glauber's Sal Mirabilis* with Sea-Salt, or with Nitre, Salt of Colcothar, calcin'd Alum, and other Bodies in which there is this Acid, when they are by means of it combin'd with an inflammable Oil, always yield a true Sulphur. Hence therefore this Acid alone is endued with a power of generating Sulphur, tho' all inflammable Oils are properly disposed for it, in conjunction with this Acid; and hence there is never any Sulphur generated, but where this Acid first exists. From these Principles now, we may understand the reason of an infinite number of *Phænomena* that occur in the Chemical History of Fossils and Metals, and therefore it is absolutely necessary they shou'd be

be treasur'd up in the Memory. From many others that might be cited here, I'll only mention one Experiment of *Becher's*. Take *Glauber's Sal Mirabilis*, melt it in the Fire, and whilst it is in Fusion, throw into it some powder'd Charcoal, and there will be excited a sulphureous Flame, and at the bottom of the Crucible you will have a reddish brown Substance. Dissolve this in Water, and there will precipitate a true sulphureous Matter. Here then you perceive that the Oil of Vitriol in the *Sal Mirabilis* lays hold on the inflammable Oil of the Coal, and thus produces a Sulphur. In order, therefore, to foresee the event of any chemical Operation, we ought carefully to consider, whether there is any Oil of Vitriol, Alum, or Sulphur, either open, or latent in the Bodies mix'd in the Operation, and whether at the same time there is any thing inflammable that meets with them; for then you will immediately have a Sulphur, which will afterwards act in its proper capacity.

PROCESS CLXI.

The Preparation of Sulphur with an Acid and Alcohol.

APPARATUS.

TAKE of the purest Alcohol of Wine, prepared without any Alkali 8 ounces, put it into a tall glass Cucurbit, and pour upon it by drops some of the choicest Oil of Vitriol, accurately mixing them together, and waiting some time after every drop, for otherwise there will be excited a prodigious Heat, with very suffocating Vapours. Proceed in this manner till you have dropp'd in an ounce of the Oil. The Mixture then will send forth a most fragrant Smell like that of Southernwood, which will diffuse itself all over the House. But beware of it, for it is of a very suffocating quality, a small quantity of it taken into the Lungs exciting a violent Cough; and I am apt to think in a very large one, it wou'd prove instantly fatal. The Liquor will be of a reddish Colour, which digest close for the space of five days in a gentle Heat, and then luting your Vessels very nicely, distill with a soft Fire, and there will come off a wonderful subtil Spirit, which upon being smelt to, is ready to strangle one, and is so much the more dangerous, as by its grateful Scent it is apt to tempt one to draw it in more plentifully. Proceed in this gentle Distillation till the Mixture begins to grow black, and the last part of this Spirit that comes off will be vastly fragrant, and then somewhat of an Acid will begin to rise, which was not in the former. Then change the Receiver, and keep up a gentle constant Fire, that the Liquor may rise gradually, for if you raise your Fire but for a moment, this wonderful Matter becomes at once so flatulent, and rarefies to such a degree, that it runs over into the Receiver, and disturbs the whole Operation. If you proceed to distill in this easy manner, there will rise a fetid watery Liquor, and with it a pure, limpid, heavy one, which will not mix with it. After all this Liquor is drawn off likewise, and there does not remain half the quantity made use of at first, change your Receiver again, and increase your Fire by successive degrees, till you come to the greatest. By this means you will have a fetid Liquor too, that will not mix with the preceding heavy one. The Operation being over, at the bottom of the Vessel you will have a

black, brittle, acid Matter, which is not inflammable, but otherwise in some measure approaches to Sulphur. By this method then you have three distinct Liquors from this Mixture of Alcohol and Oil of Vitriol, with a sulphureous suffocating Vapour, and some remaining fixed *Fæces*, of a perfectly singular Nature.

U S E.

THIS very strong fossil Acid, by being simply mix'd with that exceeding subtil Oil Alcohol, produces such a prodigious Heat, that if they are imprudently mix'd together, they are ready to burst into Flames, with a very considerable Effervescence. The very instant they are mix'd, they send forth a very fragrant Smell, which diffuses itself about to a great distance; but by a long Digestion they acquire a fetid Smell like that of Garlic. The pleasant Smell however carries along with it a suffocating Acid. Hence there is separated from this Mixture by Distillation, first a spirituous, fragrant, suffocating, inflammable, acidish Liquor, tho' the Oil of Vitriol was so fix'd just before, nor by any means of a sweet Smell; in the second place a fetid sulphureous Liquor, that is neither inflammable, nor acid, but aqueous, tho' there was not much Water to be discovered, either in the Oil of Vitriol or the Alcohol; and thirdly, a limpid heavy Liquor, that has both a grateful, aromatic Smell and Taste, which will not suffer itself to be mixed with the former, but may be diluted with Alcohol of Wine, and then will extract somewhat of Tincture from calcined Gold. Hence this is look'd upon as the *Oleum Vitrioli Philosophorum*: Certainly it is a sweet Oil of Vitriol; concerning which consult *Isaac Hollandus*, *Conrad Gesner*, in *Euonymo*, *Boyle's Original Forms*, p. 282 to 290, but particularly *Hoffman's Diff. Chem. Phys.* from p. 173, to 180. The remaining black *Fæces* being diluted with Water, almost return again to an acid Oil of Vitriol. Hence then you see how many and what unexpected *Phænomena* arise from this Combination. Is this the *Spiritus Vini Philosophorum*, which by its grateful Fragrance draws Persons to it whilst it is making, concerning which *Lully* wrote? Is it the fragrant *Spiritus Vitrioli Dulcis* of *Paracelsus*, which he so extolls in Epilepsies? And is it with this that *Paracelsus's* Tincture of Gold is drawn, so as to make an *Aurum Potabile*, digested, as he says, in the Stomach of an Ostrich? This Operation certainly should excite the curious to examine, but with prudence, whether any of these great *Arcana* lie concealed here. In the mean time we see that absolute Sulphur is not generated by this means, tho' there is an appearance of some of its Properties.

III. Upon M E T A L S.

P R O C E S S CLXII.

Vitriol of Iron.

A P P A R A T U S.

1. TAKE some pure Rain-water, put it into a clean Urinal, and drop into it $\frac{5}{8}$ th as much of the choicest Oil of Vitriol, continually stirring them about, in order to mix them thoroughly together. Into this pure acid Liquor throw a small portion of the cleanest Filings of Iron that are not rusty, and there will be excited a prodigious Ebullition, and the Liquor will grow hot, and become opake, and of a greyish Colour. At the same time too there will rise a perfect fossil Vapour, of a very singular Smell, in which, however, there is somewhat like that of Garlic. When the Effervescence is over, and the Solution is compleat, throw in some more Filings, and so proceed, till at last some part remains undissolv'd at the bottom of the Vessel. Let the Liquor stand quiet, deposite its *Fæces*, and become pure, and it will be of a greenish Colour, and have a sweetish styptic Taste.

2. The pure Liquor that swims at top being filter'd through a paper Bag, becomes exceeding limpid, and of a beautiful green Colour. Let this be put into a very clean Urinal, and be inspissated with a gentle Fire to the appearance of a Pellicle, and then let the Vessel be set in a still, cold, subterraneous place, and in a short time there will be formed at the bottom some pretty pellucid Crystals of a green Colour like an Emerald. If these are separated from the liquid part, and are gently dried upon a Paper in a dry, clean, warm Air, and are then put up into a Vial, they will continue in this form a long time. Inspissate the remaining Liquor, and set it by as before, and it will again shoot into fresh Crystals, and so on till the whole is almost reduced to a Vitriol, tho' the first Crystals will be always the finest.

U S E.

THE Metal of the Iron attracts the fossil Acid from the Oil of Vitriol diluted in the Water, exactly as the Alkali did in the *Tartarus Vitriolatus*, *Process* 148. In this respect therefore Iron agrees with an Alkali. Hence the Iron being by this means united with the Acid, it becomes soluble in Water, and thus the Compound acquires the disposition of a metallic Salt. This Vitriol, now, consists of Water, a Metal, and an Acid, combin'd together in a certain proportion, which being preserv'd, the Mass so long continues equably beautiful and pellucid; but as soon as ever the Water only is separated by a somewhat greater degree of it, it immediately becomes opake, and losing its agreeable green Colour, acquires a greyish one. In this respect therefore again it resembles the Crystals of Salts, and hence the Chemists have call'd it (*Sal-Martis*) Salt of Iron. Some however have thought it ought rather to be call'd a Ma-

gestery of Iron, inasmuch as the whole substance of the Iron becomes concreted with its solvent into a Mass that is perfectly homogeneous. It has obtain'd the name too of Vitriol of Iron, as it perfectly resembles native fossil *Calcanthum*, in every property. Hence then we see the manner in which hard Metals, by union with an Acid, become, like Salts, dissoluble in Water, and by this means potable. Then too they acquire a new, metallic, saline Taste, and very particular Vertues, with regard to the human Body. If this Salt of Iron is diluted with a hundred times as much pure Water, and is drank upon an empty Stomach to the quantity of 12 ounces, the Patient walking gently after it, it opens, relaxes, purges, promotes a discharge by Urine, destroys Worms, brings them away, renders the Excrements very black, or like Clay, and strengthens the Fibres, and hence cures a great many, and those very different Diseases. On account, now, of their Taste, Smell and Colour, and their tinging the Excrements, a great many Persons have been of opinion, that the medicinal chalybeate Water were produced by Nature too, in the same manner; especially as both these Liquors, if they are exposed to the Air, let fall some yellow *Fæces*, call'd Ochre: But this error the famous *Hoffman* has judiciously corrected, by some Experiments which he has given us in that noble Treatise *De Aquis Medicatis*. It is necessary however to take Notice, that this Salt of Iron, by meeting with any alcallescent or putrid Substances, will have its Acid absorb'd, and by this means be converted into an astringent, heavy, inert, metalline Matter, and will then occasion the worst kind of Obstructions; and hence in putrid Fevers it proves prejudicial. But experience evinces, that Filings of Iron, being taken by the female Sex, when they are weak, and dispos'd to breed Acids, by their meeting with the Acids cause *Ruētus's* that have a Taste like that of Garlick or rotten Eggs, the Stools at the same time being almost black, and the Body being restor'd again to its proper Heat; and then it is found that the Filings of Iron taken in Powder do more service than the most laborious chemical preparation of it. Hence we learn, that in those Habits of Body where Acids are predominant, it does good, though it proves hurtful in hot bilious ones. But from the consideration of this Experiment we understand too the origin of all the green metalline Vitriol in the World; for it is Iron corroded by a vitriolic fossil Acid. And lastly, upon this Experiment depends the preparation of almost all sorts of Ink.

P R O C E S S CLXIII.

Ludóvici's Vitriol of Iron with Tartar.

A P P A R A T U S.

1. TAKE of Vitriol of Iron, not acid, but perfectly saturated, 1 part, of Crystals of Tartar 4 parts, and of Rain-water 20 parts: Boil these together in a glass Vessel, keeping them frequently stirring with a Stick, till you have reduced them to a thick greyish Mass, almost of a solid consistence, which you must take care is not burnt in the least degree. Put this Matter into a tall Bolthead, pour upon it as much common Spirit of Wine as will cover it to the height of four inches, and boil them for one or two hours, by which means

means you will have a red Liquor at top. When the whole is grown cold pour off the pure Liquor, and filter it. Upon the *Residuum* put fresh Spirit as before, and treat it in the same manner, and repeat this as long as the Matter will give out any Colour. The Tinctures being all filter'd, mix them together, and you have *Ludovici's* medicated Tincture of Iron.

2. If this Tincture is distill'd to the appearance of a Pellicle, the Spirit is drawn off, and the Tartar forms itself with the Salt of Iron into medicinal Crystals. And if you take what remains after you have drawn your Tincture with the Spirit, and boil it strongly with ten times as much Water, and filter it through a woollen Bag boiling hot till it becomes limpid, and then proceed to pour on more Water, boil, and filter, and so on till all the matter is dissolv'd and depurated by running through the Bag, then if the Liquor is inspissated to a Pellicle, and set in a cold place, you will here again have *Ludovici's Tartarus Martialis Aperiens*, which must be kept in a Vial well stop'd.

U S E.

THE Physicians observing that the excellent medicinal Vertues of Iron, in some measure explain'd in the preceding *Process*, retain'd their efficacy as long as the Iron continued dissolv'd by a gentle Acid, but were destroy'd, nay and the Iron became precipitated too into a hurtful *Calx*, as soon as ever it met with an Alkali; hence they prudently combin'd Salt of Iron with a vegetable Acid, in hopes that in this saline form it wou'd continue and act in the human Body with greater constancy. And this is the reason of uniting Salt of Iron with the oily, vegetable, acid Salt of Tartar, *viz.* that it might not easily precipitate in the Body into an astringent *Crocus*, or cineritious Matter. This Preparation opens, attenuates, corroborates, stimulates, and moderately evacuates, both by Stool and Urine. Hence in leucophlegmatic, scorbutic, icterical, hypochondriacal, and hysterical cases, where there is a laxity and weakness from an *Inertia*, it proves of service, as likewise in the Rickets, and Worms. If the Tincture is drank fasting, to the quantity of 3 drachms, diluted in 6 times as much Water, and divided into three doses, taking after each of 'em 4 ounces of very thin Whey, and walking gently so as not to sweat, and this is prosecuted for nine days successively, it has often a very good Effect. To rickety Children, and those that are troubled with Worms, and are hence fallen into a bad habit of Body, a few drops of this Tincture given in Honey, or a proper Syrup are sufficient. A drachm of the *Tartarus Martialis* taken in a Morning fasting will answer the same purposes as 3 of the Tincture. Hence we see the method of converting Metals into various medicinal forms, in which they must then be used with judgment. It is a very good sign that these Medicines have a proper Effect, when they gently move by Stool, and the *Fæces* are black, or greyish.

P R O C E S S CLXIV.

A white, grey, and red Calx of Vitriol of Iron.

A P P A R A T U S.

1. **T**AKE of the best dry Vitriol of Iron half an ounce, reduce it to a very fine Powder in a glass Mortar, and lay it upon a glass Plate, in a Heat of 150 degrees, keeping it continually stirring with a Stick, by which means there will exhale somewhat of a watery Vapour, and the Powder will grow white like Flower, and have an inky, sweet, styptic Taste: This is the white *Calx*.

2. If this *Calx* is exposed to a stronger Fire, one for instance of 300 degrees, it will acquire a greyer Colour, and will have a rough Taste.

3. And if this second *Calx* is ustulated in a Crucible in an open Fire, it then grows yellow and red, and at last you have a purple red Powder, which has a rough and somewhat caustic Taste. And here the stronger the Fire is, and the longer it is in it, the more in proportion are these last qualities heighten'd, so that at length it becomes nearly caustic.

U S E.

HENCE we see that Vitriols, or metallic Salts lose their pellucid form as soon as ever their Water is separated from them, and then moulder as it were into Ashes, on which account this Operation is call'd Calcination, and the Matter thus produc'd is call'd a *Calx*. And when they come to be expos'd to a strong degree of Fire, they then lose their solubility in Water, as in the third *Calx* is always found to hold true. The first *Calx* is esteem'd in Medicine, as it retains its native Vertues, and may now be easily mix'd with Sugar, and so given to Children. Some Persons have imagin'd, that the Acid, if it shou'd happen to predominate, wou'd be expell'd by this calcination; but certainly Oil of Vitriol won't suffer itself to be separated by so small a degree of Heat. The second too has the same Vertues, but is somewhat more astringent, and is less soluble in Water. But the third, as it will not dissolve in the human Body, and yet has a caustic quality, can scarcely ever be internally administer'd with safety. Externally, however, it is of excellent service in eating down and then incarning the Lips of stubborn Ulcers, and in stopping Fluxes of Blood, *Serum*, and Lymph. If this red *Calx* of Vitriol of Iron is calcin'd for a good while with an intense Fire, and then boil'd in Water, it gives the Water a vitriolic acidity, and if you then decant the Water, put on fresh, boil and pour off, and so on, till the last Water comes off as insipid as it was put on, there will then remain a red, insipid, astringent Powder, which goes by the name of *Crocus Martis Astringens*, containing the Body of the Iron calcin'd by the Acid, and Fire, and hence generally made use of as an astringent. The acid Waters being insipidated to a Pellicle, and then fet by, yield somewhat of a vitriolic Salt.

P R O C E S S CLXV.

A Liquor of Iron per Deliquium.

A P P A R A T U S.

IF the red *Calx* of the preceding *Process* strongly calcin'd, but not washed, is reduc'd to powder, put into a glass Plate, and expos'd to a damp Air, it grows moist and is at last converted into a kind of liquidish red Matter, which may be call'd Oil of Iron *per Deliquium*.

U S E.

IN Vitriol of Iron is contain'd an exceeding strong fossil Acid, together with Water. When the Water is separated by the Fire, there remains only the metalline part, and the pure Acid, which is now in a dry form, and being in its Nature averf'd to being kept so, attracts the Water out of the Air: This is the true reason of this *Phænomenon*, and holds good in all similar Cases. If Metals now are thus dissolv'd by their proper Acids, then dried, moisten'd by the Air, dried again, and so on, by this repeated coagulation and inspissation, they are wonderfully open'd, and resolv'd, and at last become volatile. The *Calx* thus dissolved by the moisture of the Air, has the same Vertues it had before.

P R O C E S S CLXVI.

A Golden Tincture of Vitriol of Iron.

A P P A R A T U S.

TAKE of the very red *Calx* of Vitriol, prepar'd according to *Process* 164. No. 3. and exceeding dry 1 part, put it into a tall Bolthead, and pour upon it 20 parts of the best sweet Spirit of Sea-Salt: Digest them together for the space of a month, and you will have a golden Liquor of a sweetish, styp-tic, inky Taste. Decant this Liquor, and put on fresh Spirit, and digest as before, and by a repetition of this Operation, there will remain at last an inert metallic Powder, whilst the Liquors mix'd together make the Tincture we want.

U S E.

BY this Experiment it appears, that Liquors ting'd with a remarkable Colour, may be procur'd from Metals without a Solution of their whole Body; for this Tincture truly contains part of the Substance of the Iron, inasmuch as one drop of it is greatly efficacious in producing a black Colour, as you'll see at the end of these Lectures. The Spirit however is never capable of dissolving the whole *Calx*, but only extracting part of it. A few drops of this Tincture taken fasting in *Spanish* Wine, invigorate, and destroy Worms. The chemical *Magi* placed their medicinal Gold in Iron: Is this therefore their me-
dicated

dictated *Aurum Potabile*? See *Tachen. Hippocr. Ch.* p. 11. and *Basil Valentine*, concerning this Tincture.

PROCESS CLXVII.

Iron dissolved in Rhenish Wine.

A P P A R A T U S.

WITH 2 ounces of clean fine Filings of Iron, not at all rusty, in a tall Bolt-head mix 24 ounces of the strongest Rhenish Wine, and digest them in our wooden Furnace in 200 degrees of Heat for the space of three or four days, frequently shaking them about: Afterwards let them stand quiet for four and twenty hours, and then pour off the Wine, which will be blackish, filter it, and put it into a Bottle, and stop it close: This will have an inky, sweetish, styp-tic Taste. Upon the *Residuum* pour fresh Wine, and proceed in the same manner, and then too you will have an Iron Wine, but no ways comparable to the preceding; for that particular part that is thus drawn from the Wine is soon exhausted, the whole substance of the Iron not being here dissolv'd, but something only being extracted from it. This therefore is more properly a Tincture than a Solution.

U S E.

HENCE then we see, that in Iron there is one part that is soluble in this gentle, oily, fermented, vegetable Acid, whilst the other will not dissolve in it. The first part of these now, is the noblest Medicine that I know of, either in Art or Nature, for restoring the human Body to its *hæmatopoietic* Vertue, when this is lost from too great a laxity and weakness of the Solids, or a cold, inactive, watery disposition of the Fluids: Certainly, if the medicinal Power of Metals appears in any Experiment, it does remarkably so here; for you will never in this case be able to do so much by the help of any Vegetable or Animal preparation, or any *Regimen* of Diet whatever, as you will by this Tincture of Iron. In strong Health, however, and full Habits of Body, it does harm. I have often thought with myself, whether this was not the potable Sulphur of Metals, which alone was said to be sufficient for assisting the infirmities of Nature? Certainly this is infinitely preferable to any *Aurum Potabile*, that has yet been divulg'd, nor is ever prejudicial, if it is but administred in proper cases. But hence likewise we learn, that there is something in Iron that is not so remote from the nature either of Vegetables or Animals: This certainly is evident, that it dissolves with the greatest ease. If a drachm of this Wine mix'd with three times as much Syrup of Sugar for a dose, is given by a judicious Physician to young Persons of either Sex, it proves an incomparable Medicine.

P R O C E S S CLXVIII.

A Solution of Iron in Vinegar.

A P P A R A T U S.

TAKE of fresh Filings of Iron 1 ounce, put them into a tall Bolthead, pour upon them 20 ounces of the sharpest distilled Vinegar, and let them boil in our Furnace for the space of four and twenty hours. By this means, after the whole is grown cold, you will have an exceeding red Liquor, of a styptic, sweetish, disagreeable Taste, and thicker than the preceding Tincture made with Wine. This astringent Tincture of Iron, when it is filter'd and depurated, will tinge the Vial it is kept in, in such a manner, that the stain will scarcely ever come out. If upon the remainder of the Filings you pour more Vinegar, and treat it in the same manner, you will again extract a Tincture, but in less quantity, and of a paler Colour, tho' still evidently containing somewhat of Iron: And if this is repeated, there will at last remain a considerable quantity of the Iron that will not be dissolved by the Vinegar.

U S E.

IT'S surprising here what a considerable difference there is betwixt this Tincture of Iron prepared with Vinegar, and the former with Wine, whether you regard the Colour, Taste, Smell, Thickness, or Effects. Hence it is evident, that this Metal may be easily dissolved by Acids, but in a manner very different. This Solution of Iron by Vinegar, has a wonderful astringent quality, and hence is corroborating, and of service in case of Worms, but must not however be every where made use of without proper consideration. If it is taken with Sugar, it is more mild. How frequently now must Iron in Solution get into the human Body, as it so often in the common course of things meets with Acids, is dissolved by them, and so is taken in with our Meat and Drink? Will it therefore insinuate itself into the Blood, intimately mix with the Juices, and so furnish Matter for a Stone in the urinary Passages, as was the Opinion of Dr. Lister? This is certain, that it grows almost every where, and is every where constantly consuming, and hence is produced from the Earth, and return'd to it again, so that if there is any Metal that is mutable and destructible, it must without all dispute be acknowledged, that this is so remarkably.

P R O C E S S CLXIX.

Sublimation of Iron with Sal-Ammoniac.

A P P A R A T U S.

TAKE of the freshest Filings of Iron, and the driest Flowers of *Sal-Ammoniac*, of each 4 Ounces, put them into a glass Mortar, and rub 'em together for a good while, the longer indeed the better. By this means, from these

two Bodies, which were inodorous before, there presently begins to rise a volatile, very subtil, and as it were alkaline Vapour; for the acid part of the *Sal-Ammoniac* is attracted into the Iron, and hence its volatile alkaline part is set at liberty, and spontaneously flies off. Let there be ready a large, dry, glass Cucurbit, pretty wide at top, into which put the Powder thus prepar'd, taking care that it is spread broad at the bottom, and then fit on a Head, and apply a Receiver, luting the Joints with a common Lute made with Linseed Flower. This being done, place the Cucurbit in a Sand Furnace, cover it with Sand quite to the rim of the Head, and give a Fire of 200 degrees. By this means then there will rise a very acrid Vapour, which will distill into a very penetrating and exceeding volatile alkaline Liquor. When nothing more will come off with this degree of Fire, increase it 'till the top of the Head grows hot, and then there will begin to rise Vapours, first of a white Colour, and then of various others, and at last the whole internal surface of the Head will be cover'd with a variety of white, red, yellow, green, and blackish Colours intermix'd with one another, and thus in a good measure representing natural Flowers, from which they have taken their name. Keep up this degree of Heat for six or eight hours, and then let the whole spontaneously cool, and in the Receiver you will have an exceeding penetrating, volatile, alkaline, golden Liquor, with a small quantity of a white and yellow Matter, and in the Head and its Beak, a very subtil, dry Substance of various beautiful Colours, which must be immediately remov'd, put into a hot dry Vial, and stop't up very close, for otherwise it will soon grow moist with the Water in the Air, and run into a gold-colour'd, oilyish, rough, saline Liquor: In the dry form this Matter is call'd Flowers of Iron; in the latter fluid one, Oil of Iron *per Deliquium*. All the sides of the Cucurbit too will be cover'd with the same sort of Flowers, but they appear here more compacted, being melted as it were, and so consolidated by the stronger action of the Fire: These too must be carefully taken off, and kept dry. At the bottom of the Cucurbit there will be left a brownish red Matter, of an exceeding rough Taste. This in its nature is averse to being kept dry, and hence, with a moist Air, melts, and runs into a thick, astringent, golden Liquor, which is another metallic Oil *per Deliquium*. When this is exposed to the Air it rarefies, and puffs up in an extraordinary manner, and thus in some measure represents a kind of Fermentation. Betwixt the sublim'd Flowers, now, and this *Residuum* there is a great deal of difference.

U S E.

Sal-Ammoniac, which consists of a Spirit of Sea-Salt and a volatile animal Alkali, by being rubb'd with the Iron unites part of its Acid with its metalline Body, by which means the alcalious part belonging to that acid one, is set at liberty, becomes volatile, and flies off: But at the same time another portion of the *Sal-Ammoniac* retaining its own proper nature, by being mix'd with the Iron thus corroded by the Acid, divides, carries up, and sublimes a particular part of the Metal, which otherwise is so fix'd in the Fire; for it is not so easy as some Persons tell us, to make the whole Body of the Iron rise by the help of *Sal-Ammoniac*, but it seems here to be divided into one part, which becomes more volatile and ascends, and another which is more fix'd, and remains at the bottom:

bottom: This at least appears to me to be the case, and hence I think I see the separability of Iron into different parts. From this Operation then we learn the singular volatility of *Sal-Ammoniac*, which, now it is divided, is capable of carrying up a Metal that is naturally so fix'd and hard to fuse. Hence the Philosophers have call'd it the *Avis Rapax*, the *Aquila alba*, and the Key that unlocks the Bodies of Metals. These Flowers have nearly the same Vertues as the *Ens Veneris* of Mr. Boyle; for they are a wonderful restorative, warming, aperient Medicine, containing the opened Body of the metallic Sulphur. They have an anodyne quality, likewise, often rising to a semi-narcotic one. These Flowers being digested with Alcohol when they are exceeding dry, give out a considerable quantity of a metallico-sulphureous, golden Tincture. The *Fæces* too that remain at the bottom with Alcohol yield a Tincture of the same kind. Curious Persons who are not sparing of their labour take this *Residuum* of the Iron and *Sal-Ammoniac*, expose it to the Air, and thus dissolve it, then inspissate and coagulate it again, and so on, till at last they so surprizingly and profoundly (*eviscerant*) embowel the metalline part, that they never repent either of their trouble or charge. Who that knows any thing of Chemistry is not acquainted with the Precept so often inculcated, dissolve and coagulate? If this work now is sufficiently repeated, may there at last be a true Mercury procur'd from the resolved Metal? For my own part, I confess, I have tried this, but it has not succeeded. It is certain, however, that Experiments upon Metals with *Sal-Ammoniac* are of infinite use.

P R O C E S S CLXX.

A Preparation of Iron and Sulphur.

A P P A R A T U S.

1. TAKE of Filings of Iron and Flowers of Sulphur, of each 1 ounce, mix them and rub them together for a considerable time in a glass Mortar, the longer the better, by which means they will grow hot and send forth a fetid Smell. Boil this fine Powder in Water for the space of half an hour, and then pour off the decoction, filter it, and set it by. Upon the *Residuum* put more Water, and treat it in the same manner, and so proceed till it at last comes off without any Taste. Mix all these Waters together, which have a kind of inky Taste, and inspissate them, and you will have somewhat of a very pure Vitriol of Iron.

2. Take such another mixture of Iron, but 8 ounces in quantity, and work it with Water into a stiff Paste. Press this hard down into an earthen Pot, and set it by, and in a short time it will spontaneously grow warm, hot, very hot, emit Fumes, and often at last take fire. When this agitation is over, you will find the Matter altered, and converted into an equable Mass. Rub this very well, and then boil it in Water, as in the preceding case, and you will hence too have an exceeding pure Vitriol of Iron, endued with beautiful medicinal Vertues.

3. Into Sulphur, in fusion in the Fire, dip the end of an Iron Rod for some time, and it will be calcin'd and brittle. Or if upon the same melted Sulphur

you sprinkle some Filings of Iron, you will have a *Calx* of Iron, which being treated as before, will yield nearly the same Matter.

4. And lastly, if to Iron perfectly ignited you apply a roll of crude Sulphur, it will soon make the calcin'd Metal run down in drops, which being pounded, produce the same kind of *Calx*.

U S E.

IN these four Experiments the very acid Oil of Vitriol which constitutes one part of Sulphur, being by rubbing in the two first cases, and fusion in the two last, applied to the Iron in a greatly increas'd surface, begins to act exactly in the same manner as was explain'd *Process* 162, leaves the other oily part of the Sulphur, and unites with the Metal. And as this action always produces a great degree of Heat, it is no wonder at all that the oily part, which is easily inflammable, shou'd at last take Fire, that is to say, when these Substances are mix'd together in a considerable quantity, and then are thoroughly rubb'd and work'd together, and hard press'd down. *Mem. de l'Ac. Roy. des Sc.* Vol. II. p. 52. As soon as ever, therefore, in any of these four ways the Acid of the Sulphur has corroded the Metal, there is immediately produced the Matter of a Vitriol of Iron, and that an exceeding pure one too, as the Flowers of Sulphur are quite free from any metalline Taint. By this means then may be made true artificial chalybeate Waters. These Powders the Chemists have call'd (Saffrons) *Croci*, on account of their Colour, and *Croci Aperientes*, because there is in them an aperient, vitriolic Vertue; whereas other Powders prepar'd with an Acid and Fire are call'd astringent ones. Thus then, Gentlemen, in the *Processes* from 162 to 171, I have laid before you the principal methods by which this Metal may be chang'd in such a manner, as to produce something new under various forms, and sometimes such Bodies as by means of the Fire, and other helps, may be made to give back again the very same Metal. As in various Metals, however, there occur particular *Phænomena*, hence they all require a peculiar management.

P R O C E S S CLXXI.

A Calx of Lead with the Vapour of Vinegar.

A P P A R A T U S.

YOU see I have here a large Cucurbit, cut off in such a manner as to have a very wide Mouth, which is fitted to this large Head. Within this I dispose some thin plates of Lead, setting them pretty upright all round the circular Channel, so that they mayn't fall down. I then pour some Vinegar into the Cucurbit, place it in a Sand Furnace, fit on the Alembic with the leaden Plates, apply a Receiver, and with a gentle Fire distill for the space of twelve hours, and then desisting leave the whole to cool for twelve hours more. Let the Plates be then gently dried, and they will grow white, and be cover'd with a white Powder which being gently brush'd off with a Hare's Foot, goes by the name of Ceruss, or White-lead. And if you repeat this Operation a sufficient number

number of times, the whole Body of the Lead will at last be converted into this white Powder, which is perfectly insipid, and inodorous. The Vapour of the Vinegar which rises during this Operation, condenses into a Liquor, which is whitish, turbid, sweet, nauseous, and Styptic, and is call'd Vinegar of Lead, or a Solution of Lead.

U S E.

HENCE then we learn, that Lead is very easily corroded by this gentle Acid, and from a malleable state is soon converted into a loose Powder, or brittle Scales. The Liquor too that rises during the Operation is pregnant with the dissolved Metal, and is a real solution of Lead, yielding a true Salt of it by inspissation. When Lead therefore is expos'd to an Air, that is full of Acids, this operation is continually going on of itself, and hence leaden Bodies in these circumstances are by degrees converted into a white *Calx*, and so gradually waste away, and that so much the sooner as the Air is more replete with an Acid. If Iron or Copper are treated in the same manner, they likewise will be resolved on their surfaces, the first into a *Ferrugo* or red *Calx*, the other into an *Ærugo* or green one, whilst the Liquor that distills from the Iron is of a Gold-colour, that from the Copper green. The Cerufs, now, thus produced is composed of the acid Liquor of the Vinegar, and the dissolved substance of the Lead; but the Acid lies conceal'd there, as we saw before in Iron. This Cerufs by being sprinkled upon them is of Service in gleetings, watery Ulcers, and disorders of the Skin. If, when it is reduced to a fine Powder, it is received in with the Breath in inspiration, and carried down into the Lungs, it causes terrible Asthma's, that are almost incurable, and generally at last prove fatal. If it is taken in at the Mouth, and swallowed with the Spittle, it produces the worst kinds of Disorders in the *Viscera*, Languors, Weakness, Pains, with intolerable Oppressions, and in the end Death itself. Sad instances of the very pernicious effects of this Metal one sees daily amongst those Persons who work Lead in any form, but particularly amongst the Workers in White-lead. Let us beware therefore of this Poison, which having neither Smell nor Taste, is scarcely taken notice of till it discovers itself by fatal Inconveniencies. From this Operation, now, we learn how easily Lead will lose its metalline Nature, and be converted into a *Calx*: The same thing too appears in abundant different ways: Thus, if you melt Lead with a gentle Fire in an earthen Vessel that is not glaz'd, it looks at first like pure Mercury, but presently the Surface grows dull and has a pellicle form'd upon it, which being carefully taken off with an iron Ladle, is a kind of a *Calx*. The Surface then regains its Brightness, but there soon appears such another Pellicle, and so on 'till at last the whole Body of the Lead will be converted into such a Scum, which has likewise a poisonous quality. If this *Calx*, or the former Cerus's, is calcin'd for a good while, and kept stirring upon the Fire, it is at length found to be increased in its weight, and acquires a bright scarlet Colour, and is then called *Minium*, or Red-lead: This likewise is observ'd in the leaden ore upon a long calcination. In separating Silver from the Ore there is form'd a Scum, which consists chiefly of Lead, and when it is of a yellowish red Colour is call'd Litharge of Gold, when paler, Litharge of Silver, which are nearly the same both in Matter and Vertue. The

fossil Plumbage too don't differ a great deal from all these, as it is a pretty natural leaden Ore. Lead therefore, though it exists under these various colours, weights, and forms, still continues to be truly the same Lead, is dissolv'd by the very same *Menstruums*, and what it yields is the same; nor does it much signify whether you corrode Cerufs, Litharge, *Minium*, or Plumbage, with Vinegar, for you hence have always the same Salt of Lead. These have all too the same power of drying, and the same poisonous quality is always found to continue in them. *Minium* acquires a considerable weight from the Fire. Is this from the Acid of the combustible Matter attracted into the Lead, or from an addition of the substance of the Fire itself? See Boyle, *Of the Ponderability of Flame*.

P R O C E S S CLXXII.

Vinegar of Lead.

A P P A R A T U S.

1. **B**OIL Cerufs for the space of four hours, with 20 times as much strong distill'd Vinegar, in a tall Bolthead plac'd in our wooden Furnace, often shaking the Glafs. Let the whole cool, pour off the pure Liquor, filter it, upon the *Residuum* pour fresh Vinegar, and proceed as before, and repeat this till almost all the Cerufs is dissolv'd into a limpid form. All these Vinegars then being mix'd together, are found to have lost their Acidity, and to be sweet, nauseous, and styptic: These are call'd Vinegars of Lead, and *Lac Virginale*, because the Ladies make use of them to take away any red Spots, Pustules, or little Ulcers in the Face. If these Vinegars, when they are filter'd till they are very pure, are distill'd in clean Vessels till only one quarter remains, there comes off a nauseous Water, which has a disagreeable and very particular Smell, but is not acid, all the acidity of the Vinegar being retain'd in the dissolv'd Cerufs. Let the *Residuum* be kept under the Title mentioned, and be look'd upon as having the same Vertues with Vinegar of Litharge.

2. If instead of Cerufs, you take Litharge of Gold or Silver, *Minium*, or Plumbage, and reduce them to Powder, and then boil them with Vinegar in the manner describ'd, you will procure from all of them a Vinegar of Lead, that cannot be distinguish'd from one another. There is one thing indeed particular in it, and that is, that when it is cold, it is filtered with more difficulty, the Paper being clos'd up as it were, though it passes through easy enough when it is hot.

3. If upon this inspissated Liquor of dissolved Lead you pour fresh distill'd Vinegar, and boil them till they are reduced nearly to the consistence of Honey, the Vinegar that is drawn off is found to have lost a great deal of its acid quality, the Acidity being retain'd in the metalline Liquor that is left behind, which is oily, pinguious, of a sweet Taste, like Sugar, and is call'd Oil of Lead, consisting of the Metal and Vinegar. And the oftner this affusion of fresh Vinegar and inspissation is repeated, the more pinguious does the Liquor grow in proportion, and is afterwards dried with more difficulty.

U S E.

HERE then we have a new method of calcining, dissolving, and reducing to a liquid form a very heavy metal. And by this union of it with the Vinegar, we see there is produced a new Smell and Taste, the acid part of the Vinegar being attracted and separated by the Metal till it is impregnated and saturated. If Bodies are immers'd in this Vinegar of Lead till they are well penetrated with it, and are then dried, they are secured from Putrefaction, and remain incorruptible for a great length of time. The Humours of Animals it coagulates too, and so preserves from corruption. If it is diluted, and then used as a Wash, it in a great measure removes Pustles, Redness, Erysipelas's, and Phlegmons, and gives the Skin a beautiful whiteness, but at the same time often proves injurious to the health, at last bringing on a Consumption, of which there have been melancholy instances. But when the condensed Oil of Vinegar of Lead, abovementioned, is mix'd with an equal quantity of Oil of Roles, it makes a white chemical Balsam, which is greatly commended by the Surgeons.

P R O C E S S CLXXIII.

A Salt of Lead with Vinegar.

A P P A R A T U S.

1. **T**AKE some Vinegar of Lead, put it into a low Cucurbit with a very wide Mouth, and inspissate it till you have reduc'd it nearly to the consistence of an Oil, then set it by in a cold still place, and there will be form'd at the bottom a white Mass inclining to grey, consisting of fine *Spicula*, standing upright. Pour off all the liquid part, and gently dry the remainder, and it will have a Sweetness like that of Sugar, and is call'd Sugar of Lead.

2. Let this common Sugar of the Shops be dissolv'd in very strong distill'd Vinegar, and let the solution by standing quiet be depurated from its *Fæces*, and then be inspissated to the thickness of an Oil, and set in a cold place, and it will shoot at the bottom into thick solid Crystals, exactly resembling those of vegetable Sugar, and having a saccharine Taste.

3. If these Crystals again are dissolved in fresh Vinegar, and depurated and inspissated to the consistence of an Oil, as before, you have a Liquor that is not easily dried with a small Fire, so as to become hard, but is somewhat of a more fix'd nature, and with a gentle Heat melts like Wax. And the oftner it is thus impregnated with fresh Vinegar, and dried, the more fix'd does the Matter become in a small Heat, nor fumes, but easily melts. And if this is then expos'd to a moderate Fire a considerable time, and whilst it continues fluid is poured into another cold Vessel, it surprizingly coagulates, even whilst it is pouring through the Air, and becomes form'd into fine Threads, just like those of a Spider's Web, which look exactly like Silver, and make a pretty appearance. This a *Jesuit* formerly published as a Secret, under a parcel of hard Words, form'd by a transposition of their Letters. *Phil. Trans. Abr. Vol. III. p. 325.*

4. As soon as ever the Body thus coagulated into Threads is exposed to a somewhat greater degree of Heat, it will melt again, and may be pour'd out as before. And if it is thus carefully and patiently melted and inspissated a pretty many times, the *Fæces* being every time thrown away, and the Matter is then soften'd for a good while with a gentle Fire till it becomes one concreted Mass, it will easily from its look pass upon People that are not aware of it for true Silver. Here *Isaacus Hollandus* deserves to be consulted concerning the Stone prepar'd from Lead. This *Process* may at pleasure be protracted by those Persons, who are pleas'd with such appearances of Bodies as are not common.

U S E.

THIS Preparation is call'd a Sugar, Salt, Magestery, and Vitriol of Lead, and teaches us how Lead may be so combin'd with a fermented vegetable Acid as to form a Body that is dissoluble in Water. It is astringent, and styptic, and coagulates the Blood pretty readily. If it is dissolv'd in Water it makes a Vinegar of Litharge, which does service externally in Inflammations. Internally it is commended in Spitting of Blood, Hæmorrhages, Pissing of Blood, Gonorrhœa's, the Whites, and such kind of Disorders, as also to allay and soften any sharpness in the Blood. But for my own part I confess I never dared to make Trial of it, as I have seen no very happy success from its use by other Persons, and as I know that there is scarcely a more deceitful or deadly Poison, than there is in this Lead, which will immediately return to Ceruss, as soon as ever it meets with any thing that will absorb its Acid. Hence you introduce a Poison into the Body, which can scarcely be afterwards extirpated. If Salt of Lead is gradually distill'd in a Retort, and at last urg'd with the strongest degree of Fire, there comes off a pinguious inflammable Spirit, perfectly of another nature than the Vinegar was which was made use of, and at the bottom there remains a kind of Glass, which being exposed to an intense Fire insinuates itself through almost all kinds of Vessels, and causing all other Bodies but Gold and Silver to vitrify, carries them along with it.

P R O C E S S CLXXIV.

A Salt of Lead with Spirit of Nitre.

A P P A R A T U S.

1. **U**PON 1 ounce of Shot, Ceruss, Litharge, or *Minium*, in a tall Bolt-head, pour of Spirit of Nitre or *Aqua Fortis* diluted with 10 times as much Water 15 ounces, upon which there will be excited a violent Ebullition with a white Froth. When the Effervescence is over, place the Vessel in our wooden Furnace, and let the Liquor boil for five or six hours, and then stand quiet and grow cold. Pour off the pure Liquor at top, filter it, and distill it in a Cucurbit to the appearance of a Pellicle, and there will come off a Water that is nauseous, but not acid. Let the Remainder be set by in a cold place, and it will shoot into solid white Crystals, that are very heavy, will not dissolve in the Air,

Air, but are pretty durable, and are of a sweet Taste, but at the same time rougher than those prepared by the preceding *Process*. The Liquor too, after the Solution, Distillation, and Crystallization, has a saccharine sweetness like that of the Salt.

2. If upon the Salt thus prepared, you pour fresh *Aqua Fortis*, dissolve it, and inspissate the Solution, you may thus too obtain an Oil of Lead, which is not dried without a pretty deal of difficulty, but gradually grows fix'd, so as to melt like Wax with a gentle Fire.

3. If this Salt is thrown dry upon a live Coal, it will not take Fire, but crackle most violently, and being impatient of the Fire flies about to the great danger of the By-standers. If it is reduced to Powder, it may be melted with a strong Fire.

U S E.

HERE then we have a new method of generating a metalline Salt and its Oil; of producing a sweet Taste from a very acid and an insipid one; and of procuring Glafs from Metal: And here we see, that Spirit of Nitre does not produce an inflammable Salt with every Metal, as it does with Silver. This Salt has the same Vertues as the preceding, but is more corrosive and astringent.

P R O C E S S CLXXV.

Salt of Lead managed with Alkali's.

A P P A R A T U S.

UPON 2 ounces of the Crystalline Salt of Lead of *Process* 173, 174, very carefully dried, and finely powdered, pour 4 ounces of Oil of Tartar *per Deliquium*, and set them a digesting, the longer the better. When they have stood a proper time, add 1 ounce of *Sal-Ammoniac*, mix 'em well together, and commit them to digestion again in a close Vessel. The saline Liquor that rises whilst they are thus digesting, pour on again, and digest as before, and when you have repeated this three or four times, dry the Matter perfectly with a gentle Fire, expose it to a moist Air that it may be dissolved, and then dry it again, and distill it in a glafs coated Retort with successive degrees of Heat, till you come to the greatest that it is possible to excite with Sand, applying at the same time a large Receiver that has some clean Water in it. By this means then there will come off a threefold Matter, which you will be somewhat surpriz'd at, and there will remain a very singular Body at the bottom of the Retort, that is wonderfully altered.

U S E.

THERE are a great many very curious things learn'd by this Experiment, which, if you'll give yourselves the trouble to try it, you'll observe with pleasure: For the Metal being so successively open'd and resolv'd by the opposite Salts, and then dried and dissolved in the Air, is greatly chang'd, attenuated,

tenuated, and separated from every thing that is not a metalline Mercury, so that it may by this means give us the true metallic mercurial part freed from all the rest, if this, by a diligent application to the Art, can be at last attained to.

PROCESS CLXXVI.

A Calx of Vitriol of Lead.

APPARATUS.

TAKE the Vitriol of Lead of *Process* 173, 174, dry it very well with a gentle Fire, and reduce it to a very fine Powder. Put this Powder into a glaz'd Plate, set it upon the Fire, and keep it stirring with a Tabacco-pipe till in a strong Heat it will emit no more Fumes. By this means you will have a fine and almost insipid Powder, which is another *Calx* of Lead made by the assistance of a Liquid.

USE.

ALL the Acid that was united with the Lead whilst it was in the form of Vitriol, is here separated from it by the force of the Fire, except that part which intimately adhered to it and did not appear externally, which is by this means still much more closely combined with it.

PROCESS CLXXVII.

A Balsam of Lead with express'd vegetable Oils.

APPARATUS.

1. IF you put granulated Lead, any of its *Calx*'s, Cerufs, Litharge, or *Minium*, into a glaz'd Pipkin, and add to it twice its weight of any express'd Oil, and gradually expose it to an increasing Heat, the Lead will begin to be melted before the Oil boils. And if you then continue to raise your Fire by degrees till you bring the Oil to boil, the Body of the Lead, or *Calx*, will disappear, and will be so accurately mix'd with the Oil as to make a true Balsam, which by farther boiling may be reduced to a Body that will be very thick, and of some consistence in the cold, and appear of a semi-metalline nature, but will melt again, and grow ductile with Heat.

2. If instead of Lead, or its *Calx*, you take that *Calx* that is prepared by *Process* 176, or even Salt of Lead, so that it is but well dried, by mixing an express'd Oil with it, and treating it in the manner describ'd, you will have just such another Balsam of Lead, consisting of true Metal and Oil.

USE.

HENCE then we see, that a true Metal, and that a very heavy one too, may, by the assistance of Fire, be dissolved by a vegetable Sulphur, and be so

so mix'd with it, and disperfed through it, as to lie quite concealed. How often therefore may we be at a lofs about the admixture of Metals with other Bodies? How wonderfully may they lie hid from our Obfervation? How frequently therefore may they be extracted from Bodies in which one wou'd not have fufpected they were contained, and then be falfly fupposed to be produced by tranfmutation? Let us hence be caution'd to be aware of the wiles of the Sophifts. Plaifters made with thefe Balsams ftrengthen and cherifh the Parts, prove difcutient, and by their abforbent quality draw out and obtund fharp Humours. But they are particularly of fervice when we want to make Veffels capable of holding Water: For if *Minium* is boil'd in Oil to a proper thicknefs, and is then well rubb'd upon a Stone Wall, made nearly red hot, fo that it may penetrate into it intimately, it will prevent any Water's soaking through it, as well as if it had been built with Cement. We ufe it likewise to faften Faucets into their Casks, by which means they are prevented from leaking.

P R O C E S S CLXXVIII.

A Balsam of Lead with a diffill'd vegetable Oil.

A P P A R A T U S.

TAKE the Sugar of Lead of *Procefs* 173, dry it very gently, and then upon the Powder thus produced pour four times as much ætherial Oil of Turpentine, and boil 'em for fome time in a tall Bolthead, which may be eafily done by fetting it in Linfeed Oil, and heating that juft enough to make the Oil of Turpentine boil, which will happen a good deal fooner than the Linfeed Oil will boil, itfelf. By this gentle ebullition, then, almoft all the Sugar of Lead will be diffolved in the Oil of Turpentine, and thus you will have a Balsam of Lead with a diffill'd Oil.

U S E.

THIS Balsam is fit for the fame ufes as that of the preceding *Procefs*.

P R O C E S S CLXXIX.

Glafs of Lead.

A P P A R A T U S.

1. **T**AKE of *Minium* 2 parts, of very clean Sand ground to a farinaceous Powder 1 part, rub 'em very well together till they are thoroughly mix'd, put the Mixture into a clean Crucible, melt it, and when it has been in fufion for fome time, if upon dipping a Tobacco-pipe into it, the melted matter adheres to it, and appears pellucid, pour it out upon a Marble, and you will have an infipid, inodorous, yellow, pellucid, brittle Body, which will grow hard in the Cold, but will melt again with Heat. This therefore has acquired the name

of Glass of Lead. This, when it is in fusion in the Fire, runs through all the Vessels we know of in the World, as Water does through a Sponge. And the same, when it is melted, converts almost all the Bodies we are acquainted with into Glass, and then carries them along with it through the Pores of the containing Vessels, leaving Gold and Silver, however, unaffected. That the *Minium* and Sand may sooner run into Glass, some Persons add Nitre, others Sea-Salt, and then urge them till the Salt is melted.

2. If Sugar of Lead is expos'd in a Crucible to a Fire gradually increas'd, the Vinegar being dissipated, it will flow and be converted into a yellow Glass, and at the same time there will appear in the Metal some surprizing beautiful Colours, like those of the Rainbow, or a Peacock's Tail.

3. If Lead is melted, and kept a good while in fusion in the Fire, it will produce a Spume, and by degrees be almost all converted into it, and if this is then melted with a stronger Fire, the Lead will by this means be converted into Glass, without the addition of any thing else, though not without much labour, and that prudently directed; whence at last the Art is easy.

4. Take of *Minium* 4 parts, of Sand 1 part, and of Sea-Salt decrepitated, and very dry, 2 parts. Mix them well together, the more intimately the better. Put the Mixture into a Crucible, cover it very close, fuse it thoroughly, and then let it stand quiet. By this means then the Salt will be melted into a Mass at top, and at the bottom, upon breaking the Crucible, you will find a Glass that must be carefully separated from the other Parts, and preserved for metallurgic uses, for there it is of vast service.

5. If these Glasses are mix'd with a little Charcoal, and then melted, a true Lead is easily recover'd from them again.

U S E.

THUS then, by the help of Fire, dissipating a very poisonous metallic Vapour, we see this Metal chang'd from its perfectly malleable nature, into a very brittle Mass that is truly glassy, nay which, by an admixture of a *Calx* of Sand, or Flints, becomes perfect Glass. In what surprizing forms, therefore, may Metals lie concealed? And how easily may they often be brought back again to their natural state? When a certain sulphureous part is separated from them, do Metals vitrify in the Fire? A proper reflection on the preparation of Glass of Antimony, and other Experiments, wou'd persuade one to think so. And, upon this Sulphur's being restor'd again, do they regain their metalline form? This seems confirm'd by many Observations, especially in the management of Lead. *Mem. de l'Ac. Roy. des Sc.* 1709. p. 218. &c. This Glass of Lead is that severe probationer of Metals, which in the Fire destroys every thing but Gold and Silver, and leaves them exceeding pure without any diminution of their weight. Upon this principle depends the whole docimastic Art, which is of such vast service in human Life. And let this suffice for beginners. Upon this head, if your curiosity leads any farther, consult Mess. Boyle, Bohn, Homberg, and Geoffry. But before I pass on to the next Metal, let me once more caution you, to beware of the Fumes, Powder, and indeed every part of Lead, for it always proves one of the worst of Poisons.

P R O C E S S

PROCESS CLXXX.

The solution of pure Silver in Spirit of Nitre, or Aqua Fortis.

APPARATUS.

1. **I** TAKE 1 ounce of Silver purified by being coppell'd according to Art with ten times its weight of Lead, which I melt in a very clean Crucible, and when it is in fusion pour it into some cold Water contained in a cylindrical Vessel, holding it about 8 inches above the Water. The Silver, then, you hear, enters with a hissing noise, and falls to the bottom in little Grains, and is now call'd granulated Silver. This I put into a clean Urinal. I then take 2 ounces of *Aqua Fortis*, into which I throw a grain of pure Silver, and if I find that it is in a short time intirely dissolv'd, so that the Liquor is quite limpid, I know that the *Aqua Fortis* is good; but if it will not dissolve, or only renders the *Aqua Fortis* turbid, it is a sign that the *Aqua Fortis* is not pure. The first sort is call'd by the Assayers proved *Aqua Fortis*. 2 Ounces of this then I pour upon the ounce of granulated Silver in the Urinal, upon which the *Aqua Fortis* presently begins to be put in motion, boil, smoke, and hiss about the surface of the Silver, and then to grow hot, be agitated more violently, emit red Fumes, and dissolve the Silver in such a manner that it intirely disappears. By this means then you have a pellucid, colourless Liquor, of a very acrid, bitter, and most violent caustic taste. At the bottom of the Vessel, however, there is always somewhat of a very black Powder; and this is pure Gold, which is either constantly mix'd with the Silver, or else perhaps, according to Monsr. *Homburg's* opinion, is easily produced by the Lead and Fire, and being not dissoluble in the *Aqua Fortis*, is precipitated from the dissolved Silver. Pour out the limpid Liquor into a very clean Glass, and you have a solution of Silver.

2. If instead of *Aqua Fortis* you make use of Spirit of Nitre the Solution will be more violent, and sooner effected, but the *Phænomena* will be all the same: For *Aqua Fortis*, and Spirit of Nitre, either prepared with Bole, or Oil of Vi-triol, seem scarcely to differ from one another, except in a greater or less degree of the very same kind of Acidity. But here let me observe, that if the smallest quantity of Fountain-Salt, *Sal-Gem*, Sea-Salt, *Sal-Ammoniac*, or any of their acid Spirits, happens to be mix'd with the Spirit of Nitre, or *Aqua Fortis*, either during the Distillation of them, or afterwards, then they will not be capable of dissolving Silver.

USE.

IF this Solution is pellucid, and without Colour, it is a proof that the Silver was pure; but if it has a greenish cast, it is a sign it had somewhat of Copper in it, and then the Solution is not fit for the following *Processes*. Here then we see, that the Silver, by being united with the Acid part of the Nitre keeps suspended in the watery part of it. If a drop of this Liquor is applied to any soft, warm part of the human Body, it burns and consumes it in an instant; and hence it at once eats down the hard callous Lips of Ulcers, separates semi-

putrid parts, and immediately extirpates Marks, Scars, Warts, and small Cancers. It may be diluted with pure Water, without growing turbid, or causing a Precipitation; but if there is the least admixture of Salt in the Water, it loses its clearness. This diluted Solution is one of the greatest Detergents, but wherever it touches the Skin, it makes a black spot that cannot be removed till the *Epidermis* itself is separated. How wonderfully therefore may pure heavy Silver lie conceal'd from the Eye in light limpid Water? Its Taste, however, which is exceeding bitter, will discover it.

P R O C E S S CLXXXI.

Vitriol of Silver.

A P P A R A T U S.

1. **I**F into the Solution of the preceding *Process*, you throw a grain of pure Silver at a time, till the last grain will not be dissolved, then if this saturated Solution is set by in a cold place, there will soon begin to appear very thin, white, smooth, little *Lamellæ*, applied to, and lying upon one another, and being made up of triangular *Spicula*, as it were, exceedingly like those of Nitre. When these are formed, pour off the remaining Liquor, and you will have Crystals, Salts, or Vitriols of Silver, which can scarcely be dried, and which on account of their exceeding Acrimony, are quite intractable.

2. And if the former Solution, not saturated with any more Silver, is a little inspissated, so as to lose, for instance, about $\frac{1}{15}$ th part of it, and is then set quiet in the cold, the Silver will become concreted at the bottom of the Vessel into a white solid Crystal, in other respects the same as the preceding, but more acrid, inasmuch as it is impregnated with a greater quantity of Acid. This therefore is a much more violent Caustic.

U S E.

HENCE then we learn the mutual attraction there is betwixt Silver and this particular Acid, whereas it resists almost all others, growing black, indeed, when it is exposed to them, but not dissolving. This Vitriol of Silver is the most ready Caustic, producing a black spot on the Skin if it does but lightly touch it, which will not be remov'd till the Cuticle peels off.

P R O C E S S CLXXXII.

The Lunar Caustic, or Lapis Infernalis.

A P P A R A T U S.

1. **T**AKE a piece of Potter's Clay that is well work'd, stiff, and not very moist, form it into a cubical figure, and set it on a Table, and with a conical Iron pierce it perpendicularly in several places from the upper surface almost quite through, taking care that the Holes are smooth within, that the
Matter

Matter which is pour'd in may not be rough. When you have thus made as many Holes as you have occasion for, press the tops of them with your Finger in such a manner as to form a spherical Cavity round each of them, that you may the more easily pour in the melted Matter.

2. This being done, take the bottom of a glass Urinal, cut out, lay upon it the first Crystals of the preceding *Process*, and set it upon a live Coal, by which means the Crystals will send forth a noxious Fume. When they are melted, and do not fume any longer, pour them out cautiously into the conical Cavities made in the clay Cube, which the melted Matter will enter with a hissing Noise. If any of it happens to harden in the Glass, set it on the Fire again, and so proceed till you have poured all your Silver into these moulds.

3. As soon as ever the Matter has acquired a solid Consistence, break the Clay, take out the silver Cones, lay them on a dry hot Paper, and on that dry them thoroughly. As soon as you observe this is the case, wipe the surface of them with a dry, hot, Hare's Foot, and then put them immediately into a dry Vial, which stop as close as possible. Thus then you have the *Lapis Infernalis*, which is of excellent service in Surgery, and may be kept good for many years.

U S E.

THE Acid of the Nitre, whilst it is over the Fire, has its Water separated from it in form of Vapour; and that part of the Acid too is carried off, which is more than what the Silver in the Crystals is capable of retaining. The Silver, however, holds fast a certain portion of the Acid in such a manner that it will not fume, but remains fix'd with the Metal, even when it is in Fusion. This Acid being retain'd with the Body of the pure Silver, constitutes a solid Body, and is, perhaps, the purest and strongest Acid that can be any ways prepared. When the Acid thus adhering to the Silver in a solid form, is exposed to the Air, from its impatience of dryness, it attracts the Moisture out of the Air, and so dissolves. This *Lapis Infernalis*, too, may be intirely dissolved in Water, and then, by the assistance of Copper, all the Silver may be recovered from it, which is then found to be insipid, inodorous, inactive, neither acid nor corrosive, but exceeding simple, pure, and perfectly native, without any alteration at all. The Acid therefore adheres only to the surfaces of the Elements of the Silver, without at all affecting their proper nature, and hence the Silver may be procured from it again in its original form. This Stone is an exceeding powerful Caustery, burning the warm moist parts of the human Body to an Eschar in an instant. Under this Eschar, Nature will of course produce an Inflammation, and so throwing off the Eschar will render the crude part pure. By this means, therefore, disagreeable, fungous, and cancerous Excrescences on the surface of the Body are successfully removed. Hence the Surgeons greatly extoll its usefulness. The Physician too may hence learn the surprizing power of this Acid, when it is thus collected and fix'd by the Silver. If it is given in this form internally, it is the most immediate escharotic Poison; and for this reason must never be made use of upon any account whatever. I knew a Chemist to whom this production of his own Art prov'd fatal.

P R O C E S S

P R O C E S S CLXXXIII.

The Silver Hydragogue of Mr. Boyle or Angelus Sala.

A P P A R A T U S.

1. **T**AKE of the best Nitre 1 ounce, which dissolve in the purest distill'd Water, that the Solution may be as perfect, and the Liquor as limpid as possible. Then take of the choicest Crytals of Silver, prepared according to *Process 181. No. 1.* 1 ounce, which dissolve in 3 times as much of the same Water, so as to have a perfectly pellucid Liquor, without the least appearance of any thing turbid. This being done, mix these two Liquors together, and the Mixture will be clear, homogeneous, and simple, nor will the Silver precipitate, but be most accurately combined with the Nitre. Put this pure Liquor into a clean Urinal, and with a Fire that is not at all smoky, and in a place that is not dusty, evaporate to a Pellicle, and the Water that exhales will be pretty pure. Set the remainder by in a cold still place, carefully covering the Glas that no Dust may fall in, and it will shoot into Crytals like those of Nitre. Gently pour off the fluid part, and treat this as before, and the Silver and Nitre will be united together in the simple form of Crytals. Dry these very gently.

2. Have in readiness the lower part of a Urinal, cut off as high as the middle of the Belly, upon this lay the Crytals thus form'd from the Silver and Nitre, having first dried them upon a Paper. Set the Glas with the Crytals so near the Fire, that it shall make them fume, and dry them, but shan't be strong enough to melt them. This then being carefully guarded against, keep the Matter constantly stirring with a glass Rod, that by this means the whole being successively exposed to a pretty strong Fire, it may be dried thoroughly, and so be intirely freed from the sharp Acid which adhered to it, and rendered it caustic, and which may be separated by this gentle Calcination, whereas if the Fire is strong enough to melt the Mass, it will more intimately fix it with its corrosive Acrimony. This Calcination must be continu'd a good while, and the Matter must be kept constantly stirring till it will emit no more Fumes, tho' the Fire is almost strong enough to melt it; for towards the end, if it should accidentally be put in Fusion, it is not of so much consequence, as the Fire then will have separated all the external Acid. Thus then you have a purging Silver of an exceeding bitter Taste, which must be kept close stopp'd in a dry Vial.

U S E.

THIS is a secret and surprizing Art of combining Silver with Nitre. By this means, designing Men can conceal Silver in a considerable quantity of Nitre, 10 times as much, for instance, which being then spread upon an equal quantity of Lead in Fusion, will remain in the Cupel after all the rest is gone off, and thus will impose upon the unwary Spectator, who will hence imagine, that the Lead by this Art has one 10th part of it converted into Silver. If you
I have

have a mind, however, to discover the cheat, dissolve the Mass of Nitre and Silver in ten times as much pure distill'd Water, and put a polish'd Plate of Copper into the Solution, and all the Silver, not a Particle excepted, will be immediately precipitated upon the Copper, and the bottom of the Vessel, and then be perfectly pure, being freed both from the Spirit of Nitre and the Salt. If any of these Cheats, therefore, pretend to a Salt that will produce Silver, examine it in this manner, and you will know the truth of it. If the Matter, now, thus compos'd of the Salts of Silver and Nitre, is reduced to a very subtil, dry, Powder, it will have an exceeding bitter Taste, but will by no means be so caustic as the Crystals of Silver were before. If a little of it is applied to an Ulcer, it has the same effect as the *Lapis infernalis*, but in a much less degree. If 2 grains are rubb'd very fine in a glass Mortar, with 6 grains of Loaf-Sugar, and this Powder is made into nine Pills, with 10 grains more of Crumb of new Bread, and taken fasting by a grown Person, drinking presently after them 4 or 6 ounces of warm Water and Honey, they will purge very gently by Stool, carrying off a thin Water, which is often ready to pass without ones perceiving it. It is good in the Worms, killing both the *Tæniæ* and *Ascarides*, It cures many inveterate Ulcers too; and it does service in dropical cases, purging without any considerable griping. Beware, however, of too large Doses, or the too frequent use of it; for it always corrodes and particularly weakens the Stomach. In such case *Rob* of Juniper Berries do great service.

P R O C E S S CLXXXIV.

Burning Silver.

A P P A R A T U S.

TAKE a live Coal of *Dutch Turf* that is thoroughly on Fire and does not emit any Smoke, make a little hole in its upper surface, in which lay a drachm of *Lapis infernalis* that is very dry, and it will immediately melt, take fire, burst into Flame, crackle, look exceeding bright, and in every respect resemble burning Nitre. When the Flame is gone out, there will remain just as much pure Silver in the cavity as was made use of in preparing the Stone, out of which therefore it may be taken without any loss.

U S E.

THIS beautiful Experiment teaches us, that Acids adhere only to the surfaces of the Elements of Silver; shews us the manner in which Acids act when they are united with Metals, being then dispos'd only round the heavy, metal-line Particles, and thus arming them with sharp *Spicula*; demonstrates, that Silver remains absolutely immutable whilst it is corroded by an Acid, and that it may lie concealed and act under a great many various forms; and points out to us the difference there is betwixt that potable Silver, which subsists in a saline form by means of an Acid adhering to it, and that other of the Adepts, where the very ultimate Elements of Silver are suppos'd to be converted into a Liquor that will mix with our Humours, nor can afterwards be reduced to Silver again.

But

But here we see particularly that the acid Spirit of Nitre, whilst it is combined with the Silver in a solid form, is as inflammable when it is mix'd with combustible Matter, as the Body of the Nitre was itself: This seems owing only to the Silver which is immutable by the Spirit of Nitre. And lastly, this is the only method in which pure Silver can, by simple combustion, be separated from heterogeneous Bodies united with it. It appears, therefore, that the Acid does not act upon the mercurial part of the Silver, nor upon its fixing Sulphur. Many more things might be said upon this head, but as they are not absolutely necessary to our present purpose, I omit them.

P R O C E S S CLXXXV.

The recovery of Silver from its solvent Spirit of Nitre.

A P P A R A T U S.

TAKE 1 ounce of the purest Silver well dissolved in Spirit of Nitre, dilute it with 20 times as much distill'd Rain-water, and then into this very limpid Solution, heated in a cylindrical Glass, put some polish'd Plates of Copper. As soon as ever this is done, the polished surface of the Plates will begin to grow dull, will acquire a greyish Colour, and in a short time sprout out as it were, and be covered all over with a kind of thick Down; and at the same time too the Liquor, which before was like Water without any Colour, will grow greenish, and proportionably deeper and deeper, as more of this Down fixes upon the Copper. If you then strike the Plates, there fall off flocculent Sheaths to the bottom of the Vessel, upon which others will be again presently formed from the Liquor, exactly like the former. The Liquor too will become still greener, and the Plates will be diminished. These being shook off, you have again more, and so on. When you perceive at last that nothing farther will fix upon the Copper, leave the Vessel for six hours, strike off the greyish Down from the Plates, gently pour off the Liquor from the subsiding Matter, and filter it, and it will be of an exceeding beautiful green Colour, sharp, and perfectly copperish. The Plates at the same time will be a great deal diminished, both in bulk and weight. Let the Matter that remains at the bottom of the Glass be wash'd, by frequent additions of clean hot Water, till it is render'd very pure. Then dry it thoroughly over a clear Fire, and you will have a very fine, shining, silver Powder, which will give you back again almost all your Silver, pure, mild, and insipid, containing nothing at all either of the Acid, or the Copper.

U S E.

HERE then you have a method of calcining Silver into such a very fine Powder, as you can't easily equal in any other way. If this is rubb'd with Mercury, it very readily produces an *Amalgama*, which otherwise is so difficult, nor can be obtained without a considerable loss of Mercury. If you melt this Powder in a Crucible, you have the Silver again you made use of in the Solution. Hence then it appears how superficially the Acid of the Nitre adheres to the Silver,

Silver, as all of it without any remainder is easily attracted from the Silver to the Copper. If you view the Liquor with a Microscope during the Operation, you evidently see little Masses of Silver carried rapidly, with the Acid of the Nitre, to the immersed Plates, from every point of the Solution. But when these *Spicula* come to the polished surface of the Copper, then the Acid is attracted into the Copper, and the particles of Silver, now deprived of their Acid, remain upon the surface, and being there continually increased by the application of new ones, form a soft kind of Sheath, which incloses the Copper; and, which is pretty surprizing, this attraction is carried on so efficaciously, that at last there don't remain the least portion of Silver in the Solution. The Copper therefore attracts the Acid of the Nitre more powerfully than the Silver does. Hence this Operation is effected by the attraction and cribration of the Acid from the Body of the Liquid, the Acid passing on through the Pores of the Copper, whilst the Particles of Silver not being able to enter, are collected upon its surface: Examine these *Phænomena* with a Microscope, and you'll be very agreeably entertain'd. Here then the Acid of the Nitre remains unalter'd in the Silver, is collected perfectly the same in the Copper, and may be procured from that again.

P R O C E S S CLXXXVI.

The Luna Cornea.

A P P A R A T U S.

1. **I** N T O the purest Solution of Silver made with Spirit of Nitre, according to *Process* 181. No. 1. and then diluted with 4 times its quantity of pure Water, and put into a large glass Vessel, drop a small quantity of a very pure strong Brine of Sea-Salt, made almost scalding hot. The very moment then that it falls in, it grows white, and in the twinkling of an eye the Liquor becomes so thick that a Person that was not aware of it, wou'd be quite surpriz'd at it: But there does not appear any Effervescence. Proceed to drop more of the Brine in, till the Liquor will not grow turbid with it any longer; and then let it stand quiet, and there will be a large quantity of a thick, white Matter collected at the bottom, and you will have a limpid Liquor at top. Pour this off very gently, and drop into it a little more hot Brine, and if it then is not disturb'd, it is a sign you have obtained your end, but otherwise there will still remain some Silver to be separated from it. Upon the precipitated white Matter pour very clean hot Water, and wash it till you find it to be quite insipid. Then put it into a Urinal, boil it a little with the purest Water, and shaking them well together, pour them into a paper filtering Bag, upon which the Water will pass through, and there will remain a white Matter in the Paper, which must be dried with a gentle Fire. This then is a *Calx* of Silver precipitated from Spirit of Nitre, or *Aqua Fortis*, by Sea-Salt; and the weight of this is found to be nearly one fifth more than that of the Silver made use of, so much being added to it by these Salts.

2. Let this *Calx* of Silver be put into a clean Crucible, plac'd in a wheel Fire, and stand till it is melted, which is easily effected. As soon as ever it is in fusi-

on, pour it out upon a Marble, and it becomes a heavy, shining, opaque, brown Mass, which, though it is brittle, yet has some degree of tenacity, and hence has acquired the epithet *cornea*, or horny. In this, now, is truly contained all the Silver that was dissolved in the Spirit of Nitre, together with the Acid of the Nitre, and the Sea-Salt, which are become surprizingly concreted with it, nor are easily separable from it again: For if with the intensest Fire you endeavour to force out the Spirits, which was so easily done in the *Lapis Infernalis*, the greatest part becomes volatile, and flies off, whilst the *Residuum* will scarcely be recovered to Silver, but remains altered by the combination of these Salts, so intimately united and fixed in it, nor discovering themselves by any saline quality. If 1 part of the purest Silver, calcined according to *Process* 185, is mix'd with 2 parts of *Mercurius sublimatus*, and the Compound is distill'd in a Retort, at last, with the strongest Sand Heat, there will a *Luna Cornea* remain at the bottom of the Retort, which will be perfectly the same as the former. If instead of Sea-Salt too you mix Spirit of Sea-Salt with the solution of Silver, you will have the same likewise. And Mr. Boyle says, that Silver precipitated from Spirit of Nitre by Oil of Vitriol, and then washed and melted, will be converted too into a true *Luna Cornea*. *Orig. Form.* p. 203, to 209.

U S E.

THIS Experiment, which is of infinite use, teaches us, that the smallest difference of some physical circumstance, may occasion the greatest difference in the Body physically produced: For if Silver is exposed to *Aqua Regia*, it will not unite with its Acid, and yet when the same is dissolved in Spirit of Nitre, if you add Sea-Salt to the Solution, and thus only make an *Aqua Regia*, the Acid of this will be intimately combined with the Silver, and that with some very surprizing *Phænomena*. Thus, for instance, if to 2 parts of this precipitated *Calx* of Silver you add 1 part of *Regulus* of Antimony, and after you have ground them well together, distill the Mixture in a Retort with a sand Heat, you will by this means procure a Butter of Antimony of the same weight with the *Regulus* you made use of, the Silver at the same time remaining at the bottom with part of the *Regulus*, which being recover'd again, always yields a true Gold. Hence then we are certain, that the additional weight of the *Calx* of the Silver was owing to the *Aqua Regia* that was combin'd with it, because here we see it goes into the mercurial part of the Antimony. No wonder therefore that some of the top Masters in Chemistry, as *Becher*, *Boyle*, *Homburg*, and *Stahl*, have in this Experiment so much considered the Power, and latent arsenical Nature, as it were, of Metals and Salts. Who could have imagin'd, that in the exceeding insipid Body of the *Luna Cornea* $\frac{1}{3}$ th part should be the vastly corrosive acid of *Aqua Regia*? But what a singular power has Sea-Salt upon Metals? How wonderfully may it lie concealed among them, and yet at last be recover'd from them again in its full strength? Nay here we see that Gold itself may be procur'd from a Matter, in which no Gold could be discovered before by any docimastic Art whatever. So that here again the Adepts whisper into their Children's Ears, in *Sale & Sole*, Nature has plac'd the utmost perfection. If this *Calx* of Silver now is privately mix'd with Nitre, and then thrown into melted Lead, it will yield you both Gold and Silver, which will then be

falsly

fallly imagin'd to proceed from the Lead: Let us therefore beware of such impositions. But the Nature of our present design forbids us to enter into these things too minutely; and therefore I leave them to your own meditation. Give me leave to add, however, that Monsieur *Homborg* asserts, that by the assistance of Tartar, Quick-lime, *Sal-Ammoniac*, and Whites of Eggs, he extracted from $\frac{1}{2}$ a pound of Silver, 3 drachms, and 50 grains of true Mercury. But thus much of the nature of Silver for our present demonstrations. This *Luna Cornea* is not dissolved either by *Aqua Regia*, *Aqua Fortis*, or Fire.

P R O C E S S CLXXXVII.

A Solution of Tin in Aqua Regia.

A P P A R A T U S.

1. **I**F to *Aqua Fortis*, or Spirit of Nitre, you add a 6th part of Sea-Salt, *Sal Gem*, Fountain-Salt, or *Sal Ammoniac*, or Spirit of Sea-Salt, it by this means becomes an *Aqua Regia*, and dissolves Gold, but not Silver. And again, if by Distillation you draw *Aqua Fortis* off of Sea-Salt, or Spirit of Sea-Salt off of Nitre, you will have the same *Aqua Regia*. And lastly, if you take 2 parts of Nitre, 3 parts of Vitriol, and 5 parts of Sea-Salt, and mixing them together, distill as in the Distillation of *Aqua Fortis*, you will by this method procure the best *Aqua Regia* likewise. This therefore is owing to a Mixture of Nitre and common Sea-Salt.

2. Into some *Aqua Regia* contained in a clean Urinal, throw a small quantity of Tin, and there will appear a violent Solution: Proceed in this manner till it has dissolved as much as it is able, and you will have a thick, and kind of oily Solution. If this is then diluted with 20 times as much, or more Water, there will be precipitated the dissolv'd Matter of the Tin, which being perfectly wash'd with warm Water, and then dried, produces a white Powder, called a Magestery of Tin.

3. If Tin is thrown into *Aqua Fortis*, there arises a prodigious Effervescence, and the Tin dissolves, puffs up, and appears in the form of a thick Soap, or the White of an Egg.

U S E.

THIS is a particular manner of Solution. The dissolved Matter is in some measure bitterish, and in that respect resembles a Solution of Silver. The *Calx* prepared according to No. 2. is prescribed by many Physicians as a singular Remedy in hypochondriacal and hysterical Disorders. But I confess I am not fond of this metalline preparation, as there are others that are safer, which will answer the same purpose. If it is mixed with a proper quantity of *Pomatum*, it makes a famous Cosmetic for Persons whose Faces are disfigured with little ulcerous Pustles. It is very difficult, with the intensest Fire, to reduce it again to Tin. By this Experiment it appears, that of all Metals, Tin dissolves with the least quantity of Acid. It's surprizing now, that this Metal, when it is dissolved in *Aqua Regia*, does not fume: If it is mix'd however with double its

quantity of *Mercurius Sublimatus Corrosivus*, and distill'd in a Retort, the first Liquor that comes off always emits fumes, and exhales till none of it remains.

P R O C E S S CLXXXVIII.

The Solution of Copper in distill'd Vinegar.

A P P A R A T U S.

1. **I**F Plates of pure Copper are disposed in an Alembic, as we directed some time ago concerning those of Lead, *Process* 171, then the Vinegar, as it distills, becomes a green Liquor, and if you continue the Operation long enough, the whole substance of the Copper will by this means be dissolved. The Liquor thus procured being filter'd and inspissated with a moderate Heat, acquires a green Colour like that of an Emerald, becomes of a disagreeable nauseous Smell, and the very smallest drop of it proves instantly emetic. The Plates being dried, yield an *Ærugo* or Flower of Copper, but not the true Verdgrease of Copper, which is made only at *Montpelier* in a very particular manner, by the help of the Vapour of red Wine, digested with Grapes that have been press'd: Hence this *Menstruum* is scarcely acid, as the former is, but oily, pinguius, and unctuous.

2. If the common *Ærugo* of the Shops is boil'd in a tall Bolt-head with pure distill'd Vinegar till you have a Tincture, and you then pour that off and add fresh Vinegar, and boil, and so proceed till the last Vinegar by boiling will be tinged no longer, there will then remain a good deal of indissoluble Matter at the bottom, and thus demonstrate that it is not corroded Copper alone that produces this *Ærugo*. If all these ting'd Liquors are depurated by Filtration, and are then distill'd till there remains only $\frac{1}{4}$ th part they make a strong Liquor of Copper. See *Process* 53. From this by inspissation you have green Crystals, which being too much dried have their Acid expell'd, and hence grow blackish.

U S E.

THIS *Process* then demonstrates the easy solubility of Copper, shews us the origin of Flowers of Copper, or the common *Ærugo*, explains to us why polish'd Copper grows black so readily, and by Copper's thus growing so very easily green with Acids, will help us to discover this Metal, (which has a surprizing emetic and purgative quality,) when it lies conceal'd in Silver. If watery, loose, sanious, virulent Ulcers are touch'd with this Liquor, it helps to quicken, contract, dry, and cleanse them.

PROCESS CLXXXIX.

The Solution of Copper in Sal Ammoniac.

APPARATUS.

WITH 1 part of Filings of the purest Copper, mix 3 parts of *Sal Ammoniac*, and 4 parts of clean Water, and with a moderate Fire, in a Cucurbit cut for the purpose, dry the Paste, and then suffer it to dissolve again in the Air. Repeat this Resolution and Exsiccation some number of times, and you will at last obtain almost an intire Solution of the Copper. Boil this Mixture in Water, filter it, and inspissate it a little, and you will have a blue Tincture, and if according to art you bring this to crystallize, you will have some agreeable saline Crystals of Copper.

USE.

HERE then you see how Copper and Salts act upon and unite with one another. This Liquor is the famous Anti-epileptic for Children. If a few drops of it are given to them fasting in Mead, it moves by Stool, excites a *Nausea*, and has a wonderful effect upon their tender Stomachs, quickens them, brings away any Water or Mucous lodg'd in the Stomach and Intestines, and destroys Worms. By this means therefore it cures some bad habits of Body, and some kinds of Epilepsies.

PROCESS CXC.

The Solution of Copper in Aqua Fortis.

APPARATUS.

INTO common *Aqua Fortis*, or Spirit of Nitre in a clean Urinal, throw a small quantity of very fine Filings of pure Copper. Upon this there will be excited a prodigious Effervescence with red Fumes, and in an instant the whole Liquor will acquire a pleasant green Colour. Proceed in this manner till the last Portion thrown in will not grow green any longer. When the Liquor is depurated by standing quiet, and being filtered, inspissate it to one half.

USE.

HENCE we see the effect of this Acid of Nitre upon Copper. This proves an Emetic in the very smallest quantity. It kills all Insects, and hence if it is diluted with a good deal of Water, it expeditiously destroys Fleas, and Lice, both the common and Crab-lice. It has the same effect upon Ulcers as the Vinegar of Copper; but must be used with prudence.

PROCESS

P R O C E S S CXCI.

The Solution of Copper in Aqua Regia.

A P P A R A T U S.

INTO *Aqua Regia*, or Spirit of Nitre, throw Filings of Copper, and proceed as in the former *Process*, and the effect will be just the same.

U S E.

Aqua Fortis, therefore, and *Aqua Regia*, equally dissolve Copper. There is no ground therefore for the Opinion of those Chemists, who from any diversity in them, have pretended to account for one's dissolving Gold only, and the other Silver. This certainly arises purely from the singular reciprocal disposition of Bodies to one another, nor can be come to the knowledge of but by Experiments alone. And for the same reason they argue as unreasonably concerning the resemblance of the nature of Metals, from their being dissolved by the same *Menstruum*. Sound Chemistry proceeds very cautiously in things of this nature, and is afraid of Universals, unless when collected from Observations alone.

P R O C E S S CXCII.

The Solution of Copper in a volatile Alkali.

A P P A R A T U S.

1. **U**PON 1 drachm of Filings of Copper in a clean glass Vessel, pour 12 times as much of a good alkaline Spirit of *Sal Ammoniac*. Stop the Vessel, shake it about frequently, and you will have a Tincture at first of an azure, and afterwards of a violet Colour, which will be extremely beautiful. Pour off the Tincture, upon the *Residuum* put fresh Spirit, and by this means almost all the Copper will be gradually dissolv'd and converted into a Tincture.

2. If Filings of Copper are moisten'd with 3 times their quantity of Oil of Tartar *per Deliquium*, and then digested, dry'd, and dissolv'd, and this is repeated some number of times, and then the Matter is boil'd, filter'd, and inspissated, you will by this means obtain such another Liquor, but a fix'd one.

U S E.

THIS volatile alkaline Tincture beautifully contains the substance of the dissolved Copper. If a Person takes it fasting in a little Mead, and walks gently after it, beginning at first with 3 drops, and afterwards doubling the dose every morning, and then repeating the last dose, *viz.* 24 drops for some days, it opens, attenuates, warms, and proves the most powerful and speedy Diuretic. By the help of this alone, I formerly cured a perfect *Ascites*, such a prodigious discharge of Urine being excited, that it run as out of an open'd Cock, upon which the Integuments of the *Abdomen* became so loose that they might be wrapt over one another. I then only ordered a dry restorative Regimen,

gimen, and the Patient grew perfectly well, and enjoy'd a good state of health many years after. This, as it happen'd in my younger days, gave me great encouragement, but upon trying the same Medicine afterwards in like cases, the ineffectual use of it gave a check to my vanity, and taught me that Nature has a great hand in these happy events. Now I am convinced, that among the various kinds of Dropsies, some may be cur'd by different methods, and some not at all. In acid, watery, weak, cold, mucous, pituitous Disorders, the same Tincture, however, is often used with success. But it's time for us now to pass on to the examination of Mercury, and therefore I shall only add here, that the Solution of Copper in all acid, alkaline, and compound Salts, either latent or open, appears by every kind of trial to be very easy; for even the express'd Oil of Olives, and the distill'd Oil of Turpentine, and others, which always contain a latent Acid, will by being digested with Copper, acquire a green Colour, and at the same time be rendered fit for some chirurgical uses.

P R O C E S S CXCIII.

The Purification of Mercury.

A P P A R A T U S.

1. TAKE some Mercury bought of the Company at *Amsterdam*, put it into a Bag made of a round piece of Leather, which tie as close as possible with a piece of strong Packthread. Lay this Bag with the Mercury upon a large glaz'd Dish, and then press it with a good deal of force, and the Mercury will run out pure through all the parts of the Bag. When it is almost all out, twist the Bag round, and if you manage it artfully, you will be able to press it all through. Upon treating the Mercury of *Amsterdam* in this manner, I have not found any foulness in the Leather.

2. I took 2 pounds of the same Mercury, and putting it into a clean glass Retort, with a sand Heat, distill'd it into a glass Vessel that was open at both ends, and at bottom had an orifice that lay under Water; and the whole Body of the Mercury rose without any *Feces*. This Distillation I repeated three times with the same Retort; and I recover'd my 2 pounds of Mercury. In the Retort, indeed, there remained a very small quantity of a fine red Powder, but it did not weigh any thing worth taking notice of; even then, however, there appeared nothing feculent. So that this Mercury, even by this method of treatment, gave no sign of being at all foul, which is an excellent proof of the goodness of the Commodity.

3. Take of the same Mercury 1 pound, put it into a Retort, and add of pure Lime slack'd in the Air 2 pounds, and then distill with a sand Heat in a Retort, and you will have your pound of Mercury again; nor even by this means will you have any *Feces*, which had there been any, would in this way certainly have discovered themselves.

U S E.

THESE are the common methods of purifying Mercury, in order to fit it for the following Operations. From this *Process* then, we learn the volatility

tility of Mercury, and the degree of it; and hence appears the great purity of that which is sold by the Company at *Amsterdam*. Concerning the Alchemistical Purification of it, perhaps I may treat in another place.

PROCESS CXCIV.

The Solution of Mercury in Aqua Fortis.

APPARATUS.

TAKE of pure Mercury 4 ounces, of *Aqua Fortis* 6 ounces, put them into a clean Urinal, which surround with a small Fire, that the whole may grow hot. The globular Body of the Mercury then at the bottom will begin to discover an Effervescence, and will consume with exceeding red Fumes, and a production of Heat. When this is all dissolved, add a little fresh Mercury, and so proceed, till there at last, in this Heat, remains some part undissolved. Let the Liquor grow cold, and pour it into another Vessel, and you will then find the Mercury dissolved into a pellucid Liquor, even to a Microscope appearing homogeneous, which has an abominable rough Taste, the Smell of Spirit of Nitre or *Aqua Fortis*, and the Colour of Water.

USE.

HERE then we see Mercury, which is one of the opaquest of Bodies, grow pellucid with *Aqua Fortis*, or Spirit of Nitre. This Body, therefore, which is 14 times heavier than these fluids, continues suspended in the middle of them, without producing any effect at all from its greatly superior specific gravity. And even here it remains perfect Mercury, absolutely unchang'd, being only surrounded by the Acid, as will appear hereafter. And again, it is so equably distributed through every part of the Solution, that if you take only one drop of it, and examine it according to Art, you will find the Mercury in it bear the same proportion to the whole Mercury dissolved, as the drop does to the whole Solution. Here then is Matter of meditation, both for the Lovers of Chemistry, and Hydrostatics. How minutely must the Mercury be here divided? How equably must the Acid be united with every Particle of it? And how equably must the acid part, now it is united with the Mercury, be distributed with that, through its own watery Phlegm? This Solution is very caustic, and almost intractable, burning all the parts of the Body it is applied to with very great Pain, and excessive Heat. Hence it proves efficacious in extirpating Warts. If a very small Particle of it touches the Skin, it soon turns it of a red purple Colour. *Aqua Regia* now does not easily dissolve Mercury, nor Spirit of Salt; and yet corrosive sublimate of Mercury is a true Salt of Mercury dissolved by Spirit of Sea-Salt, or *Aqua Regia*, for it produces all the proper effects of *Aqua Regia*, and being poured upon Salt of Tartar, gives back again the Sea-Salt. If it is first precipitated, it may be dissolved by *Aqua Regia*. With Sea-Salt alone it may be sublimed into a mercurial Salt.

PROCESS CXCIV.

Vitriol of Mercury.

APPARATUS.

1. IF such a Portion of Mercury is dissolv'd in hot Spirit of Nitre, or *Aqua Fortis*, that it will at last take up no more but leaves a small Portion undissolved, then, if this Solution is pour'd into a cold Vessel, there will spontaneously concrete a saline, pellucid, whitish Matter at the bottom. And if you then pour off the Liquor at top, there will remain an exceeding acrid, moist, saline Body, that will dissolve in Water, but that is intractable.

2. If the remaining Liquor is inspissated to one half, and then set in a cold place, it will shoot again into Crystals like the former.

3. But if you take 1 part of Mercury, and 2 parts of the purest decrepitated Sea-Salt reduced to Powder, and put them into a Cucurbit, and expose them for five or six hours to a very strong Fire; then, if after they are grown cold, you break the Cucurbit, you will have a solid dry sublimate of Mercury in a true vitriolic form. The common sublimate of Mercury too is a true Vitriol of Mercury, but a semi-volatile one.

USE.

MERCURY, therefore, by Spirit of Nitre, is reduced to an imperfect Vitriol, by Spirit of Salt, to a perfect one: But at the same time, the Vitriol from the Spirit of Nitre is fixed, that from the Spirit of Sea-Salt, volatile; which is a considerable difference. The Acrimony too from the Spirit of Salt is greatest.

PROCESS CXCVI.

White Precipitate of Mercury.

APPARATUS.

INTO a solution of Mercury so strong, that the *Aqua Fortis* or Spirit of Nitre will take up no more, and which consequently contains no more Acid than what is just requisite to dissolve the Mercury, pour twice as much clean Water. At the same time take care to have by you a strong Brine of the purest Sea-Salt made hot, which drop into this diluted solution of Mercury. By this means then the Liquor in those places where the Brine falls in, will immediately become white, opaque, and turbid. Shake the Vessel about, and the whole will grow white and thick, and a white Powder will be precipitated to the bottom. Proceed thus as long as the Solution is affected by the Brine in the same manner, and by this means it will be separated into a white Precipitate, which will fall to the bottom, and a clear Liquor swimming at top. When the Brine will render the Liquor no longer turbid, let the Vessel stand quiet a little, and all the white Powder will subside. Gently pour off the limpid Liquor, and keep it by

itself. Shake about that part of the Liquor that remains at the bottom with the Powder, pour them together into a paper filtering Bag placed in a Funnel standing in a Bottle, and there will drop through a pellucid Liquor, which you may add to the former. In the filtering Bag then will remain a white Powder, upon which pour some Water, made very hot, and it will pass through the Paper, saline, and acid. Proceed in this manner till the last Water comes off as insipid as it was put on, and then there will be a white, and almost insipid Powder left in the Bag. Dry the Paper and Powder with a gentle Fire, and keep the Powder under the Title of *Mercurius præcipitatus albus*.

U S E.

THE acid Spirit of Nitre, attracted into the Mercury, and now diluted with Water, as soon as ever the Sea-Salt is mix'd with it, becomes an *Aqua Regia*. But *Aqua Regia* does not dissolve Mercury as Spirit of Nitre does, and hence the Body of the Mercury is expell'd from its former Solvent, and falling to the bottom makes a precipitate; and then the hot Water washes away the *Aqua Regia* that externally adheres to this Powder. There is some of the Acid, however, still remains united here with the substance of the Mercury, and hence it has a particular Vertue, as appears by many Experiments. This Powder, if it is rightly made, of all the preparations of Mercury that we are acquainted with, for internal use, is perhaps the very best; for it acts efficaciously, and safely enough. If it is rubb'd with three times its weight of Loaf-sugar, it furnishes us with a Medicine, which, may be, better deserves the name of a *Panacea Mercurialis*, than any other prepar'd from Mercury in the most laborious manner. For treat Mercury in what way soever you will, its medicinal Vertue will principally depend upon the quantity of Acid that adheres to it: If this Acid, therefore, is in greater abundance, and adheres to the Mercury more externally, it then acts rougher, and not so safe; if there is less of it, and it is more intimately combined, its effect is milder, and less dangerous; but this is the case in this precipitate. If the Powder with the Sugar abovementioned is given fasting to an adult to the quantity of 9 grains, it purges by Stool, gently provokes Vomiting, destroys Worms, opens, frees, and purges the chylopoietic system, and attenuates a pituitous Matter, and thus cures Gonorrhœa's, the Itch, venereal and other Ulcers, and many other Disorders. If this dose is repeated once a day for some time, it brings on a gentle Salivation. If you accurately mix a drachm of this precipitate with an ounce and a half of *Unguentum Pomatum*, or *Rosatum*, it makes a safe and efficacious Ointment for extirpating Insects in the Skin, and cures the Itch, Ulcers in the Face, and other very stubborn ones. You won't wonder therefore that I wou'd substitute it in the place of the boasted *Panacea's*. If you lay this precipitate upon a glass Plate, expose it to a soft Fire, and keeping it constantly stirring with a glass Pipe, calcine it gently for a considerable time, it becomes so mild that it will neither vomit nor purge any longer, nor will scarcely raise a Salivation. Hence if it is given internally, it acts exceeding mildly; and then the Chemists extoll it for a Diaphoretic, and Corrector: But indeed it is then so mild, that it often does but little good. If this Powder is rubb'd upon hot polish'd Brass, it makes it look exactly like Silver; but the Colour is presently destroyed again by the Fire, or will wear away of itself.

P R O C E S S

PROCESS CXCVII.

Red Precipitate of Mercury.

APPARATUS.

1. TAKE half a pound of the liquid solution of Mercury of *Process* 194, put it into a Retort that will hold twice the quantity, and then applying a Receiver, distill almost to a dryness in our wooden Furnace, taking care that your Fire is so gentle, that it shall never boil. At the bottom then you will have a solid, white, heavy Mass, which is vastly corrosive, igneous, and quite intractable. About the sides of the Retort, too, you will here and there have somewhat red, yellow, and white, arising from the Mercury, beginning there to be dried, and making an agreeable appearance. The Liquor that is drawn off is a pretty pure weak Spirit of Nitre, and may be kept for cleaning Glasses, or other uses. This then is a sort of reduction of dissolved Mercury into a Vitriol.

2. Place the Retort in a Sand Furnace, lute on a Receiver, and distill with a gentle Fire that there may be so much time betwixt the drops, that one may moderately tell four or five, and proceed in this manner, till you begin to perceive some red Fumes: Then immediately apply another large Receiver. The Liquor that thus comes off is a good Spirit of Nitre, stronger than the former, which you must save for its proper uses. Urge the *Residuum* with a gradually increased Fire, and there will continue to rise red Fumes, which at last will be exceeding red, and fiery, and fill the Receiver. Then raise your Fire to the greatest degree, and keep it up for the space of two or three hours, and you will have a vastly strong yellow Spirit of Nitre, which, if it is immediately stopt up in a glass Vessel, will after years emit gold-colour'd Fumes; so that this is one method of preparing the strongest Spirit of Nitre, or a kind of rectification of it. It must be confess'd, however, that its nature is by this means somewhat altered; for it won't so readily excite a Flame with distill'd Oils as other Spirit of Nitre does. When all is grown cold, at the bottom of the Retort you will have a solid Mass of a bright scarlet colour, and betwixt this and the Neck, and in the Neck, there will be a great variety of very beautiful Colours, arising from a white, yellowish, yellow, greenish, red, and very red Matter that is lodged there. Break the Retort cautiously, and take the red Mass out of the Belly, carefully separating that part that lies at top, and is not of such a fine scarlet Colour; for that is very corrosive. The very red Mass keep under the Title of *Mercurius præcipitatus ruber*.

3. The Chemists being surprized at the beautiful bright Colour of this mercurial Powder, and the remarkable fixity of it now, though it was volatile before, took it into their heads, that by proceeding on in the same manner, they could convert this fix'd Matter into Gold. Upon this Precipitate, therefore, they pour'd fresh Spirit of Nitre, and drew it off again, and, by repeating this a great number of times, they thought Gold would be generated, which *Sylvius*, in his *Posthumous Works*, asserts, did actually succeed. To Persons, however, who think coolly of these things, this does not at all appear to be credible.

Paracelsus himself, in the preparation of his precipitate, orders Spirit of Nitre to be drawn a good many times from the Mercury.

U S E.

HENCE then we learn the mutable nature of Mercury, which here we see chang'd from a fluid form to a solid one, from a volatile Disposition to a fix'd one, from a soft to a corrosive one, and from its own proper Colour, to almost all others. Manage it however in what manner soever you will, by the assistance of an alkaline Salt, Quick-lime, or Filings of Iron, and Distillation in a Retort, it always returns in its original form, and weight, without any alteration at all. This which is call'd *Vigo's* Precipitate, is acrid, corrosive, excites pain if it is applied to parts that lie bare, produces an Eschar, and generates a thick white *Pus*, and so cleanses the Lips and Bottoms of semi-putrid Ulcers, and disposes them to an easy cure. Internally it is not given without danger, as by its caustic quality it is ready to inflame the *Viscera*, producing very great pains, and both vomiting and purging with extreme Gripings, as well as provoking a discharge both by Sweat and Urine. If it is given in too great a dose, which should never exceed 3 grains, or if it is repeated too often, it raises a Salivation with all its Symptoms, and then cures many Diseases that are not easily cured by any other method. It is rougher and more dangerous than the white Precipitate. *Paracelsus* and *Van Helmont* teach us to correct it, by drawing Alcohol off of it some number of times by Distillation, and by this means, as a good deal of the Acid is separated from it, it does grow milder, and must then be given in a larger dose. And they made use of the Water of the Whites of Eggs for the same purpose, and with the same success. Others by boiling it in strong distill'd Vinegar, dissolve it, and by filtering it, depurating it, and distilling the Vinegar from it a pretty many times, procure a milder Powder. But what do we get by this? The white Precipitate is such a medicine as this already, without all this trouble. In a word then, it is the corrosive Acid that is combin'd with the Mercury, that makes it operate powerfully in a small dose. The more, therefore, there is of it, and the more externally it adheres to the Mercury, the more violently it acts; as the less there is, and the more intimately it is united, it is milder, and must be taken in a larger quantity to produce the same effect. If this Precipitate is put into a thin glass Plate, and set upon the Fire, and kept continually stirring with a Tobacco-pipe, it becomes of a deeper Colour; and if you continue this Calcination for a good while, it at last becomes so mild that it will scarcely operate at all.

P R O C E S S CXCVIII.

Sublimate of Mercury.

A P P A R A T U S.

DISSOLVE half a pound of Mercury in a sufficient quantity of *Aqua Fortis*, according to *Process* 194, and then cautiously inspissate it to a white dry Mass, according to *Process* 197. No. 1. Take of decrepitated Sea-Salt 10 ounces, and the same quantity of common Vitriol calcin'd till it is white; rub

these by themselves very strongly, and for a good while in a marble or glass Mortar, with a glass Pestil, and in a dry hot place, and then mixing them nicely together, add the Mercury, which must be mixed intimately with them likewise. Put the Powder into a glass Bolthead, the Belly of which is so large that the Mixture will but one third fill it, and the Neck of which is cut off so low, that it is not above 7 inches long. Place the Bolthead in a sand Furnace, taking care that the bottom of the Cucurbit touches the iron Pot, and that the Sand rises just as high about it as the surface of the included Powder, and no higher. Then give a very gentle Fire, which increase by the slowest degrees, till a Vapour begins to exhale out of the Mouth of the Cucurbit, of which beware, for it is prejudicial to the Lungs. When all the Moisture is perfectly evaporated, cover the Mouth with a Paper, and then increase your Fire to such a degree as to make the Pot red hot, and the Matter will rise upon the sides of the Cucurbit into semi-pellucid white Crystals, which go by the name of *Mercurius sublimatus corrosivus*. When the Cucurbit is grown cold, break it, and take out the sublimate, separating it carefully from the *Fæces*, and the soft Powder that lies upon it, and keep it in a dry Vial. Concerning the *Venetian's* method, see *Tachenius* in *Hippocr. Chem.*

U S E.

THE white mercurial Mass consists of Mercury and *Aqua Fortis* combin'd together: The white *Calx* of Vitriol being mix'd with the Sea-Salt, endeavours to expell its Spirit, viz. a Spirit of Sea-Salt: Whilst therefore these, by the assistance of the Fire act upon the mercurial Powder, from the Spirit of Nitre which is in the Mercury, and the Spirit of Sea-Salt which is dislodged by the superior Acid of the Vitriol, there is produced an *Aqua Regia*. The Phlegm of this is carried off by the first gentle Heat, and then its strong Acid unites with the Mercury, and corrodes it. But as *Aqua Regia* is of the Nature of Sea-Salt, and the Spirit of that does not, like the Spirit of Nitre, fix Mercury, but rather renders it semi-volatile, hence the Mercury is here sublim'd. This sublimate, now, is a true, solid, dry, Vitriol of Mercury, which is considerably durable even in the Air itself. Its *Basis* is a very pure Mercury, and the other part is the strongest Spirit of Salt that can be obtain'd by any Art, and which here exists in a solid form. And with regard to this acid Spirit of Sea-Salt, it is a *Lapis Infernalis* of Mercury, and is the most powerful corrosive we know of, consuming all the parts of the animal Body it does but touch, and producing an Eschar which quickly separates. Hence it eats down the most stubborn Lips of Ulcers, and extirpates Warts and indurated Glands. This that famous Surgeon *Joannes a Vigo* knew very well, as appears from his *Trochisci de Minio*, which is an incomparable Remedy for consuming and eradicating scrophulous Humours by supuration. The Taste of this Vitriol is horribly rough. A grain of this diluted in an ounce of Water, is a Cosmetic, if it is used with prudence. By simply washing with it, it proves a Poison to all Insects in the Skin. If a drachm of such a Mixture, softened with Syrup of Violets, is taken two or three times a day, it performs wonders in many Diseases esteemed incurable. But it must be cautiously administred by a prudent Physician. Beware, if you don't understand the proper method. This corrosive sublimate of Mercury, when it is mixed with Metals, has a very beautiful, nay inimitable effect upon them, and indeed,

deed, which the Chemist may a little wonder at, it surprisngly changes even Silver itself. *Boyl. Orig. Ferm.* p. 196, to 203. Certainly, this Preparation of Mercury is a Key that lets us into an infinite number of profound chemical secrets. By means of this, possibly, Silver has some part of it converted into Gold, no ways discoverable in the Silver before. See *Process* 186. *Use*. Hence is prepared the *Menstruum Peracutum* of Mr. Boyle, as well as many others. And I may venture to say, no Chemist will ever repent of the labour he employs upon this corrosive sublimate of Mercury. Here you see that *Aqua Regia* dissolves Mercury, first dissolv'd in *Aqua Fortis*, more beautifully than any *Aqua Fortis* can; and that the Spirit of Sea-Salt sublimes it, tho' it was before fix'd by the Spirit of Nitre. Sublime this *Mercurius Sublimatus*, according to Mr. Boyle's advice, with an equal quantity of *Sal Ammoniac*, and you will have a surprizing Salt.

P R O C E S S CXCIX.

Turbith of Mercury.

A P P A R A T U S.

1. TAKE of the purest Mercury 4 ounces, put it into a clean Urinal, and pour upon it of the choicest Oil of Vitriol 8 ounces. Heat the Vessel very gradually, and when it is grown hot, set it upon live Coals, that the included Matter may boil very gently, and it will emit Fumes which are poisonous, for which reason let the Urinal be placed under a Chimney, that the Vapour may not be disperfed, and come at your Lungs. The Mercury then that has collected itself at the bottom of the Oil of Vitriol will begin to be dissolv'd, and if you keep up the same Fire, the Solution will at last be compleat. By this means you will have a very white Mass, which, by continuing the Fire, calcine till it will fume no longer. The Powder then will be exceeding white, perfectly like Snow, and horribly corrosive and intractable, and is called, a *white Calx of Mercury, prepared with Oil of Vitriol*. This may be made in the manner described, but scarcely in the common ones.

2. Reduce the dry hot Mass to a very fine Powder in a glass Mortar, and at the same time have by you a glass Vessel with some very pure hot Water, at least 20 times as much as your Mercury. Throw the powder'd *Calx* into the Water, and the instant it is in, as it falls to the bottom, it loses its white Colour, and acquires a very beautiful lemon Colour. Shake the Vessel well about for a good while, that the Powder may be thoroughly mix'd with the Water, and then let it settle, and pour off the Liquor into another Vessel. Wash the Matter that remains at the bottom till it is become absolutely insipid, and then dry it thoroughly with a gentle Fire, and you will have an agreeable lemon-colour'd Powder, which is the Turbith Mineral we want.

3. Let the first Liquor pour'd off stand quiet for some time, and then filter and inspissate it to $\frac{1}{2}$ th, and you will have a mercurial Water; for if you drop into it a little Oil of Tartar *per Deliquium*, there will be precipitated a reddish Powder. This Liquor therefore may be kept under this Title.

U S E.

THUS the exceeding strong Acid of Vitriol, being united with the Mercury, produces a very fix'd white Powder that will bear a great degree of Heat, for it is really much more fix'd than any one, not versed in these things, wou'd be aware of. How different now is the effect of various Acids, with regard to their production of Colours? With the greatest degree of Fire this white Colour is not altered, which happened so easily with Spirit of Nitre. This white Powder, by Calcination, becomes extremely corrosive, and hence poisonous. But in what a singular manner does this acquire a new Colour, by only coming into contact with Water? For if this Powder prepared in a right manner, is but exposed to the open Air, its surface in a short time becomes yellowish, with the moisture it attracts out of it. This Powder seems to be the Medicine, by the prudent use of which, *Paracelsus* performed such very extraordinary cures. This appears from that little Treatise of his called *Nosocomium*, and is sufficiently confirm'd by *Oporinus*, who tells us that he frequently made it. But he rendered it milder by burning Spirit of Wine upon it according to the method of the ancient Chemists, who used by this means to free metalline *Calx's* from the Salts that adhered to them externally, and hence were too acrid, leaving those only behind that were combined more intimately. The judicious *Sydenham*, who was very sparing of his commendations of the Chemists, gratefully acknowledges in his Treatise *De Lue Venerea*, that by the help of this Medicine, some Diseases are cured, which are otherwise insuperable. The great *Boyle* tells us too, that by using it as a Sternutatory in a gentle dose, the whole Body has undergone such an alteration, that Cataracts have been truly resolved by it. And a Woman formerly at *Paris*, is said with it to have cured Persons whose cases were quite desperate. This Medicine therefore is a match for stubborn Diseases, but requires the direction of a skilful Head, nor should be made use of, except when the Malady won't yield to gentler Methods. In Dropsies it is not less efficacious, nor in venereal Disorders of the Glands. *Van Helmont* says, that the Oil of Vitriol, by simple contact with the Mercury, is converted into Alum; but this sure is either talking improperly, or not consistent with truth. But when that famous Man orders the Fire of Vitriol of Copper to be pour'd upon the red Precipitate of *Joannes a Vigo*, and to be thence distill'd in order to prepare the purging *Arcanum* of *Paracelsus*, then certainly, if I understand any thing of the matter, we shall have the same Medicine we have here: For if by the Fire of Vitriol of Copper, he means an exceeding strong Oil of Vitriol, then as soon as ever this is poured upon the red Precipitate, it immediately dislodges the Spirit of Nitre from the fix'd Mercury, and renders it volatile, and at the same time taking possession of its place itself, produces such a *Calx* of Mercury as we are here talking of; and when from this the Water of the Whites of Eggs is distilled some number of times, the external Acid is separated, and the Powder becomes milder, and yet works very well, and often effects what is scarcely within the power of any thing else. If by Fire here, however, we are to understand something else of a more subtil nature, I confess, I know nothing of the matter; but by comparing *Helmont* and *Paracelsus* together, I think it is no more than what I have mention'd: This you yourselves may examine. Metals now, when they are alone, act very little upon our Bodies, except by their
size,

size, figure, and weight; but by being combined with exceeding acid Salts, they acquire new powers that are frequently very surprizing, and very various according as the Acids are more intimately fix'd within them, or adhere to them more externally. In form of a Vitriol they act exceeding violently. If this is calcin'd, the *Calx* grows by degrees more and more mild; and indeed, by a strong, and long continued Calcination, as the Acids are gradually expell'd, the roughest Preparations of this kind become mild, as happens even in Turbith itself: But at the same time that their Operation is gentler, it becomes proportionably less efficacious; and hence those Chemists and Physicians have been mistaken, who observing the wonderful effects of Turbith, but seeing it work violently, have endeavour'd to soften it, which is easily done, and then expected the same good from it, when it was mild, as they had before experienced when it was rough. The Methods now of mitigating its Acrimony, are separating its Acid, by washing it thoroughly with Water; by Distillation of simple Water from it, repeated a good many times, and always to a dryness; by treating it in the same manner with Alcohol; by burning Alcohol upon it; by rubbing it with a good deal of a metalline Matter as in the Preparation of *Mercurius Dulcis*; by the addition of alkaline Salts, which absorb the Acid out of Metals calcin'd with Acids; by grinding it with Chalk, *Lapis Cancrorum*, Oyster-shells, or the like substances which are true Sponges to Acids; by calcining it with a strong Fire, and for a long time; and lastly, by fixing it in the Fire, by beginning with a gentle degree, and gradually increasing to as great a one, as the Glass will bear without melting.

P R O C E S S C C.

An igneous Oil of Mercury.

A P P A R A T U S.

UPON Mercury calcined with Oil of Vitriol into a snowy dry *Calx*, according to the preceding *Process*, and grown cold, I pour in this clean Urinal an equal quantity of Oil of Vitriol. I boil then to a dryness as before, using all possible caution to keep clear of the Fumes; and I find that it is now dried with more difficulty than it was before, requiring both a stronger Fire, and a longer time to effect it. When the Powder at last becomes dry, I add again the same quantity of Oil of Vitriol, and proceed as before, and by this means it will at last scarcely be dried by an intense and long continued Fire, but begins to remain in form of a fix'd Oil, which is vastly corrosive and caustic, so as to be perfectly intractable, like *Paracelsus's* Infernal Fire. The Mercury, therefore, by this management, becomes so fix'd with the Oil of Vitriol, that it will not rise with a prodigious Heat.

U S E.

THIS *Process* serves to demonstrate the impregnation, saturation, and inceration of Metals by Acids, to any degree, as well as the fixation of volatile Mercury by Acids, as far as it is possible. By this means, however, it will never be converted into any Metal; for let Mercury be render'd ever so fix'd by

by Acids in the most artful manner possible, do but grind it with twice as much Filings of iron, and then distill the Mixture in a glass Retort with the greatest sand Heat, and the Mercury will be set at liberty, and recover its original form, the Acid being attracted into the Iron.

P R O C E S S CCI.

Æthiops of Mercury.

A P P A R A T U S.

TO 1 drachm of the choicest Flowers of Sulphur, in a glass Mortar, add 3 drachms of Mercury, and rub them well together for a good while, and the Mercury will begin to vanish, the Sulphur at the same time acquiring a greyish Colour: Proceed in this manner, and the Mercury will intirely disappear, and you will have a black Powder, which will be proportionably more so, as it is longer rubb'd. By this method you may easily prepare what quantity of it you please. When this Preparation has stood by some time, it hardens spontaneously into a solid black Mass, which however may, by rubbing, be easily reduc'd again to a Powder.

U S E.

HERE then we see how easily, by a simple mechanical attrition, Mercury is combin'd with crude cold Sulphur, and that in such a manner, that the union becomes considerably strong, nor to be afterwards very easily dissolv'd. The Powder prepar'd in this manner, is inodorous, insipid, by no means acid, nor is it dispos'd to be intimately mix'd with any thing. When it is taken into the human Body, it is not capable of entering either the venous, chyliferous, or lymphatic Vessels, but being carried on directly through the Intestines, passes off by Stool, and perhaps in its passage may destroy Worms. Every person therefore, I imagine, will be deceived, who expects any better effects from it, which I have never yet been able to observe. And I can't but think, that those Persons act somewhat imprudently, who order such large quantities of this fossil Matter to Infants, and People of very tender Constitutions, as it is foreign, and not to be subdued by their natural powers, and is so much the more to be suspected, as it is of a more sluggish nature, and remains longer in the Body. Who knows the effect of a substance, which so long as it remains compounded, don't seem more active than any other heavy insipid Earth? That the Acid of the Sulphur, now, is not attracted from the oily part into the Mercury in this Operation, we are sufficiently convinced, as there is nothing produc'd by this means but a homogeneous, insipid, inert Mass, that discovers no degree of Acrimony at all.

P R O C E S S CCII.

Factitious Cinnabar.

A P P A R A T U S.

I Take 4 ounces of the best Flowers of Sulphur, and putting them into a tall earthen Vessel that runs out into a rim at top, melt them with a clear gentle
 VOL. II. Fire,
Y y

Fire, taking care that the upper part of the Vessel shall be at a considerable distance from the Fire, for fear it should set fire to the Sulphur, which lights with a vast deal of ease when it is in fusion. This being done, I take 12 ounces of Mercury made hot, but not to such a degree as to begin to fume, and by means of a Vessel with a spout to it, pour a little of it into the melted Sulphur, which immediately begins to grow somewhat tenacious. I then keep them constantly stirring with a thick Tabacco-pipe, and pour in the Mercury a little at a time, till the whole is made use of, and intimately mix'd with the Sulphur. There then usually arises a great hissing with dense red Fumes, and the Matter takes fire with a considerable noise. Cover the mouth of the Vessel with a Tile, and let the whole grow cold, and you will have a black Mass.

2. This, which is like the *Æthiops* of Mercury, *Process* 201, put into a *Hessian* Cucurbit, and lute on an Alembic very close with a Lute made of Clay and Lime, or else cover it with an inverted Cucurbit small enough to stand in the mouth of the former. Set the Cucurbit in a sand Furnace, taking care that the bottom of it stands upon the iron Pot, and that the Sand about it rises a little higher than the included Matter. Raise a Fire gradually, from the gentlest degree to the greatest, and there will first come off a small quantity of an insipid Water; then a few whitish Flowers; and at last somewhat black. When the Fire has been kept up at its height for the space of three hours, let the whole gradually cool, and you will find a dense substance adhering to the sides of the Cucurbit, which will be blackish on the outside. Take the mass out, and brush off the black with a Hare's Foot, and then when it is reduc'd to Powder, it is of a scarlet Colour, and is called *Fæctitious Cinnabar*. At the bottom of the Cucurbit there will remain somewhat of *Fæces*.

U S E.

HERE then we at first have an *Æthiops* by Fire, as we had by rubbing in the preceding *Process*. The Cinnabar is the Mercury and Sulphur combin'd together by Fire into the form of a simple Fossil, such a one as we find prepared by nature in a great many Mines, without any considerable difference. Its vertues in the human Body are nearly the same with those of the *Æthiops*. The great *Crato* indeed calls it the *Magnes Epilepsiae*, but for my part, I never saw any such extraordinary effects from it. If it is join'd with Purgatives, then it is carried sooner through the Intestines, and does no more than we mention'd of *Æthiops Process* 201. If it is mixed with Pomatum, it makes a Cosmetic that gives a red Colour. It is used for Fumigations in venereal Disorders of the Nose, Mouth, and Throat, but frequently with little, and often with unhappy success. The Mercury may be recovered again from the Cinnabar exceeding pure, by only rubbing it with twice as much Filings of Iron, and then distilling with a Retort into Water with the strongest sand Heat.

PROCESS

P R O C E S S CCIII.

An Amalgama of Mercury with Lead, and other Metals.

A P P A R A T U S.

1. **M**ELT some pure Lead in a clean iron Ladle, and then put into it an equal quantity of hot Mercury, and stir them about with an iron Rod. Let them grow cold, and you will have a homogeneous Mass of a silver Colour, which will be considerably hard, but by rubbing will grow softer and softer. Put this Mass into a glass Mortar, rub it, and then add to it what quantity of Mercury you please, and it will mix with it as Water with Water.

2. An *Amalgama* of Tin you may prepare too exactly in the same manner, and this likewise may be diluted by the addition of more Mercury.

3. Take a solution of the best Copper in *Aqua Fortis*, saturated to that degree that it is capable of dissolving nothing more, dilute this with 12 times as much clean Water, heat the Liquor, and put into it plates of polish'd Iron, and the Copper will be precipitated to the bottom in form of a Powder, and the Iron will be dissolv'd: Proceed in this manner till all the Copper is precipitated: Pour off the Liquor at top, and wash the precipitated Powder with hot Water, till it is grown perfectly insipid. Dry the Powder thoroughly, put it into a glass Mortar, and by rubbing, mix with it an equal quantity of hot Mercury, and you will have an *Amalgama*, in which the Copper will be combin'd with the Mercury, and which may then be diluted by a farther addition of it. An *Amalgama* of Copper in any other manner, upon trial, you'll find sufficiently difficult.

4. Pure Silver, precipitated from *Aqua Fortis*, may in the same manner be reduced to an *Amalgama*, as I took notice in our History of Silver, to which therefore I refer you.

5. Dissolve the purest Gold in *Aqua Fortis*, till it will take up no more; dilute the Solution with 12 times as much pure Water; put into it some Plates of polish'd Copper, and a Powder of Gold will be precipitated to the bottom, and upon the Copper. Let it stand hot till the Copper you put in will be no longer affected, shake the Plates that all the Gold may fall to the bottom, pour off the Liquor at top, wash the precipitated Powder with Water, dry it, and then in a glass Mortar you may reduce it to an *Amalgama* with Mercury, and afterwards dilute it with more as you please. Or take a mixture of Gold and Silver, coppel it with Lead, and by means of a good assaying *Aqua Fortis*, separate the Silver. Then wash the black Powder of Gold that remains at the bottom, dry it, and whilst it is hot, rub it with Mercury, and it will presently be reduced to an *Amalgama*, which will bear dilution as before. All *Amalgama's* now are white, prepare them from whatever Metal you please.

U S E.

BY these methods then, you may, without any loss, make an *Amalgama* from all Metals but Iron. There are other ways of doing it likewise, but not without losing a good deal of your Mercury, and being in danger from the

Fumes. Hence we see that Mercury is the true solvent Water of Metals. These now, when they are thus reduced to an *Amalgama*, may be mix'd and blended together, and lie concealed among one another. This solution of Metals by Mercury, I look upon to be the *Basis* of Alchemy. Hence some of your avaritious Tricksters adulterate Mercury with Lead; but by exhaling a grain or two of it, the cheat is easily discovered. And hence perhaps happens the coagulation of Mercury, ascrib'd both by *Paracelsus* and *Van Helmont*, to the fixing fume of Lead, and a wonderful fixing metalline Spirit: For if you melt some Lead, and when it is beginning to cool, but is not harden'd, you make an impression on the surface with a Stick, and gently drop a little cold Mercury into it, in a short time it will acquire a solid consistence. But does not this happen from the hot Lead's being receiv'd into the Mercury, and so amalgamated, and of consequence forming a pretty hard Mass? Certainly, if you'll take a little of this fix'd Mercury, and putting it into a small Vessel, expose it to the Fire, you'll be convinc'd. This Art now, of making *Amalgama's*, has given rise to a common Cheat; for if you combine Gold or Silver with Mercury in this manner, by only adding Lead to them in the Fire, you may recover them again, and thus make a plausible shew of producing these Metals. But only take a little of this Mercury, put it into an iron Ladle, and set it on the Fire, and then the Mercury flying off, and leaving the Metal, will at once discover the fraud. On these principles depends the Art of gilding with Gold and Silver.

PROCESS CCIV.

The Ablution of Metals by Mercury.

APPARATUS.

TAKE an *Amalgama*, rub it in a glass Mortar, the longer the better, and it will begin to grow black. Pour clean Water upon it, and continue to rub it and the Water will grow black and turbid. Pour this out, add more Water, and rub again, and this will be changed as the former. Repeat this till the last Water, after rubbing, remains clear. You will then have a pure *Amalgama* that looks like Silver. And here all *Amalgama's*, treated in this manner, make the Water thus black, more or less, that of Gold however least of all. The Powder that comes away, when it is dried, is neither found to be Mercury nor Metal. In the other Metals try if you can find any end to this work: I am apt to believe you scarcely will.

USE.

HENCE we learn that pure Mercury, by being mixed with Metals, becomes so united with them, that something which lay concealed in one or both of them before, is now by this means expelled. If in this manner you procure a good deal of this Powder from Gold and Silver, as the Matter both of one and the other remains exactly the same in Weight, without the least addition or diminution, the Powder must necessarily in this case be produced from the Mercury. But this is a matter of deep speculation, concerning which I hope to publish my thoughts elsewhere, and therefore here I add nothing farther.

PROCESS

P R O C E S S C C V.

The Solution of Gold.

A P P A R A T U S.

TAKE of *Aqua Fortis* 4 parts, of the purest Sea-Salt 1 part, mix them together, and you will have a yellow Liquor. Pour this into a clean Urinal, put into it of the purest Gold beat into Plates 1 part, set the Urinal upon the Fire, that they may be thorough hot, and the Gold will dissolve. Then throw in 2 or 3 grains of Gold at a time, till at last, whilst it stands thus hot, some part remains undissolved. Then pour out the Liquor, and you will find it of a golden Colour. If there remains nothing black at the bottom, it is a sign there was no Silver intermixed with the Gold; for if this had been the case, it would have precipitated in form of a black Powder. This then is a solution of Gold, which will be brought about by every *Aqua Regia* prepared in what manner soever you please, as we have taken notice, and explained already.

U S E.

HENCE we see the reason of the name *Aqua Regia*. If this Solution touches the Skin, it changes it of a purple Colour. It is caustic, and taken internally has a poisonous quality. By a fixed or volatile alkaline Salt the Gold is precipitated, and falls all to the bottom. If the Powder is then thoroughly washed and dried very carefully with a gentle Heat of 80 degrees, it will weigh more than the Gold that was dissolved. If you heat this gradually, when it comes to be hot to a certain degree, it on a sudden is discharged with a great report, and disappears. Hence it is called *Aurum Fulminans*, or *Aurum Tonitruans*. This now is a surprizing *Phænomenon*, nor explicable, as I conceive, either *a priori*, or by analogy; at least all the endeavours hitherto to explain it, appear to me to be insufficient. When this has gone off in this manner in a very large glass Vessel, there has a vastly subtle Powder of Gold been recovered from it. They who under the notion of an *arcanum* have given it internally, at extravagant prices, promising extraordinary things from it, have brought great Pains, Gripings, and other Disorders upon their Patients. What beautiful discoveries therefore may be made in the chemical Art that do no manner of service to Physick?

IV. Upon S E M I - M E T A L S.

I. Upon saline ones.

P R O C E S S C C V I.

The Analylis of Vitriol, or Resolution of it into a Spirit, Oil, and Colcothar.

A P P A R A T U S.

I TAKE of the common green *Gofelar* Vitriol 8 pounds, put it into two earthen Long-necks, each of which will hold 4 pounds, cover both of these

these with a Tile, and set them upon the Hearth under the Chimney. Place Fire round them, that they may grow gradually hot quite through, and the Vitriol will begin to fume. Bring the Fire nearer, and increase it, and then the Vitriol will melt, and become liquid, but upon raising it still higher, it will thicken, and acquire a greyish Colour. Then place the Fire all about the Long-necks in such a manner as quite to surround them, that the included Matter may grow yellowish, and about the Sides begin to grow reddish. When you see this is the case let the Fire go down, and you will find the Long-necks split. Take out the Vitriol, and reduce it to Powder, which will be of a yellowish Colour. This then is the Calcination of Vitriol, for the Distillation of the Spirit, and Oil. And this indeed is very convenient, for otherwise in order to separate the Phlegm safely, the Operation will be exceeding tedious, or else by its rising hot the Receiver will be broke; and then the distilling Vessel being press'd by the melted Matter, will be cracked likewise. Hence the Vitriol must be calcined till it won't any longer melt in the Fire. In this first part of the Operation there is generally lost 5 pounds out of the 8.

2. Take the remaining 5 pounds of Vitriol, thus calcin'd, put it into a strong earthen Long-neck that is big enough to contain twice the quantity, and place it in the same Furnace that is used for drawing Spirit of Nitre, and Salt, which, together with the Long-necks, you'll find described in the Distillation of Spirit of Nitre, and Spirit of Sea-Salt, with Bole. When this is well secured in the Furnace with Bricks and Mortar, fix a cylindrical Segment into the Mouth, and with a stiff Lute made of Clay and Lime, very closely secure it all round. About the other end of the Segment wrap a wet Cloth, and then insert that into a very large glass Receiver, taking care that it fits it as exactly as possible, and does not go in above two inches. And here you must take care that the axis of the Receiver, the cylindrical Segment, and the Long-neck are in the same right line, for fear either the Neck of the Receiver or the Segment should be broke. Let this last Joint be clos'd as nicely as possible with the same Lute as the former, and then wrap round it a Cloth daubed with the same. This being done, let the whole be left four and twenty hours, that the Lute may be dried.

3. Raise a Fire with exactly the same cautions as you find given *Process* 141, 144, and there will first come off a white Fume, and the Receiver will grow hot, upon which keep up the Fire in the same degree for the space of six hours. Then increase it, and there will begin to appear *Striae* of Spirits, running like an Oil down the sides of the Receiver; proceed with this Fire for six hours more. And last of all urge the Matter another six hours, so that the Long-necks shall be all the time perfectly red hot all over, and you will then have the last thick Oil. And here if any Vapour perspires through the Lute, you may cover the Crack with a little bit of Cloth, daub'd over with the same, and made hot, and by this means it will be sufficiently secured. Continue, now, your Operation ever so long, you will always find a Vapour coming off, though the Liquor it produces won't pay for the trouble and Charge, and therefore I think it should not be protracted above eighteen hours. Let the Fire then gradually sink, till the middle Segment has not much Heat in it, and the Receiver is grown intirely cold.

4. Have by you a Bottle with a large bottom, and narrow Neck, with a pret-
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ty large Funnel standing in it. Very cautiously wet the Cloth and Lute about the Mouth of the Receiver, and when it is sufficiently moistened, draw it off very gently in a horizontal direction, for fear of cracking it; and take care that the Fumes don't come at you, nor any of the Lute fall into the Receiver. When it is off, wipe the Neck of the Receiver, and then cautiously inverting it, pour the Liquor into the Funnel, and so into the Bottle, which stop close, and set the Receiver by for the same use another time. By this method then I generally have 21 ounces of a black, thick, strong, fuming Oil of Vitriol, there remaining in the Long-neck a light, powdery, rough, red *Calx*, somewhat blackish, to the quantity of 52 ounces; so that 7 ounces are dissipated and lost.

U S E.

IN this manner then is drawn Oil or Spirit of Vitriol, which is of very great and extensive use both in Chemistry and Physick; for it is the most powerful, heaviest, and most antiseptic Acid, but a caustic one. Vitriol therefore consists of this Acid, Colcothar, and the Phlegm that was first expelled in the Calcination of it. This Oil of Vitriol cannot be brought to boil with a less Heat than one of 600 degrees. If it is put into a clean glass Cucurbit, and urged with a Sand Heat of 500 degrees, it gives out a sylvestrian, suffocating Spirit, and a Water, and then from black it becomes limpid, exceeding heavy, and igneous, and if it is poured into a wet glass Vessel, it instantly produces such a Heat, as to make it fly, and like a Magnet attracts the Water out of the Air. If you take 4 ounces of this Oil, put it into a clean small Retort that has a long Neck, very much bent, and distill with a Sand Heat, directing your Fire in such a manner that there shall be about 6 seconds betwixt the Drops, which must fall into clean Water in the Receiver, then you will have an exceeding pure Oil of Vitriol, which will be as good as Spirit of Sulphur *per Campanam*: But this requires a skilful Operator. Every drop, as it falls into the Water makes a hissing noise, as if it was Fire. If one of these Drops falls upon the bare Glass, it immediately flies with the Heat of it, as if it were cut with a Diamond. And if you urge it with too strong a Fire, you break the Neck of the Retort, and lose your labour, and there exhales a pernicious suffocating Vapour. If ever therefore there is caution necessary, it is here. But otherwise this is an elegant *Process*, both with regard to the nicety, and the use of it, as by a prudent practice in the chemical and medicinal Arts you yourselves may experience. *Paracelsus* tells us, the best method of preparing this Oil is to distill the Vitriol in a *Hessian* Vessel to a dryness, and then pour the Liquor back again upon the *Residuum*, and draw it off again, and to repeat this a great number of times, the oftner the better. And then he promises you, that you will have a Liquor that is greatly useful if it is used with judgment. But here you must take care that the Vessel is not broke by the too great quantity of the calcined Vitriol, which is guarded against by making use of but a small quantity at a time in proportion to the Vessel.

P R O C E S S

PROCESS CCVII.

Ens Veneris.

APPARATUS.

1. TAKE the Colcothar that remains in the preceding *Process*, put it into a large Crucible, which cover close with a Tile, and place in the hottest part of the Furnace, *viz.* under the Chimney, where there will some more Oil of Vitriol still be expelled. Let it be kept thoroughly red hot during the whole time, and by this Calcination the Colcothar will become exceeding red. Boil it in Water in a glass Vessel, stirring it well about, let it settle, pour off the Liquor at top, filter it boiling hot, and it will have the Taste of Vitriol. Upon the *Residuum* pour more Water, boil, decant the Liquor, and throw it away, and so proceed till the last Water, by being boiled with the Colcothar, will acquire no manner of Taste. You will at last then have remaining a fine red Powder, which keep under the title of a *sweet Calx of Vitriol*. If the first Liquor, after it is rendered pure by Filtration, is inspissated, it will yield a kind of yellow Vitriol, whence we learn what a surprizing Body Vitriol is in regard of its fixity in the Fire, even in the saline part of it.

2. Take of the sweet *Calx* of Vitriol, and the driest Flowers of *Sal Ammoniac*, of each equal parts, put them into a hot glass Mortar, and with a glass Pestil rub them very strongly, and for a good while, till they are thoroughly mixt and work'd together, taking care at the same time that they don't acquire any moisture, for which reason this should be done on a clear dry day, and in a hot place. Put this Powder into an earthen Cucurbit, not too high, fix on a broad Alembic with a wide Beak, hang on a small Receiver, and then place the Cucurbit in a sand Furnace, so that the bottom of it shall almost touch the iron Pot. Then cover the Cucurbit with Sand to half its height, and give a gradual Fire. In the first place then there will come off an acrid, volatile, yellowish Liquor, of an intolerable Smell, and a very corrosive, igneous Taste, nearly as it happen'd in the sublimation of Iron, *Process* 169, for the physical *Ratio* is pretty much the same. The Fire being increased after the Liquor is expell'd, there rises into the Alembic some white Flowers, then yellow ones, and in a short time exceeding red ones. Keep up the Fire for the space of 6 hours, and at last let it be so strong as almost to make the Pot red hot. Then let the Fire sink, and you will find in the Alembic, and about the upper part of the Cucurbit, a sublimate of a very beautiful red Colour, which is salt and astringent, and very much like Flowers of Iron. This being carefully taken out, and put immediately into a dry Vial, you will have at the bottom of the Cucurbit a red Matter of a rough Taste, which in the Air readily puffs up, and in some measure dissolves. It is necessary however to observe here, that these productions will be different, according as you make use of Vitriol of Copper, or Iron.

USE.

THE most fix'd metalline part of the Vitriol, by the assistance of the *Sal Ammoniac*, and the Fire, is here render'd volatile. And the qualities of the
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the Iron in the Flowers prepared from this calcined Vitriol, are nearly the same as in those made from the crude Iron, *Process* 169. This Preparation, therefore, if we must use these terms, should rather be called the *Ens primum Martis*, and that from the blue Vitriol, the *Ens Veneris*. Hence then we understand the death and resuscitation of Metals, talked so much of by *Paracelsus*. One grain of this Sublimate turns a large quantity of an Infusion of Galls into Ink. Mr. *Boyle* promises prodigious things from this Medicine, in those Disorders that arise from too great a laxity and weakness of the solid *Stamina*, as in the Rickets, and the like; and there it is of great service. And hence *Helmont*, in his Treatise called *Butler*, says a great many pretty things of something of the same nature. Since we see now, that after the extremest torture of the Fire, sustain'd both in a close and open Vessel, there still remains something vitriolic here, it is no wonder at all that Vitriol will continue to emit Fumes, tho' you distill it ever so long. This wonderful Body certainly deserves the most careful examination.

II. Upon sulphureous Semi-Metals.

P R O C E S S CCVIII.

The Solution of Antimony in Aqua Regia.

A P P A R A T U S.

TAKE of the purest Antimony, collected from the tops of the Cones, half a pound, reduce it to Powder, and put it into a glass Vessel that is low and pretty large, and cut off in such a manner, as to have a wide Mouth. Set the Vessel with the Antimony under a Chimney that will carry the Fumes up without dissipating them, and then pour upon it half a pound of *Aqua Regia*. By this means there will be excited an incredible Effervescence, with a prodigious Heat, Noise, and very red and dense Fumes, all which will soon be over. There will then remain at the bottom a moist, thick, pappy Matter, of a greyish and yellowish Colour. Dry this with a very gentle Fire, keeping it now and then stirring with a Stick.

U S E.

THIS is called an immerfive or humid Calcination of Antimony, by which this Fossil, which before was neither emetic, nor purgative, acquires the most virulent qualities. The yellow Matter interspersed through this *Calx*, is a true Sulphur of Antimony, which the Acid not being able to dissolve, is discharged from the other metalline part of the Antimony, which is corroded by the *Aqua Regia*. Hence therefore in this Operation, there is both a Calcination and Separation. This *Process* is necessary to those that follow.

P R O C E S S CCIX.

True Sulphur of Antimony.

A P P A R A T U S.

UPON the *Calx* of the preceding *Process* pour some clean Water, shake them together, and pour off the turbid Liquor into another Vessel; add more Water, shake and decant as before, and proceed in this manner till the yellow, lighter part, being thus dispersed through the turbid Waters, is separated from the heavier metalline one. Mix the decanted Waters together, pour off the whitish Water at top from the sulphureous Matter that falls to the bottom, which dry with a very gentle Fire, and it will be a true Sulphur in every character. If you put larger lumps of Antimony into *Aqua Regia*, and so perform the Solution, then the Masses of Sulphur will be larger; for the *Aqua Regia* penetrating to the bigger portions of the Metal that lie concealed in the Sulphur, will dissolve and extract them, and so render the Masses of Sulphur more remarkable.

U S E.

HENCE then it appears how intimately Sulphur may lie concealed under the appearance of a shining Metal; and how surprizingly the *Aqua Regia* can find out the metalline part amongst the Sulphur. But how wonderfully does the Sulphur here retain its proper nature without any alteration? This is that Sulphur of Antimony which *Van Helmont* orders to be extracted, and which he says scarcely differs from the common, except that it is a little more upon the greenish; and indeed there is hardly any difference. Nor perhaps does the Cinnabar that is made with it, in regard of its Vertues, deserve so much trouble: Certainly, the subliming it seven times, as he directs, is not so easily done as directed. In this Operation, however, we have an ocular demonstration, that Antimony consists of a sulphureous and a metalline part.

P R O C E S S CCX.

Glass of Antimony.

A P P A R A T U S.

1. **T**AKE of the purest Antimony reduced to Powder 2 pounds, put it into a large earthen Dish that is not glazed, and in the open Air place it over a Fire, in such a manner, that the Powder shall fume, but not melt. On hitting this nicely depends the whole Operation. Keep the Powder continually stirring with an earthen Rod, and there will rise a white, thick, fetid Fume, which is prejudicial, and therefore must be cautiously avoided by the Operator's standing so that the Wind shall blow it from him. Carefully continue this Calcination in an equable manner till the Matter fumes no longer. Then increase your Fire a little, and if it begins to fume again keep it up till it ceases, and then make your Fire pretty strong till the Dish begins to be red hot, and the

included Matter emits no more Fumes, and you will by this means have a *Calx* of a greyish Colour. If you proceed to calcine this with a still greater degree of Fire, till the Powder grows red hot likewise, you will then have a yellow *Calx*, which is more purified from the volatile part. If in the beginning of the Operation your Fire should happen to be so strong as to melt the Antimony, and make it run into Lumps, you must immediately slacken your Fire, and reduce these again to Powder. This is the calcination of crude Antimony by means of Fire alone, and it is of great use.

2. Put this *Calx* into a Crucible, round which place fire at a distance, gradually bringing it nearer and nearer, that the Crucible may gently and equably grow warm, hot, very hot, and at last red hot, it being all the time close covered with a Tile, that no Coals or Ashes may fall into it. Increase your Fire till the *Calx* is put in fusion, in which state let it stand for half a quarter of an hour, and then pour it out upon a very hot, dry Marble, and you will have a brittle, sub-pellucid, hard Cake, of a dark yellow Colour, which is called Glass of Antimony, and is so much clearer, as it stands longer in the Fire.

U S E.

ANTIMONY consists of common Sulphur (*Process* 209), and a metalline glebe. All the Sulphur becomes volatile by the Fire made use of for this calcination (*Process* 150), but the metalline part bears a melting Fire, as appears when it is melted into Cones, but then it always yields a white suffocating Fume. Hence then we understand, that when Powder of Antimony is ustulated with such a Fire as is not able to melt it, then the external Sulphur is gradually expelled, by which means the metalline part is purified, and at last is converted into a torrifed *Calx*, which, though the Antimony was harmless before, is a most virulent emetic. How this should happen, now, is not hitherto well explained. This *Calx*, being put in fusion, is Antimony converted into Glass, as we formerly saw in Lead. And indeed the Adepts say, that there is a great Agreement betwixt Lead and Antimony, which is confirmed by the melting this *Calx* into Glass. This is almost a fatal Emetic. And why? If it is infus'd in a soft Wine, not too acid, it yields an Emetic with very little loss of its Substance. The Vertue however may be pretty soon drawn out by repeating the infusion. This makes the emetic Wine every where sufficiently known. This Glass of Antimony consumes almost all metalline Bodies in the Test, but to Gold it gives a beautiful Colour.

P R O C E S S CCXI.

A Regulus of Antimony with Salts.

A P P A R A T U S.

1. *A Regulus* is procur'd from Antimony by every method in which the metalline part is separated from the sulphureous one; and the more accurate this separation is, the purer always is the *Regulus*. In order to this then, the fossil Antimony in its native Glebe, is sometimes put into conical earthen Pots, and melted with a moderate Fire that only makes it lightly red, and thus is formed into Cones, the

lower parts of which, or those towards the *Vertex*, are heavy, purer, and more metalline, whilst the broader parts towards the *Base*, are less solid, darker, and more sulphureous. In this manner is Antimony depurated to a *Regulus* by Fusion alone.

2. Take of common crude Nitre 2 parts, of good Tartar 3 parts, and of pure Antimony 4 parts, dry these well, and separately reduce them to a fine Powder, and whilst they are exceeding dry, by rubbing, mix them intimately together. Make the Mixture moderately hot, by all means very dry. Take a large Crucible, heat it gradually in the Fire till it is perfectly red hot, and then throw into it 2 drachms of this dry, hot Powder, which will take fire violently, and with a great noise, and throw out Sparks on every side. When every thing is quiet, throw in the same quantity more, and you will again have the very same *Phænomena*. Proceed in this manner till you have consumed all your Powder. And here the following cautions are absolutely necessary: Let the Crucible be a large one, that the Matter, when it is violently agitated, may not run over: Throw in but a little at a time, lest the Mixture, when it takes fire, should fly in large Sparks out of the Vessel: Let the preceding portion be always thoroughly on fire, come to rest, and be perfectly red hot before you throw in another, for fear the matter being hotter underneath, and colder at top, should form a Crust, under which the Fire being confin'd, wou'd cause an explosion much louder, and more violent than that of a Canon; for you have here a true *Pulvis tonitruans*, from the Nitre, Tartar, and Sulphur of the Antimony: And lastly, let the Crucible be thoroughly red hot for fear of the same terrible accident. If a young Beginner, not aware of these things, goes about to make a *Regulus* according to the common directions, he runs a risque of his Life; if he observes these cautions, he may perform the Operation safely. After the detonation is compleated in the manner described, cover the Crucible with a Tile, and increase your Fire till the Matter flows like Water. Have by you at the same time a metal melting Cone, perfectly dry, a little warm, and rubb'd over on its inside with Tallow, into which pour the melted Matter with one stream, and immediately strike the Cone. Upon pouring in the Matter, a sudden Flame will burst out from the lighted Tallow. Let the whole stand quiet and cool, and then invert the Mould, and with a Hammer strike it at the *Base*, and the Cone will drop out, the lower or vertical part of which will be the metalline part of the Antimony, whilst that towards the *Base* will consist of the Salts and Sulphur. The upper surface of the metalline Mass, where it is cover'd with the *Scoriæ*, will be mark'd with the figure of a Star. The *Scoriæ* will melt, and puff up in the Air.

U S E.

AS this *Process* discovers to us the true principles of the metallurgic Art, it is worth while to consider it a little attentively. In *No. 1.* then, the fossil antimonial Glebe being melted with a proper Fire, becomes liquid and heavy: Hence the lighter Bodies that are in it, as Stones and the like, and which do not adhere to the metalline part, according to the Laws of Hydrostatics are cast upwards, and so the heavier metalline part is rendered purer. And thus in the metallurgic Art, the metalline Matter is often by fusion separated from the rest. But in *No. 2.* by another metallurgic Operation, the metalline part of

the Antimony is now freed from that sulphureous one from which it could not be freed by simple fusion, but which still remained closely combin'd with it; and this is done by the help of the Powder of Tartar and Nitre, which is therefore called a *Pulvis Fusorius*. And this we may conceive of in the following manner. When the Antimony, which consists of a sulphureous and metalline part (*Process* 208, 209.) is mixed with the Nitre and Tartar, and committed to the Fire, then the Nitre, Tartar, and Sulphur of the Antimony take fire with a prodigious *Impetus*, (*Process* 130, 132), and by this means there is produced a fix'd Alkali from the Nitre and Tartar (*Process* 130): But this fix'd Alkali, being agitated with this intense Fire, greedily attracts the Sulphur, and intimately unites it with itself (*Process* 152), and then the metalline or mercurial part, as it is called, which is unaffected by an Alkali, being freed from its Sulphur, and put in fusion, subsides from the lighter parts, and collects itself at the bottom into a Mass, which goes by the name of *Regulus*. And as the long sharp *Spicula* of the Antimony dispose themselves horizontally from the center to the surface, hence they form a Star, which the Alchemistical *Magi* call a *Stella Signata*, and have in great veneration. This *Regulus* now, tho' it appears pure, will upon being fused again with an Alkali, produce fresh *Scoriae*. Nor perhaps can it be ever intirely freed from its Sulphur, and hence may be it always remains brittle, for Sulphur will render Metals so. The *Scoriae* are the sulphur of the Antimony, dissolv'd in a fix'd Alkali (*Process* 152); and hence their virtues are easily understood. The *Regulus* is emetic as the Glass is (*Process* 210), and by infusion yields an emetic Wine in the same manner. This then is another method of purifying Metals, by the help of Salts, from every thing sulphureous, oily, and arsenical, which render the metalline Glebes brittle and volatile, and which being intirely separated, the Metals become pure and fix'd.

P R O C E S S C C X I I.

A Regulus of Antimony with Iron and Nitre.

A P P A R A T U S.

TAKE of fresh Filings of Iron 8 ounces, make them red hot in a Crucible, and then gradually add of Antimony very finely powder'd, and made hot and dry 16 ounces. Keep these in a strong Fire till they are thoroughly melted, and whilst they are in this state, throw in gradually of the purest, driest fine Powder of Nitre made very hot likewise, 4 ounces. Urge this mixture with the strongest Fire till it flows like Water, and keep it in that condition for a quarter of an hour, and then, whilst it is perfectly fluid, pour it into a melting Cone, exactly as in the preceding *Process*. By this means I have had a starry *Regulus* as bright as Silver, to the quantity of $7\frac{1}{2}$ ounces. The *Scoriae* are of a very different nature from the former, dry, hard, irony, sulphureous, saline, and acrid, and scarcely dissolve in the Air.

U S E.

THE Sulphur of the dissolved Antimony here greedily unites itself with the ignited iron (*Process* 170), and hence produces sulphureous *Scoriae* of Iron.
Upon

Upon adding the Nitre, this is strongly deflagrated with some portion of the same Sulphur (*Process* 132, 133), and hence the whole is made to flow by the intenseness of the Fire. When the Matter then is in this very liquid state, the metalline part of the Antimony, which is heaviest, sinks by its proper weight to the bottom, whilst the Sulphur of the Antimony, the corroded Iron, and Nitre, are cast to the top. *Paracelsus* asserted, that Iron would more intimately separate the sulphureous part of Antimony from the mercurial one, than could be effected by a vegetable Alkali; and hence that this *Regulus* was much the fittest to furnish us with the Mercury of Antimony, for the profounder chemical Operations. And certainly we see by this Experiment, that Iron is capable of beautifully extracting the Sulphur from metalline Glebes, and giving them fixity and malleability. Hence *Alexander Suchtenius*, a Scholar of *Paracelsus*, has, upon this head, wrote two whole Treatises of Antimony, from which is borrowed the following *Process*.

P R O C E S S CCXIII.

The Alchemistical Regulus of Antimony.

A P P A R A T U S.

1. TAKE of Iron Nails 8 ounces, put them into a strong, large, sound Crucible, cover it with a Tile, place it in a wind Furnace, and cautiously raise a Fire till the Nails are perfectly ignited. Then by a little at a time, add of the best powder'd Antimony, made very dry and hot 16 ounces, and cover the Crucible a little with the Tile. As soon as ever the Antimony is thrown in, it emits a white Fume, and not a great while after is put into fusion, and at the same time causes the Iron to melt likewise. When they are reduced to a very liquid state, which may be examin'd by a long Tabacco-pipe, throw in gradually of the hottest, driest Powder of Nitre 3 ounces. Upon every injection then, there is excited a prodigious ebullition, noise, and conflict, and sometimes a crackling; and if a Person should unwarily throw in the Nitre damp, the whole would fly about with eminent danger to the Operator. When they have stood in this condition some time, the Matter casts out lucid Sparks. Let it flow like Water for the space of four or five minutes, and then pour it out into a melting Cone, which strike gently, and when the Mass is grown cold, knock it out. In this manner I have had 11 ounces 6 drachms of *Regulus*, and 11 ounces of *Scoriae*, so that with what stuck to the Crucible whilst it was pouring out, there were lost 4 ounces 2 drachms.

2. Put this *Regulus* into another Crucible, set it in the Fire, melt it, and when it is in fusion, add to it 3 ounces of Antimony reduced to Powder, and made very hot and dry, and when this is melted, throw in by degrees 3 ounces of Powder of Nitre, very hot and dry likewise, and then fuse them with an intense Fire, and keep the Matter in a perfect liquid state for the space of five minutes, after which pour it into a melting Cone as before. By this means I have procured 10 ounces and 6 drachms of *Regulus*, which were purer than the former.

3. Take this second *Regulus*, put it into a fresh Crucible, melt it again, and throw

throw into it 3 ounces more of Nitre with the same caution as before. Melt the Mixture with a very intense Fire, for otherwise it will not flow, and then pour it into a Cone. By this third fusion I have had 9 ounces 2 drachms of an exceeding white silvery *Regulus*, that was surprizingly starry, and 2 ounces 7 drachms of *Scoriae*; so that there was lost 1 ounce 5 drachms.

4. And once more melt this third *Regulus* in another Crucible, and then add 3 ounces of Nitre as before, which will then require a prodigious strong Fire to melt it, tho' the *Regulus* flows at the bottom of the Crucible like Water. Keep them in perfect fusion for the space of an hour, and then pour them into a Cone. Thus then I have obtained 7 ounces 3 drachms of an exceeding pure and beautiful starry *Regulus*, that look'd just like Silver, together with 2 ounces 7 drachms of *Scoriae* of a golden Colour, and a perfect fiery Taste; which is a pretty extraordinary *Phænomenon*.

5. For this Operation, the Crucibles must be very sound, strong, and large, and must be heated very gradually: The Fire must be equably kept up to its greatest strength, for otherwise the Nitre will not melt: And the Cones must be moderately warm, very clean, and perfectly dry, and within rubb'd over with Tallow. If you attend to these cautions, you will meet with success.

U S E.

THERE are many useful things to be learned from this Operation. Iron, which is vastly difficult of fusion, melts in Antimony as all other Metals do in Lead, and then the Iron being corroded by the melted Antimony, becomes combined with its Sulphur, whilst both the mercurial part of the Iron and the Antimony are expell'd, and uniting into one Mass fall to the bottom, and the Sulphur of them both rises together to the top. The Nitre that is thrown in burns furiously with these sulphureous Bodies, agitates the melted Elements to their very inmost parts, and hence unites those that are similar, and separates the heterogeneous. By the power of the Antimony the Iron is destroy'd, and its metallic Sulphur, which is the Gold of the Alchemists, unites with the internal metallic Sulphur of the Antimony, and thus both remain combined with the mercurial part of the Antimony, and hence you have a *Regulus*, which is beautified with a Star, and by its fine silver Colour teaches us the exceeding purity of its Mercury. The *Scoriae* contain Iron, Sulphur of Antimony, and Nitre, united together, and chang'd into a wonderful Body, whose secret medicinal Vertues, when it is properly manag'd, and rightly apply'd, those who are acquainted with these things greatly extoll. These *Scoriae* puff up surprizingly in the Air. But let this suffice concerning the first fusion. In the second, the external Sulphur is still farther extracted, and the metalline Sulphurs of the Iron and Antimony are more fix'd with their Mercuries into a purer *Regulus*. In the third fusion, the surprizing power of the sulphureous metallic Fire that lies conceal'd in the *Regulus*, begins to discover itself, which by fixing the Nitre, renders it exceeding difficult of fusion, tho' of all native Salts it was before melted with the gentlest Fire, impressing upon it a remarkable igneous quality, so that upon being applied to the Tongue it truly burns it, tho' its proper Taste is naturally exceeding cold, making it alkaliescent, without the addition of any vegetable Substance, and causing it to run spontaneously in the Air, tho' it would remain dry in it before. The fourth fusion discovers the same things more evidently:

dently : Here the pure Sulphur, only by its odorous exhalation, as it were, and simple contact, changes the Nitre more powerfully, and thus demonstrates the secret power of metallic Sulphurs. This *Regulus* has almost turn'd the Heads of some of the profoundest Chemists. Consult *Paracelsus*, *Suchtenius*, *Philaletha*, *Pantaleon*, *Becher*, and *Stabl*. And for my own part, when I reflect upon the Time and Pains I have employed in the examining into the nature of this *Regulus*, I can't help being surprized at my own Patience, and can hardly help blushing, to think, that so great a part of my Life should have been spent in this Inquiry ; but *trahit sua quemque voluptas*. The Colour of Gold, now, as in the same manner exalted, or restored by means of this *Regulus*, as the exceeding white Nitre, by being thrown into this *Regulus* in fusion, is immediately distinguished by a golden one. The *Regulus*, depurated even in this manner, will vomit. The *Scoriæ* give a beautiful Tincture to Alcohol.

PROCESS CCXIV.

Golden Sulphur of Antimony.

APPARATUS.

BOIL the *Scoriæ* of *Process 212**, till they are all dissolved. Into the inodorous Liquor drop Vinegar, and there will instantly arise a most noisome, stercoraceous Stink, and the Liquor, which before was thin, will become very thick. Drop in more Vinegar, stir the Mixture about, and proceed in this manner, till nothing more will precipitate. Let the Vessel stand quiet, and there will a Matter gradually subside to the bottom, which will be reduced to a much less compass than one would expect. Pour off the Liquor that swims at top, wash the Precipitate with Water till it is absolutely insipid, dry it gently, and keep it under the title of *Auratum Sulphur Antimonii*.

USE.

THE *Scoriæ* of *Process 212** consist of Sulphur of Antimony, and an Alkali: These boil'd in various Waters make a sulphureous *Lixivium*; and from this, by the Acid, is precipitated the Sulphur. This has an emetic quality, but a milder one. If this is rubbed upon Silver, it makes it of the Colour of Gold, and hence it is called *Auratum*.

PROCESS CCXV.

Crocus of Antimony.

APPARATUS.

TAKE of Antimony and Nitre equal parts, and reduce them to a very fine Powder. Set an Iron Ladle on the Fire, and make it almost red hot, and throw into it a little of this Powder, which will take Fire like Gun-powder. When all is grown quiet, throw in a little more, which will go off like the former,

* Should not this be 211 ?

mer, and so proceed till the whole Mixture is deflagrated. You will then have a Matter of a brown yellowish Colour, the bottom of which will somewhat resemble Glafs, upon which there will be some lighter *Scoriæ*. Reduce the whole to a fine Powder, and then wash it with hot Water, till the *Calx*, of the Colour just mentioned, remains insipid. The Waters this is washed with being filtered, are pellucid, but, upon dropping a little Vinegar into them, become of an Orange Colour, and let fall a fine Powder, very much like that of the preceding *Process*, but more subtil.

U S E.

THE Sulphur, Nitre, and black Antimony make a sort of Gun-powder; which therefore goes off in the same manner. The metalline part is by this means calcined into Glafs and *Scoriæ*, both which are violently emetic, and being infused in Wine will give that the same quality. The change of the Colour is here remarkable. If this Operation is performed in a large Crucible, with an intense Fire, and a large quantity of Ingredients, and the Matter is then made to flow, you will have an extemporaneous Glafs at the bottom, which being separated from the *Scoriæ*, has the same medicinal effects with the laborious Preparation of *Process* 210.

P R O C E S S CCXVI.

A milder Emetic of Antimony.

A P P A R A T U S.

MIX 1 part of Powder of Antimony with 2 of Nitre, and throw them a little at a time into a red hot Crucible, and you will have the same detonation as in *Process* 215, but the Matter will be white, which being thoroughly washed, gives you a white insipid *Calx* of Antimony. If the Water that it is washed with is filtered, you'll find it salt.

U S E.

THE proportion of the Nitre here being increased produces another Colour, though the deflagration happens in the same manner. This *Calx* is much milder than the preceding, often exciting *Nausea's* only, and slight Vomitings, with a discharge of a good deal of *Saliva*, and a thick Urine from the stimulated *Viscera*. The *Lixivium* of this, upon dropping in of Vinegar, precipitates a white *Calx* nearly of the same Vertues.

P R O C E S S CCXVII.

A diaphoretic nitrated Antimony.

A P P A R A T U S.

TAKE of Antimony 1 part, of Nitre 3 parts, reduce them to Powder, throw a little of the Mixture into a red hot Crucible, and it will deflagrate

as before. Proceed in this manner till you have used all your Powder, taking a great deal of care not to throw in any of it till the preceding Portion is perfectly deflagrated. Keep the Matter in the Fire for the space of a quarter of an hour, the Crucible all the time being perfectly red hot, and then let it cool, and you will find in it a hard, white Mass. Take this out, powder it, and keep it under the Title *Antimonium Diaphoreticum Nitratum*.

U S E.

IF you take $\frac{1}{2}$ a drachm of this Medicine well prepared, it produces scarce any sensible alteration, except that on account of the fixing Nitre that adheres to it, it moderately opens, and hence in acute Distempers does some service. Then the Chemists call it a Diaphoretic, and think that the arsenical Poison of the Antimony is fix'd by means of the greater quantity of Nitre. But in the Antimony there was at first nothing emetic, tho' you took it without any preparation, or the addition of any Nitre; and yet an equal quantity of Nitre gave it an emetic quality: As we may conclude safely therefore from Experiments, let us not give too much into *hypotheses*. Let the Followers of *Basil Valentine* here learn, that there is no need of so much caution to free this diaphoretic Antimony nicely from its fixing Nitre; for it neither produces anxieties, nausea's, or vomiting, but stimulates kindly and safely. There is more to be feared from the wash'd *Calx*.

P R O C E S S CCXVIII.

The common Diaphoretic Antimony, called Sweet Antimony.

A P P A R A T U S.

TAKE the calcined Antimony of *Process 217*, reduce it to a fine Powder, pour hot Water upon it, and stir them about with a Stick, by which means, the fixing Nitre that adheres to it, will be dissolv'd. Let the white *Calx* subside, pour off the saline Liquor at top, put on more Water, and thus render the *Calx* perfectly sweet, so that there shall be no Nitre sensibly adhering to it, and then dry it, and it will be white, insipid, and heavy, and is the thing you want.

U S E.

THIS is called diaphoretic, for the reason given in the preceding *Process*. But it is an inert, noxious *Calx*, without any thing active in it, as far as one can judge by its effects, and wants every thing valuable that it had before. It acts only in a sensible manner when it is mix'd with half as much of a purgative, for then it truly quickens its Operation, as appears by undoubted Experiments in the *Pulvis Cornachini*. But otherwise I dissuade the use of it. How wonderfully now are the Colours chang'd in the Antimony, by simply varying the proportion of the Nitre in the Calcination? And what a surprizing alteration do we find in the Strength?

P R O C E S S

P R O C E S S CCXIX.

Nitrated Antimony.

A P P A R A T U S.

TAKE the Waters with which the preceding *Calx* was washed, filter them, put the *Lixivium* into a clean Urinal, and exhale to a dryness, keeping it constantly stirring to the end. By this means then you will have a white saline Matter, of a singular, and not disagreeable Taste, not like that of Nitre, but softer, which keep under the Title of *Nitrum Stibiatum*.

U S E.

HENCE we learn, that Nitre by detonation with Antimony, is converted into a new Salt. This Salt is kindly aperient, and in a phlogistic disposition of the Blood, beautifully dissolves the inflammatory density without violence, and happily disposes to Perspiration, gentle Sweats, and a discharge by Urine, and hence cools, and proves of service in the Small Pox, Measles, Plurisy, and Peripneumony. How unreasonably therefore is this Water thrown away, as being of a hurtful nature!

P R O C E S S CCXX.

Fix'd Sulphur of Antimony.

A P P A R A T U S.

INTO the nitrous Liquor of *Process* 218, put into this Urinal, and now hot, and very pellucid, I here drop some very strong distilled Vinegar, and you see it instantly grows milky, and precipitates an exceeding white, and very fine Powder. I shake them together, and proceed to drop in more, shake them again, and repeat this till the Liquor will not be affected by the Vinegar any longer. Let the Vessel then stand quiet till all the Powder is subsided to the bottom, pour off the Liquor into a clean Vessel, wash the Powder with Water till it is perfectly insipid, and then dry it, and you will have a very white, insipid, fine Powder, which is called *Sulphur fixum Antimonii*.

U S E.

IN the deflagration of the Antimony with the Nitre, the Sulphur of the former unites with the latter, as in *Process* 215. And the Sulphur thus resolv'd and combin'd with the Nitre, is dissolv'd with it in Water; but as soon as ever an Acid comes to it, it precipitates from the Nitre, as we see here upon the instillation of Vinegar, and at the same time the Acid unites with the Nitre without any sign of an Effervescence. The Powder then that falls to the bottom being wash'd, is true Sulphur of Antimony. *Tachenius* extolls this Powder taken in Vinegar, as the most powerful anti-pestilential Medicine. But for my part, I confess, I think it ought to be look'd upon as an absolutely inert *Calx*,

noxious on account of its weight and indissolubility, or at least doing no manner of good: The Vinegar, however, taken along with it, I acknowledge to be particularly serviceable in the case mentioned. In this manner are the Chemists too apt to cry up the Preparations of their Art, particularly those from Antimony, and then especially when they don't produce any sensible effects. But that acetose, nitrous Liquor, now, that swims at top of the precipitated Powder, has the most efficacious Vertues in acute febrile Disorders, both on account of the Vinegar, and the soft Nitre which is now freed from the inactive Sulphur. Thus in the Chemical Art, is the best part frequently thrown away. From all these instances then, Gentlemen, you perceive, how surprizingly Sulphur is dissolv'd, lies conceal'd, and is resuscitated in various Forms, and various Colours.

P R O C E S S CCXXI.

The distillation of Antimony into an icy Butter, and Cinnabar.

A P P A R A T U S.

TAKE of corrosive sublimate of Mercury 2 pounds, rub it in a warm dry glass Mortar with a glass Pestil, till it is reduced to a very fine Powder. Then take of the best Antimony 1 pound, which separately likewise powder very fine. Mix these as nicely as possible in a glass Mortar, and they will grow warm, and emit a Fume, of which beware with the utmost caution. Have by you at the same time a clean, dry, glass Retort, that will hold three or four times as much as your Powder, which should have a large Neck, and be cut off so low that the Mouth may be very wide. Dry the Powder very well, and then put it into the Retort made hot and dry likewise, taking care that nothing black hangs about the inside of the Neck. Place the Retort thus charg'd in a sand Furnace, so contriv'd for this purpose, that the Belly of the Retort may almost touch the bottom of the Pot, and yet its Neck may lie in a declining position. This being done, apply a large Receiver so cut that the Mouth of it may exactly admit the Neck of the Retort, and cover the Retort with Sand. Let the whole *Apparatus* stand under a Chimney that will carry up the Fumes without dispersing them, make a little Fire, and when the Retort is grown moderately hot, with a Paste made of Clay and Lime lute the Joint. Then raise your Fire very gradually, and in the first place the Receiver will begin to be clouded, and there will be a small quantity of a Liquor collected in it: Carefully keep up your Fire in this degree, till nothing more of this Liquid will come off. When this ceases, increase your Fire, but very cautiously, till you perceive a pinguious Matter rise into the Neck of the Retort, and distill into the Receiver, coagulating whilst it passes from one to t'other: Keep up this Fire to the same height, and there will be a white icy Matter concreted, and remain in the Neck of the Retort. On both sides of it, therefore, lay some live Coals first at a distance, and afterwards nearer and nearer, till the Neck of the Retort is grown as hot as the Belly of it, and then the Matter will melt and drop into the Receiver. Proceed with this degree, and then very gently increase it till no more Butter rises into the Neck, and all that has risen, is distill'd into the

the Receiver. Then remove the Receiver, taking all possible care that none of the Vapour comes to your Lungs, and presently stopping it set it by. Lute on another properly fitted for this purpose, and increase your Fire, and you will have a Matter come off, of a yellow, red, blackish, and various other Colours, upon which raise your Fire to the highest degree, and at last place Fire upon the Sand at top of the Retort, that the Sand may be almost red hot, and so leave them for the space of two hours. Let the whole spontaneously cool, and then remove the Receiver, in which you will have some quantity of crude Mercury, and a Butter rendered impure by the sulphureous Fumes of the Sulphur of the Antimony. In the Neck of the Retort too you will find a Matter of various Colours made up of the Mercury, Sulphur, and Butter; and upon breaking the Retort, there will be some antimonial *Fæces* at bottom. But at the beginning of the Neck, you will find a dense, hard, opaque, and very heavy Mass, the surface of which that is contiguous with the Glass, will have a shining appearance, whilst the other is rough, and which being reduced to Powder, is true Cinnabar of Antimony, and is sufficiently costly. In this *Process* there is need of a great deal of patience, for if the Fumes should insinuate themselves through the cracked Glass, or Lute, or any other way, and be received into the Lungs, by their caustic quality they would prove fatal.

U S E.

AS the nature of Antimony and sublimate of Mercury has appeared from what has been already laid down, the chemical *Ratio* of this *Process* is easily understood. Whilst the Fire acts upon the Sublimate, the *Aqua Regia* that is in it, unites itself with the mercurial, metallic, reguline part of the Antimony, and thus leaving the Mercury, with which it was combined before, that returns to its original form, and runs at the bottom of the Retort. Hence the *Regulus* is sublimed with the Spirit of Salt, and becomes a volatile Vitriol of Antimony, call'd a Butter, consisting of an exceeding pure *Regulus*, and Spirit of Sea-Salt combined together. When these now are separated, and sublimed, then the Sulphur of the Antimony discharged from the reguline part, and the crude Mercury freed from its Acid, remain at the bottom of the Retort, and by the action of the Fire become united together, and sublime into Cinnabar. This Butter of Antimony is the most speedy caustic we know of, producing an Eschar the soonest of any thing, which separates in a very short time, for the most part the same day it is made. It easily melts with the moisture of the Air, and then it loses its pellucidity, grows white, and precipitates a very white Powder. It dissolves with Heat too, but in the Cold returns again to its icy form. The variety of Colours in this *Process*, arises from the Sulphur of the Antimony. If instead of crude Antimony you take the very pure *Regulus* of *Process* 213, and proceed exactly in the same manner, you obtain only a Butter, and a Mercury, both exceeding pure, because then there is no Sulphur, and the Acid being entirely received into the *Regulus*, the Mercury returns in its greatest purity. Here then, Gentlemen, you see what a singular effect the Spirit of Salt, which adhered to the Sublimate, has, whilst it sublimes the fix'd *Regulus* of Antimony in a Sand Heat. But it has the very same upon all metalline Bodies, Gold itself not excepted. How wonderful a Body then is Sea-Salt? The Chemist certainly can never too much employ his Art upon it, as he will always discover somewhat that will make him amends for his trouble.

P R O C E S S

P R O C E S S CCXXII.

The Distillation of Butter of Antimony into a liquid Oil.

A P P A R A T U S.

TAKE the Butter of Antimony of the preceding *Process* broke to pieces with some glass instrument, the Neck of a Bolthead, for Instance, and put it into a clean glass Retort, taking care that it don't dissolve in the Air, nor offend you with its Vapour. With a gentle Fire, gradually increased, draw it off into a dry clean Receiver, raising it till all the Butter is come over, which at last will require a Heat considerably intense, and you will have it nearly in form of a liquid Oil of Antimony. If you distill this Oil a third time, it will still become more limpid, and if it is rightly secured in a close Vessel, will continue in this Condition. Will this, which is a pretty surprizing Experiment, illustrate some obscure places in *Paracelsus*?

U S E.

THIS beautiful Experiment gives us a great insight into the method of rendering Metals volatile, and converting them into the true form of a liquid Oil; and discovers to us the wonderful Power of Sea-Salt in giving Volatility to Metals, and its surprizing quality, whilst it remains united with Antimony, for it so long is extremely poisonous, sending forth a truly arsenical Vapour, and yet when it is separated from the Antimony again, it becomes quite harmless. Is there not some room therefore to suspect, that there lies hid here something of an alcahestical Vertue? Certainly it renders all Metals distillable in a Retort, without any Alteration in their Weight, and is recover'd from them again almost in its full power. This, if you think proper, you may inquire into. This Oil is vastly caustic, and supplies skilful Surgeons with the most speedy Escharotic. This *Process* has been ranked amongst the profoundest *Arcana*. If you have a mind therefore to try it yourselves, whatever you do, be sure take care of the Fumes: I knew a very worthy and famous Man to whom they proved fatal. Again therefore let me caution you to beware of them.

P R O C E S S CCXXIII.

Mercurius Vitæ of Antimony, and its Regulus.

A P P A R A T U S.

IN this clean clear Glass I have some pure Water, into which I let fall one drop of the Oil of Antimony of the preceding *Process*, melted and depurated. You observe then the very instant it comes to the Water, from pellucid it becomes white, and falls to the bottom. I have now in this manner dropp'd in one fourth part of Oil, with respect to the Water, and it is all converted, as you see, into an exceeding heavy white Powder, which is collected at the bottom. I stir them well together with a glass Rod, so as to mix them as thoroughly as possible,

possible, and when they have stood quiet for some time, there is a very limpid acid Liquor swimming at top, which I gently pour off. Upon the Powder then I put more Water, and when by this means I have washed it till it is perfectly insipid, I dry it with a gentle Fire, and have then a white, insipid, heavy Powder.

U S E.

THUS then we see that the Acid of Sea-Salt adheres to the Antimony so long only as it continues exceeding strong, receding from it as soon as ever it comes to be lowered with the least quantity of Water, and then being attracted into the Water. This Powder given to 2 or 3 grains is a violent emetic, and from the fatal effects it has sometimes had, has been called *Mercurius Mortis*. If it is laid upon Glass, and exposed for a good while to a gentle Fire, being kept constantly stirring all the time, it loses its strength, and becomes less active, and then is thought by many Persons to be the *Arcanum* of *Riverius*. This Powder contains nothing of Mercury in it, whatever honest *Billichius* says to the contrary in his *Paradoxæ Chemicæ*, but the purest *Regulus* of Antimony. I took 11 ounces of this *Mercurius Vitæ* prepared with my own Hands, and putting it in a strong large Crucible, placed it in a Wind Furnace; and by this means the Powder was melted as soon as ever the Crucible came to be thoroughly red hot. When it was perfectly in fusion I poured it out into a melting Cone, and had 10 ounces of a shining *Regulus*, but a little upon the greyish, consisting of *Spicula* surprizingly disposed among one another.

P R O C E S S CCXXIV.

Philosophic Spirit of Vitriol.

A P P A R A T U S.

TAKE the limpid acid Liquor of the preceding *Process*, filter it, and inspissate it to one half, and you will have the *Spiritus Vitrioli Philosophicus*.

U S E.

THIS very limpid, and gratefully acid Liquor has the Taste of Spirit of Sea-Salt, and has the very same Effect in every chemical and medicinal Operation. Nor is there any thing in the least emetic in it, but it is an exceeding pure Spirit of Sea-Salt, which, through all the Operations it has undergone, with the Sublimate of Mercury, the Antimony, its Butter, Oil, and the Water, has still retained its proper nature, nor is so much as tainted by any admixture, but has an admirable salutary Acidity. It is improperly therefore called a vitriolic Liquor, for it contains nothing at all of Vitriol, but with the alkaline Salt of Tartar, returns to Sea-Salt. As I am greatly fond now of Sea-Salt, on account of its surprizing Effects in chemical Operations, I had a mind to examine into the nature of this production of it. To this purpose I took a large quantity of this Liquor, and distill'd it in a tall, clean, glass Cucurbit, and the Liquor came off exceeding pure, nor left any thing at all at the bottom. Hence therefore I learned, that the Water, by simple affusion, in an instant extracted the

the Spirit of the Salt in such a Manner from the Butter of Antimony, that nothing at all of the Antimony remained united with it, though it before rose out of the Retort combin'd with the *Regulus* in form of a Butter. I then distilled all the Liquor again in a tall Cucurbit, and afterwards once more with a gentle Fire of 100 degrees, and there then came off a pure Water, which had not the least Taste of an Acid: This degree of Heat I kept up till nothing more would rise. The remaining Liquor I urged with a Fire a very little stronger, so that there rose a Liquor that was somewhat acidish, which I carefully separated likewise with the same degree, and kept under the Title of an acidish Phlegm of Philosophic Spirit of Vitriol: This is of considerable service, where acidish Medicines are wanted. The Liquor then that was left I distill'd with a Cucurbit, and I found it a very acid, limpid, pinguious Spirit of Sea-Salt that fum'd a little. Thus then I learned the wonderful nature of this Salt, its easy combination, and easy separation.

P R O C E S S CCXXV.

Van Helmont's *Flowers of Antimony.*

A P P A R A T U S.

1. **T**AKE of Antimony, dissolved in *Aqua Regia* according to *Process* 208, 1 pound, put it into a low, open, glass Vessel, and expose it for a good while to a gentle Fire, keeping it continually stirring with a glass Rod till the Matter is become very dry. Then in a glass Mortar, and with a glass Pestil, reduce it to a very fine Powder, to which add as much of the driest *Sal Ammoniac*, as there is of the *Calx*, and then rub them together, the longer the better, that they may be mixed as intimately as possible. Put this Mixture into a low glass Cucurbit with a wide Mouth, fit on a very large, clean Alembic, and lute the Joint with a Lute made of Linseed-flower. Place the Cucurbit in a Sand Furnace in such a manner as to stand a little leaning forwards, that the Water in the Sublimation may easily pass out of the Alembic into the Receiver. Then cover the Cucurbit with Sand up to the rim of the Alembic, raise a gentle Fire, and there will come off a limpid, acid Water, which by increasing your Fire a little will be all expell'd. Gently raise your Fire, and somewhat white will begin to rise, upon which keep it up to such a degree, that you can just bear your Hand upon the Head, and then the Alembic will be filled with all kinds of Colours. Continue the Fire in this degree for the space of eight hours, and you'll be greatly entertained with the beautifulness of the appearance. Let the whole cool, very gently take out the Cucurbit, clean both this and the Alembic from the external dirt, and then carefully remove the Head, taking care of the first Vapour, and you will find almost all the Antimony sublimed with the *Sal Ammoniac* into a variegated Matter. Take this out presently, and put it up into a dry, hot, glass Vessel, under the Title of *Helmont's salt Flowers of Antimony*. These, if they are taken in the smallest quantity, are a very powerful Emetic. At the bottom you will find something that may be sublimed with fresh *Sal Ammoniac*.

2. Put these Flowers into Water, and stir them well about, and the Water will grow milky. Let it stand quiet, and settle, and at top there will swim a

saline,

saline, ammoniacal Liquor, which pour off. Wash the Flowers in this manner till they are quite insipid, and then dry them with a gentle Heat, and you will have a very fine, red, insipid Powder, which is greatly emetic. These are called *Van Helmont's* sweet emetic Flowers of Antimony. If the *Lixiviums* these are wash'd with are inspissated, you have a *Sal-Ammoniac* fit for the same use again.

U S E.

HERE then you have an instance of the manner in which *Paracelsus* thought a chemical Death and Resuscitation, as he express'd himself, opened Metals, and by this means made them exert themselves efficaciously in the human Body. Here we see a fixed Body become volatile, and here we observe the production of all sorts of Colours. Thus the black Powder of Antimony, or Head of a Crow, being reduced to a white *Calx*, becomes the Neck of a Swan, and afterwards acquiring a great variety of beautiful Colours, is chang'd to the Tail of a Peacock: But it is emetic under all these alterations.

P R O C E S S CCXXVI.

Van Helmont's fix'd diaphoretic Flowers of Antimony.

A P P A R A T U S.

TAKE of the sweet Flowers of the preceding *Process* 1 part, of the purest driest Nitre 3 parts, and rub them well for a good while in a glass Mortar. At the same time have a clean Crucible standing in the Fire red hot, into which throw a little of this Powder, first heated, and it will deflagrate, but very weakly. When every thing is quiet, throw in a little more, and so proceed till you have made use of all your Powder. When the Matter then in the Crucible is grown cold, it will be of a white Colour, inclining to yellow. Take this out carefully, pound it, wash it with Water, and dry it, and you will have a fine white Powder. Put this into a *China* Dish, pour Alcohol upon it, set it on fire, and whilst it is burning keep the Powder continually stirring about with a *Tabacco-pipe*. When the Alcohol then is burnt out, there will remain *Van Helmont's* Diaphoretic, 36 grains of which is said by promoting Sweat to cure all intermit- tent and continued Fevers.

U S E.

HERE we have an instance of fixing a volatile Body, for chemical uses. This Diaphoretic, its Author greatly extolls. I have made it myself, however, and tried it frequently, but I could never find any such extraordinary Vertues in it, as he mentions in his *Aurora Medicinæ*, written in *Dutch*; and hence I am apt to believe, that in other Cases likewise he has indulged himself a little too much in crying up his own Preparations.

P R O C E S S CCXXVII.

The Purgans Diaceltateffon of Van Helmont with fixed Flowers of Antimony.

A P P A R A T U S.

TAKE of the fixed diaphoretic Antimony of the preceding *Process* 18 grains, of Resin of Scammony 16 grains, of Cream of Tartar 7 grains, mix them, and reduce them to a fine Powder. Or take of the fixed diaphoretic Antimony

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B b b

9 grains,

9 grains, of Refin of Scammony 9 grains, of Cream of Tartar 3 grains, and make them into a Powder. This is the description of the Purge given us by *Helmont*, which *Paracelsus* called the *Diaceltateffon*: The first is the greatest, the last the least Dose for an Adult. It must be taken without any acid, and may be stopp'd by an Acid, if it operates too violently. It must be given in Intermittents in such a manner that it may finish its Operation as nearly as possible by the time the Fit is expected. The Author says it always cures Quartans before the fourth Dose, and proves efficacious in all Intermittent and continued Fevers. *Auror. Medicin.* publish'd in *Dutch*, p. 187, 188, 288.

U S E.

HERE we have another chemical *Arcanum*, under the name of a purging *Diaceltateffon*, as you may find in the *Dutch* Edition just cited. Concerning this *Van Helmont* says, that it radically cures the Gout and Fevers, that it heals Ulcers of the *Larynx*, Bladder, and *Æsophagus*, and that it purges the Body only so long as it is not sound, and no longer. See the *Latin* Edition, p. 775, 776, where he says the Dose is 8 grains, so that the account in the *Dutch* Edition does not agree with this. But I am always ready to suspect, that this great Man, by a subtlety of reasoning, extended the Vertues of these *Arcana* farther than could be fairly warranted by Experiment. These things I have prepared myself, and upon making use of them have seen very good Effects from them, but not such superlative ones as he insinuates.

Here then, Gentlemen, you will give me leave to put an end to our chemical *Processes*, as I have now, according to my promise, exhibited all those to you that are necessary to the understanding all the rest. A few things however I think I should here subjoin concerning some Operations, that are very useful both in Natural Philosophy and Medicine, and which from a consideration of the preceding *Processes* may be easily understood. And of these let the first be,

A Chemical SOLUTION.

AND this is performed,

1. With Water, by Dilution, Infusion, Decoction, Distillation, Mixture, Fermentation, Putrefaction, and Separation.

2. With Oil, by Dilution, Infusion, Decoction, Distillation, Mixture, Separation; not so much by Fermentation, or Putrefaction.

3. With Fire, by Calcination, Ustulation, Ustion, Fusion, Sublimation, Mixture, and Separation, and by its assisting the actions of other Bodies.

4. With Air, by Fermentation, Putrefaction, Agitation, and the addition of other Particles that have a dissolving power, and excitation of those that are already present.

5. With fermented Spirits, by Dilution, Infusion, Decoction, Distillation, Mixture, and the rendering the Oils more liquid.

6. With alcalious Salts, by Calcination, Ustulation, Ustion, Fusion, Mixture, and Separation, according to the various degrees of the dry Fire made use of.

7. With volatile alkaline Salts, in a dry way, by Sublimation; in a wet one, by Dilution, Digestion, and Distillation.

8. With fixed alkaline Salts, put in motion by the assistance of Water, and Fire, by Digestion, Decoction, Dilution, Separation, and Mixture.

9. With the fixed acid Salts of Alum, Sulphur, and Vitriol, either separated in form

form of a Liquid, or lying concealed within their *Calx's*, by Dilution, Decoction, Distillation, and Digestion, or in a dry form by Calcination, Ustulation, Ustion, and Distillation.

10. With the more volatile Acids, by Dilution, Digestion, Distillation, and Penetration.

11. With compound Salts and Soaps, by Calcination, Sublimation, Distillation, and Digestion, either in a dry form, or a liquid one.

12. With Metals, by Fusion, or *Amalgama's*.

A Chemical COAGULATION,

IS effected,

1. With Water, by Congelation, ChrySTALLIZATION, and Precipitation, as in *Mercurius Vitæ*.

2. With Oil, by uniting Sulphur, Salts, and Metals with itself, by the assistance of Fire.

3. With Alcohol, upon a volatile alkaline Spirit, Whites of Eggs, *Serum* of Blood, and Oil of Vitriol.

4. With an Alkali and Acid, uniting in a solid form, as particularly in vitriolated Tartar.

5. With a fixed alkaline Salt, as in Milk.

6. With an acid Salt, as in Milk, *Serum*, and Whites of Eggs.

A Chemical PRECIPITATION,

IS the Separation of a dissolved Body from its Solvent by the addition of something new, in such a manner as to render it manifest to the Senses, though before it lay concealed. And this is of very great use, and therefore deserves to be nicely considered, and indeed has been every where taken notice of in the preceding *Processes*. This now is brought about,

1. By pouring Water upon Oils dissolved in Alcohol, which have then a milky appearance.

2. By pouring Water upon resinous Bodies dissolved in Alcohol, with a milky appearance likewise.

3. By Water, in the Distillation of oily Spirits, if in the end any Water comes off after the oily Spirits.

4. By Acids with Acids: Thus Silver dissolv'd in Spirit of Nitre, is precipitated by Spirit of Salt; as Mercury is likewise.

5. By Metals with Metals and other Bodies. Into this Glass, which contains an ounce of Silver dissolved in Spirit of Nitre, and then diluted with twelve times as much Rain-water, I immerse some polished Plates of Copper, and the Silver is precipitated immediately, and the Copper dissolved. In this Glass now I have the Copper dissolved in the Spirit of Nitre, out of which the Silver was precipitated, into which I put some pure Plates of Iron, and the Copper presently precipitates, the Iron is covered over with a pappy Matter of a Copper Colour, the Copper falls to the bottom, and the Iron is dissolved. And again, in this Glass I have the Iron dissolved in the Spirit of Nitre, from which the Copper was precipitated, and I now drop into it some Oil of Tartar *per Deliquium*, upon which the dissolv'd Iron is precipitated, and the Alkali uniting with the Acid produces a true Nitre again after so many alterations. Thus the Spirit passes out of one Body into another, scarcely becoming either better or worse, though it is attracted more by one

thing than another, till at last it rests in that which in this respect is strongest, nor will be expell'd thence except by something more powerful, as if upon this regenerated Nitre you should pour Oil of Vitriol. Upon these two Principles depend the Doctrine of Precipitations, which is the true, though often abstruse cause of an infinite number of Operations, both in Art and Nature. I take a grain of white or red Precipitate of Mercury, and rub it upon the surface of a polished Copper Plate made hot, and it presently acquires a Silver Colour: Here the Copper attracts the Acid of the Nitre out of the mercurial *Calx*, and thus produces an *Amalgama* upon its surface, which then looks like Silver.

6. Alkali's often precipitate Bodies dissolved in Acids: This happens frequently, but not always, and sometimes only in part. In Copper dissolved in an Acid an Alkali causes a Precipitation, but then the Salt, arising from these Opposites, afterwards causes a Solution.

7. Acids for the most part precipitate Bodies dissolved in Alkali's; but here too, as in the preceding case, there are some exceptions.

8. The most acrid Salts, when they lie intirely concealed in Bodies, but without any alteration, by means of the Precipitations they bring about, produce the most surprizing effects, which could not possibly have been foreseen by the help of any Art whatever. If an ounce of the most inodorous, insipid, inactive *Luna Cornea*, that don't in the Fire discover the least sign of Acrimony, is rubb'd, or with a melting Fire in a glass Retort is combin'd with half an ounce of inodorous, insipid *Regulus* of Antimony, there is produced in an instant the most virulent, caustic Butter of Antimony, the very Vapour of which is a fatal Poison. How dangerous therefore is the mixing Bodies together, and of consequence, what caution should be used on these occasions?

A Chemical EFFERVESCENCE

1. **I**S a sudden agitation arising in Bodies upon mixing them together, tho' whilst they were separate, they were intirely at rest. And this happens in a different manner, betwixt different Bodies. A short account of this therefore we shall now lay before you, but such a one as may be sufficient for your understanding what is omitted. The principal Bodies then in which this physical action is observ'd, are

1. Native vegetable Acids, as the Juices of most Trees, Shrubs, and Plants, when they are in their more liquid state in the spring Season; the Juices of most summer Fruits before they are ripe; some particular Juices that retain an Acidity even when they are ripe, as those of Oranges, Citrons, Lemons, Tamarinds, garden and wood Sorrel, and acid Apples. Fermented vegetable Acids, as acescent Meals, *Rhenish* and *Moselle* Wines and Tartar. Doubly fermented vegetable Acids, as native and distill'd Vinegars. Animal Acids, from acescent, or acid vegetable Food, contain'd in their Chyle, Milk when it is sour, Skim-Milk, Butter-Milk, and its Whey. Native fossil Acids, as the vague Acid of Sulphur, Alum, or Vitriol in the Mines, either lying conceal'd in their proper Bodies, viz. Sulphur, or vitriolic Glebes, or extracted from them by an intense Fire, or dislodged by a superior Acid, as Spirit of Nitre, Salt, Alum, Vitriol, and Sulphur.
2. True fix'd Alkali's produced from any vegetable Matter whatever, by Fire. The more volatile Alkali's, either discovering themselves spontaneously,

taneously, as in Garlic, Onions, Scurvy-grafs, Mustard, &c. or produc'd by Putrefaction from Animals or Vegetables; or procur'd by Distillation or Ustion, from either of them.

3. Certain Bodies, improperly call'd Alkali's, only because they agree with them in this property, that they cause an Effervescence with Acids, as Clays, almost all Boles, *Calculi*, Shell-fish, Corals, Horns, Chalk, Teeth, Stones, Crabs-eyes, Bones, Oyfter-shells, Earths, Clays, and Hoofs.
4. The seven Metals.
5. Semi-Metals, as Antimony, Bismuth, *Lapis Calaminaris*, the *Lapis Hæmatitis*, Zincq, &c.

For these now we lay down the following Canons.

1. The Bodies of the first Class almost always cause an Effervescence with those of the second and third, sooner or later, more or less, either when they are very strong or diluted, and the Effervescence continues till the Saturation is compleat, and then ceases, upon which the Acrimony is almost constantly found to be soften'd.
2. The Bodies of the first Class excite an Effervescence with those of the fourth, but only some of one with some of the other, and some in a weaker manner, others more powerfully, and when the point of Saturation is obtain'd, there is generally produc'd a Vitriol.
3. The Bodies of the first Class cause an Effervescence in the same manner with those of the fifth.
4. The Bodies of the second, third, fourth, and fifth Classes, upon being mix'd together, are scarcely observed to produce any Effervescence. Hence this power discovers itself in the Acids, in particular, when they are mix'd with the other Bodies mention'd; tho' even here too there is some limitation, for the strongest Spirit of Vinegar poured upon Oil of Tartar *per Deliquium*, causes no Effervescence, tho' it does afterwards, when the Alkali is render'd weaker.

2. The most pure volatile Alkali, being perfectly freed from its Oil, and hence render'd exceeding simple, produces an Effervescence with the pure Acid of Vinegar, but by this means a greater degree of Cold is produc'd, whereas other Effervescences generate Heat in various degrees, even at last to bursting out into Flames. By this extraordinary Experiment, then, it appears, that an apparent motion may be increased with a production of Cold. See *Vol. I. p. 221. Phil. Trans. Abr. Vol. III. p. 354, 356.*

3. In other Effervescences there is almost always excited a greater degree of Heat. See *Vol. I. p. 214. to 222.*

4. There are some Fluids, which, upon being mix'd together when they are cold, in an instant produce true Fire. I here put 1 drachm of fresh distill'd Oil of Cloves into a dry hot Urinal, and placing it under the Chimney, throw upon it at once 2 drachms of *Glauber's* Spirit of Nitre, well prepar'd, and you see the very moment they come into contact, there is excited a terrible Effervescence, upon which the whole Urinal is fill'd with a very thick black Smoke, out of the middle of which there bursts forth an exceeding red Flame. The *Impetus* being now over, there remains a light, spongy, brown Matter at bottom. Dr. *Stare*, *Phil. Trans. Abr. Vol. III. p. 353, to 365. Hoffman. Dissert. Phys. Chem. 38 to 45, 126.* In such cases as these, now, a very powerful Acid,

that particularly of Nitre, and a very oily Oil, almost always meet together: Not an Alkali and an Acid. Many other Effervescences, that produce Fire, or come very near it, Monsieur *Homborg* has given us an account of. *Mem. de l'Ac. Roy. des Sc.* 1701. p. 84, 95. 1708. p. 2.

5. But betwixt some cold hard Bodies, there arises a spontaneous Effervescence likewise, and that even to such a degree as produce a Flame, as we see in Sulphur, and Filings of Iron rubb'd together, and then work'd into a Paste with Water.

A short Recapitulation of the Doctrine of ALCALI's and ACIDS.

AN Alkali is a Salt, either fix'd or volatile. It is known, 1. By its Origin, which is owing either to Nature, Putrefaction, or Fire. 2. By its Matter, which is either Vegetable, Animal, or Fossil. 3. By its Effects, as its exciting an Effervescence with Acids; its causing Precipitations; its combination with Oils; its Solution, in particular, of Sulphur; its changing the Colour of the *Heliotropium tricoecum*, Roses, and Violets, green, which grow red with Acids; its Taste; and its exciting a pain like that produc'd by Fire.

An Acid is a Salt, either fix'd or volatile. It is known, 1. By its origin, which it owes either to Nature, Fermentation, or Fire. 2. By its Matter, which is either Vegetable, or Fossil. 3. By its Effects, as its exciting an Effervescence with Alkali's, terrestrial Substances, Shells of Fish, Corals, &c. its causing Precipitations; its combination with alkaline and terrestrial Bodies into a neutral Matter; its Solution, in particular, of the mercurial parts of Metals; its changing the Colour of the *Heliotropium tricoecum*, Roses, and Violets, red; its Taste; its Smell; and its exciting a gnawing, shooting Pain. Tho' this Doctrine however holds pretty generally true, yet it must not be look'd upon as infallible. Hence, if we always infer the presence of an Acid, or Alkali, from one physical mark, which may be common to other Bodies, and even to these, when there is an Acid or Alkali present, we may often fall into mistakes. Thus, if a Person should argue in this manner, An Alkali causes an Effervescence with Spirit of Nitre, and Silver does so likewise, hence an Alkali and Silver are the same, this would not hold good; and yet some of the greatest Men in the Art have been guilty of this childish error, calling every thing an Alkali that would cause an Effervescence with any Acid, than which nothing certainly can be more absurd. Gold, again, excites an Effervescence with the acid Spirit of *Aqua Regia*, hence they say it is an Alkali; but it causes none with the acid Spirit of Nitre, and hence it is no Alkali: But the errors that arise from this Root are without number. How trifling therefore is the calling in the assistance of Alkali's and Acids to explain all the *Phænomena* of natural Bodies? and yet we have seen the time when this Doctrine was so much in vogue, that it was thought an honour to the Age which entertained it. Upon this head consult Mr. *Boyle* and *Bohn*.

The Production, Destruction, and Alteration of SMELLS and TASTES.

THIS we have seen from the first of our *Processes* to the last, there being scarce any one in which it has not appeared more or less. Consult Mr. *Boyle* throughout his whole treatise, *Of the Production of sensible Qualities*. And read over and go through our *Processes*, and you will see the thing abundantly.

The Production, Destruction, and Alteration of COLOURS.

1. **A**NTIMONY, when it is reduced to Powder, is naturally black; when it is calcined with *Aqua Regia*, it is yellow and greenish; when it is sublimed with *Sal-Ammoniac*, it is white, red, yellow, greenish, and black; when the sublimed Matter is freed from its Salt by Water, it is pretty equably red; and when Antimony is fixed with three times as much Nitre, it is white. Here then from one solid Body we have almost all kinds of Colours. And thus Mercury dissolved in *Aqua Fortis*, and then distilled in a Retort, in various parts of the Retort produces various Colours from one Fluid, as we have here demonstrated before you.

2. To produce an exceeding black Colour, by only pouring a pellucid Liquor into a clean Glass: Wash a hot Glass with a solution of Vitriol of Iron perfectly saturated, and pour into it an infusion of the whitest Galls, diluted with the purest Rain-water till it has scarcely any Colour, and then made hot. Red Roses, Pomegranate-peels, Green-tea, Sage, and Oak-leaves, will have pretty nearly the same effect.

3. To change a pellucid Liquor black, by throwing into it a little quantity of a white Powder: Into a diluted pellucid infusion of Galls made hot, throw a grain of Vitriol of Iron, well saturated, calcined till it is white, and heated, and it will form a black Cloud in the place where it falls, which dispersing itself on every side through the pellucid Liquor, will render it quite black.

4. To do the same with a yellow Powder: Instead of the white Vitriol, take the same calcined only till it is yellow, or yellow *Ens Veneris*.

5. To do the same with a red Powder: Take a little Colcothar of Iron, or its Vitriol calcined till it is red, or red *Ens Veneris*.

6. To do the same with a drop of a pellucid Liquor: Take a little Vitriol of Iron, dissolve it in Water, and drop it into a hot infusion of Galls.

7. To do the same with a drop of a gold colour'd Liquor: Take the red *Calx* of Vitriol of Iron, draw a Tincture of a golden Colour from it with sweet Spirit of Salt, and drop it into the same infusion. In all these Experiments, now, as the Liquor changes from pellucid to black, there are a vast number of intermediate Colours produced, which all at last, however, end in a black one.

8. To change the black Colour produced No. 2, 3, 4, 5, 6, 7, to a pellucid one, by only pouring the Liquor into a clean Glass: Pour these black Liquors, made hot, into a Glass, the inside of which has been washed with pure Oil of Vitriol; here the Acid absorbs the Iron. The black Colours, however, from the *Ens Veneris*, and the red *Calx* of Iron, as they become pellucid, generate somewhat of a red colour.

9. To change this pellucid Colour, thus made from a black one, to a black one again: Add as much hot Oil of Tartar *per Deliquium* to the pellucid Liquor, as is sufficient to saturate the Acid, which before absorb'd the Iron. In this case there is excited an Effervescence, with a surprizing production, destruction, and regeneration of a great variety of Colours. This is best observed, when you pour in but a little of the Alkali at a time, and do it as quick as you can.

10. As soon as ever now you add again such a quantity of Acid, that it may overcome the Alkali, the Liquor will lose this regenerated black Colour, and become

become pellucid: And thus it may be reciprocally renewed and destroyed. From what has been said, then, we see how vastly efficacious Metals are in producing a black Colour; and with what a small quantity of Matter Colours may be generated. In these Experiments, too, a curious Person may observe all the intermediate Colours the pellucid Liquor runs through till it comes to be exceeding black.

11. To produce a * Silver Colour, by only pouring a pellucid Liquor into a clean Glass: Take a solution of Mercury made with Spirit of Nitre to a perfect Saturation, dilute it with clean hot Water, and pour it into a hot Glass wash'd with the strongest Spirit of Salt; or pour a very dilute Solution of Silver, made with Spirit of Nitre, into the same; or Oil of Antimony into a Glass wash'd with hot Water.

12. To produce an Orange Colour, by only pouring a pellucid Liquor into a clean Glass: Take a pellucid infusion of *Crocus Metallorum* made with hot Water, and pour it into a Glass wash'd with an Acid.

13. To produce a Gold Colour, by only pouring a pellucid Liquor upon a grey Powder: Pour hot Alcohol upon hot Sulphur dissolved by a fixed Alkali, and then powdered.

14. To change a gold colour'd Liquor to a milky one, by only pouring it into a clean Glass: Pour the Tincture No. 13. into a Glass washed with the acid Oil of Vitriol.

15. To change a Liquor that is nearly pellucid to an azure Colour: Into Vinegar of Verdegrease diluted with Water till it is almost pellucid pour Spirit of *Sal-Ammoniac*.

16. To change an azure Colour pellucid: Add an Acid to the preceding azure Liquor till it predominates.

17. To change a very green Liquor to a beautiful Violet: Into Vinegar saturated with copper till it is exceeding green, pour Spirit of *Sal-Ammoniac*, till the Alkali overcomes the Acid.

18. To change an azure Colour to a beautiful green: Into a saturated Solution of Copper, made with Spirit of *Sal Ammoniac*, pour Vinegar, or any other Acid, till the Acid predominates.

19. Betwixt the most saturated azure Colour, and the deepest green, to produce a vast number of bluish and greenish intermediate Colours: Put a perfectly saturated hot Solution of Copper, made with Spirit of *Sal Ammoniac*, into a very clean cylindrical Glass, and drop into it some Spirit of Nitre, and you will observe an alteration in the Colour, in the manner mentioned, upon every Instillation.

But let this suffice for our present demonstrations. If you have a mind to see this affair elegantly treated of, and illustrated by Experiments, consult Mr. Boyle's *Treatise Of Colours*. Thus then, Gentlemen, having finish'd our design, give me leave here to put an end to these Lectures. I return you thanks for the diligent attendance with which you have favour'd them, and the pleasure you have seem'd to express at 'em, and heartily wish they may be remember'd and improv'd in such a manner as to promote the good of Mankind.

* There is no Colour mentioned in the original, but I think it should be a silver one.

DEO SOLI GLORIA.

I N D E X

T O T H E

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PAGE 337. Line 16. read, it adds other Particles to them. P. 504. l. 38. r. a pewter Vessel, and so in other places where such kind of Vessels are mentioned.

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PAGE 33. Line 33. Read, the more acid. P. 59. l. 11. r. the least quantity of. P. 63. l. 21. r. most liquid. P. 99. l. 31. r. ; with some clean Water wet. P. 99. l. 12. r. , yet, as far as I know, does not in Distillation yield such inflammable P. 204. l. 22. r. Epidermis, P. 231. l. 26. r. the acid Spirit drawn off is 9-16ths of

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