

Observations and experiments for investigating the chymical history of the tepid springs of Buxton : together with an account of some newly-discovered, or little known properties of substances relating to several branches of chymistry, and animal and vegetable life; to which are prefixed, a chronological relation of the use of Buxton-water ... intended for the improvement of natural science and the art of physic; in two volumes / by George Pearson.

Contributors

Pearson, George, 1751-1828
University of Leeds. Library

Publication/Creation

London : J. Johnson, 1784.

Persistent URL

<https://wellcomecollection.org/works/u6drfpts>

Provider

Leeds University Archive

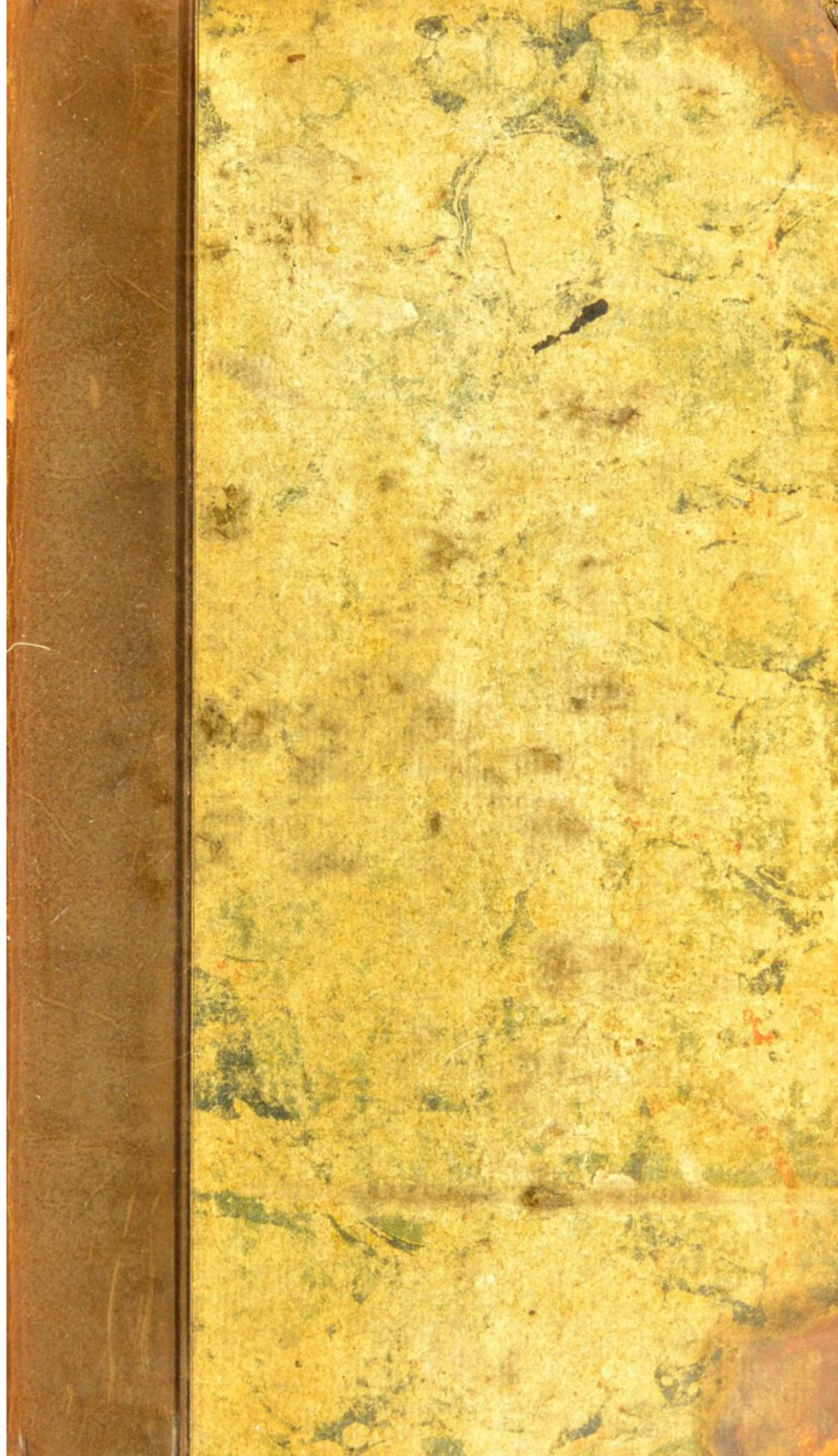
License and attribution

This material has been provided by The University of Leeds Library. The original may be consulted at The University of Leeds Library. This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.



Wellcome Collection
183 Euston Road
London NW1 2BE UK
T +44 (0)20 7611 8722
E library@wellcomecollection.org
<https://wellcomecollection.org>



✓✓
Leeds-Infirmary

MEDICAL-LIBRARY.

Entered *Novemb: 18th* 1785

Allowed for reading } Weeks Days
the first Year. }

—After the first Year

3¹¹

10

—

Forfeiture per Day for keeping { d. *1*
it beyond the Time. }

N-
S. C. 2

W. 29.

~~Y 13.~~

LEEDS UNIVERSITY LIBRARY

Classmark:

Special Collections

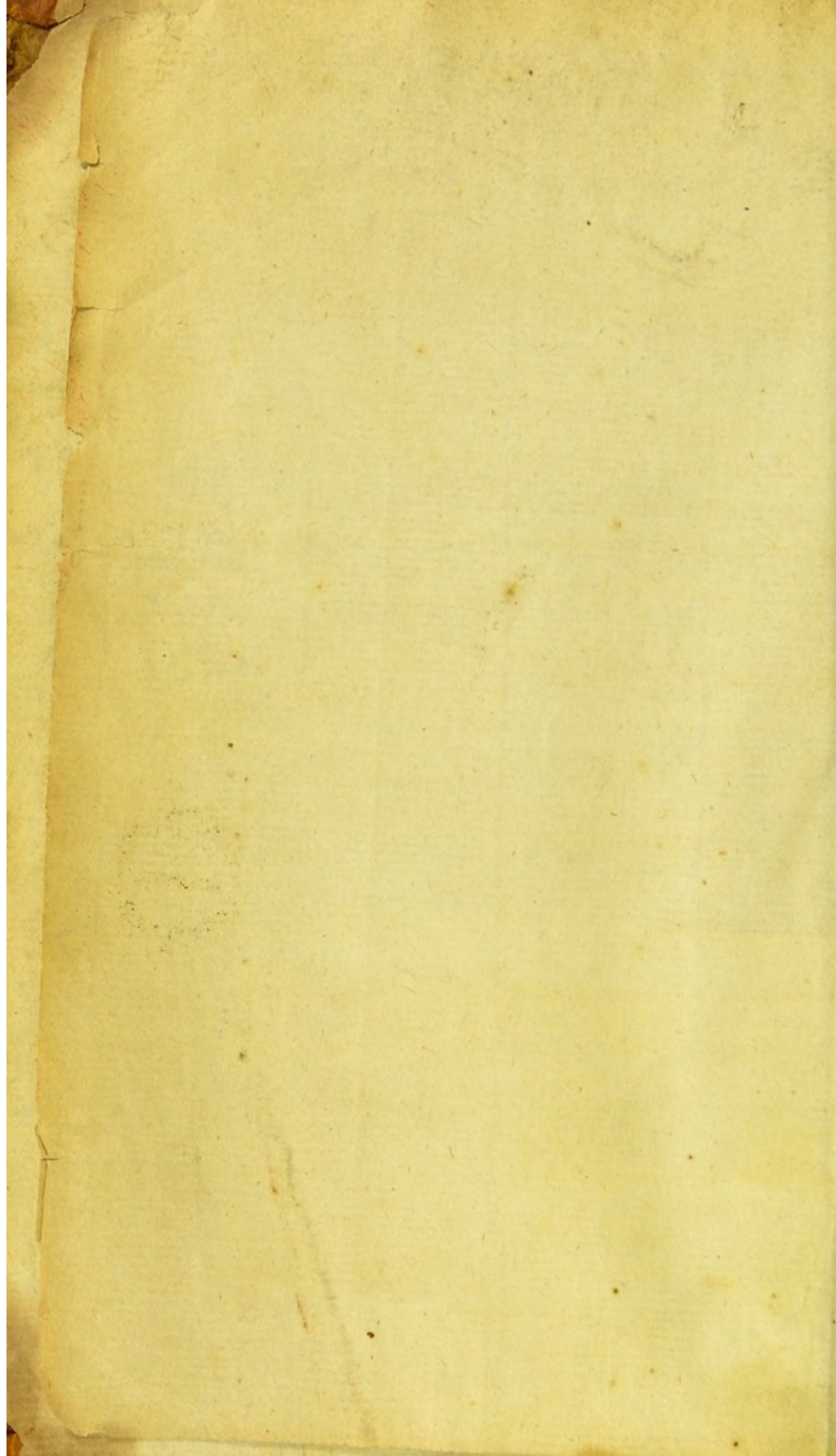
Health Sciences Historical Collection

SC2

PEA



30106016200106



OBSERVATIONS
AND
EXPERIMENTS

For investigating the
CHYMICAL HISTORY
OF THE

Tepid SPRINGS of BUXTON;

TOGETHER WITH

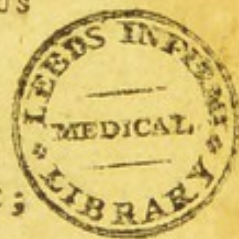
An Account of some newly-discovered, or little known
Properties of Substances relating to several Branches of
CHYMISTRY, and ANIMAL and VEGETABLE LIFE;

TO WHICH ARE PREFIXED,

A CHRONOLOGICAL RELATION OF THE USE OF BUXTON,
WATER FROM THE EARLIEST RECORDS TO THE PRE-
SENT TIME, SKETCHES OF A HISTORY OF THE ATMO-
SPHERE OF THE PEAKE, AND OF THE EXTERNAL FORM
AND INTERNAL STRUCTURE OF THE MOUNTAINOUS
REGIONS OF DERBYSHIRE;

INTENDED FOR THE

Improvement of Natural Science and the Art of PHYSIC;



IN TWO VOLUMES.

VOL. I.

BY GEORGE PEARSON, M.D.

L O N D O N:

PRINTED FOR J. JOHNSON, ST. PAUL'S CHURCH-YARD,

MDCC LXXXIV.

Monendi utique sunt Homines, et per Fortunas suas
rogandi, atque obsecrandi, ut Animos submittant, et
Scientias in Mundo majore quærant: quinetiam de Phi-
losophia vel cogitationem abjiciant, vel modicos saltem,
et tenues Fructus ex illa sperent, usque dum Historia
Naturalis et Experimentalis diligens et probata, compa-
rata sit, et confecta.

LORD VERULAM in Novo Organo.

TO THE MOST NOBLE
WILLIAM DUKE OF DEVONSHIRE,

PROPRIETOR OF THE TEPID WATERS OF

B U X T O N ;

WHERE,

FOR THE CONVENIENCY OF THE PUBLIC,

HIS GRACE HAS MUNIFICENTLY PROVIDED

SUCH VERY HANDSOME AND AMPLE

ACCOMMODATION :

T H E S E O B S E R V A T I O N S

A N D E X P E R I M E N T S ,

ARE VERY RESPECTFULLY INSCRIBED,

BY HIS GRACE'S

DUTIFUL AND

OBEDIENT SERVANT,

T H E A U T H O R .

TO THE MOST NOBLE

WILLIAM DUK OF DEVONSHIRE

REPRESENTATIVE OF THE FINE WATER OF

DEVON

WHICH

IS THE PROPERTY OF THE FINE

AND WHICH HAS BEEN RECENTLY

FOUND TO BE IN A STATE OF

DETERIORATION

THESE OBSERVATIONS

AND EXPERIMENTS

ARE VERY RESPECTFULLY

BY MR. G. A. C.

JOHN AND

CHARLES G. A. C.

THE AUTHOR

P R E F A C E.

THE Occasion of these Volumes of *Observations and Experiments*, that are now submitted to the Judgment of the Public, was the Discovery of an Error in the Opinion universally and confidently entertained, concerning the Nature of a Kind of *Air*, or, more properly, of a *permanent Vapour*, that impregnates the tepid Waters of Buxton, on which their peculiar Efficacy in Diseases was believed entirely, or principally, to depend.

Presuming that Philosophy and the Art of Physic would be benefited by the Demonstration of this Mistake, and by a Recital of the Facts which establish a different Opinion, I intended to publish the Observations and Experiments which discovered the Properties of this permanent Vapour, along with the Inferences that naturally followed from them.

In executing this Design, I found that many of my Conclusions were rendered

vague, or less extensively useful, and that others could not be drawn, for want of a general chymical History of this Spring-Water considered as an elementary Substance, and of the other Matters, besides the above permanent Vapour, that might be contained therein. For without a Knowledge of the Qualities of all the simple Substances forming a compound Body, we cannot, upon many Occasions, refer the Effects produced by it, or at least we cannot ascribe them, with any great Degree of Probability, to one or several of the component Parts of such a Body, but must consider them as the Consequences of the whole in Conjunction.

I was, therefore, induced to attempt an Investigation of the whole of the chymical Properties of Buxton-Water, and to collect the Facts already discovered upon this Subject. At the same Time, I examined attentively the Grounds on which these Spring-Waters were employed in Physic; and finding them to be vague or erroneous, I formed a Plan for establishing the Use of this Article of the *Materia Medica* upon a more solid Foundation.

In

In Consequence of these Reflections my original Plan was much enlarged, and I had now before me a wide and unexplored Field of Enquiry, a small Part only of which I flattered myself with the Expectation of being able to investigate, and even that Portion imperfectly; but I hoped my Labours therein, would render the Work which I at first intended much more useful, and make the Cultivation of this Ground less difficult for those who might desire to improve it hereafter.

My great Motive for undertaking this Work, was that of being serviceable to Mankind by labouring to contribute my Mite to the Advancement of Science, and the Improvement of the Art of Physic. I presumed that this Purpose would in some Measure be served, by making a small Addition to the present Stock of natural History; and I cannot imagine any just Reasons why my Endeavours should occasion the least Uneasiness in the Mind of any Person. I may discover the Mistakes, without undervaluing the Judgments, of those Philosophers by whom they were committed. Considering the Fallaciousness and

limited Power of the external Senses, even when aided by the best contrived Experiments and the most excellent mechanical Instruments, it is very probable, many Errors and Mistakes will in future be pointed out to have been committed in the History now presented to the Public. The Observations and Experiments here related, as the Reader will perceive, required merely Attention, Patience, and Reflection, and did not demand Sagacity, or Ingenuity; — the Instruction derived from them, was too obvious to escape the Notice of any Person of ordinary Penetration.

Left those who are engaged in the Practice of Physic principally from lucrative Motives, should be disquieted by Physicians whose main Object is the further Investigation of this Art; I shall observe, that professional Emoluments are not inseparable Accompaniments of Men who have made the most useful and important Enquiries in Nature for the Advancement of the Art of Healing; because the highest Degree of this Kind of Merit does not obtain them, without concomitant Qualifications of a very different Nature from professional

feſſional ones, and by thoſe Qualifications independent of uncommon profeſſional Merit the greateſt Honours and Emoluments have, frequently, been obtained. And here I cannot help obſerving, that I fear a principal Occaſion of the comparative Slowneſs of the Progreſs of Phyſic to that of the other Arts, and particularly the little Improvement of it ſince the Days of Hippocrates, notwithſtanding the Lights and Aids afforded by various Branches of natural Hiſtory and Philoſophy, has been, that the Profeſſors of this Art perceived that popular Reputation and lucrative Practice were not at all, or not ſpeedily to be obtained by mere Inveſtigations of Nature, without alſo beſtowing Time and Attention on Subjects foreign to the Art of Phyſic; therefore, from Motives of *Self-Preſervation*, the Deſire of *Gain*, or the Love of *public Diſtinction*, Phyſicians have oftentimes been induced to cultivate the Artifices of Inſinuation and Addreſs rather than the Field of Science:—

“Declinat Curſus, Aurumque volubile tollit.”

It may be proper to acquaint my Readers that the newly-diſcovered, or little known
Pro-

Properties of Substances relating to several Branches of Chymistry, and animal and vegetable Life, contained in these Volumes, are either Facts that were accidentally discovered during my Search after different Objects, or they were introduced for the Purpose of illustrating particular Subjects of Enquiry. On this Account I have frequently been obliged to make Digressions from what the Reader will suppose the proper Subject of the Work, and which contain Matter that might have been omitted or related in an Appendix to these Volumes: as however I wished to communicate my Observations and Experiments as nearly as possible in the Order in which they were made, I could not follow that Plan consistently with the Order of the Narrative I proposed.

In making my Observations, and describing the Result of my Experiments, I have not been influenced by any preconceived Opinions or favourite *Hypotheses*; therefore my Errors as an Historian must have arisen from the Deception or Weakness of my external Senses, and they may be detected and rectified by future Observers. If, on a Repetition of my
Exper-

Experiments and Observations, it shall be found that I have described *Properties* which do not exist; or if any Part of this Work shall appear obscure, it will afford me a high Degree of Satisfaction, to receive from any candid and ingenious Person a Communication of the Mistakes that I have committed, and a Mention of the Passages which shall require Illustration.

I have endeavoured in the Course of this Work to mention those different Observers and sagacious Interpreters of Nature, whose Discoveries I have Occasion to cite, in such Terms as shall not give Offence; and I have to the best of my Knowledge quoted the original Authors of them; nor have I, that I know of, mentioned as my own, what is the Observation of any other Person, without acknowledging to whom I am beholden.

The first Section, containing a *Chronological Account of the Use of Buxton-Water*, is composed for the Sake of gratifying those of my Readers who have Pleasure in knowing past Events independent of other Considerations; and

and because such a Relation may possibly assist in the Investigation of more useful Knowledge, namely, that of the *chymical Properties* of the principal Subject of my Inquiry.

I am apprehensive that a great Part of this Work which contains the Experiments on *permanent Vapours*, will appear somewhat unintelligible to many of my Readers. The mixing of different Solids, or different fluid Substances together; the measuring of Fluids; or the transferring a fluid Substance from one Vessel into another, are Operations too familiar to need any Explanation; but permanent Vapours, or compressible and commonly invisible Substances are so very rarely employed in the Practice of the Arts in common Life, that scarcely any Person, besides certain Experimenters, comprehends the Manner in which the Operations now mentioned are performed on them, as well as on Fluids and Solids.

It

It would not be consistent with the Plan of this Publication to describe particularly the Manner of performing Experiments on *permanent Vapours*, together with the Principles of these Experiments. Therefore, for the right understanding of many Parts of these Volumes, I must refer those Readers who are not conversant with the Subject of permanent Vapours, as Air, and other Substances in this Form, to peruse attentively the *Introductions to Dr. Priestley's five Volumes of Experiments and Observations on different Kinds of Air*, and Mr. Cavallo's *Treatise on the Nature and Properties of Air, and other permanently elastic Fluids*; likewise the Explanation of the Plate in *A Treatise on the various Kinds of permanently elastic Fluids, or Gases*, 2d Edition, 1779; and the other Authors referred to whose Instruments I have employed. I shall only just observe, for the Sake of affording a general Idea to those who want an Explanation of this Subject, that when a permanent Vapour is *transferred*, or *poured* from one Vessel, as a Phial, Jar, or Beer-Glass, into another Vessel, it must be conceived that two Vessels stand inverted, *one* filled with,

and

and placed inverted in a Vessel of Quick-silver, with the Mouth below the Surface of this Fluid, if a Substance that readily combines with Water, as Gas, is to be transferred; or if it does not at all, or but in small Quantity unite with Water, as Air or nitrous Gas, Water may be more conveniently employed than Quicksilver: the *other* Vessel containing permanent Vapour may have any Quantity of the permanent Vapour it contains thrown into the Vessel filled with Fluid, by turning it sufficiently immersed in Fluid into an upright Position and holding the Mouth of the other Vessel, with or without a Funnel therein, over the Bubbles forced out by the Fluid taking the Place of the permanent Vapour, so that they shall rise within the inverted Vessel filled with Fluid: by which Means a Bulk of Fluid will be displaced in Proportion to the Bulk of permanent Vapour that rises within it.

When a permanent Vapour is to be *measured*, the inverted Phial or Vessel filled with Fluid previously found to contain a certain Bulk may be employed; and when filled with
perma-

permanent Vapour it will contain a Bulk of this Substance equal to the Volume of Fluid ; or, *Marks* may be made on the inverted Vessel of Fluid, denoting that when filled as high as certain Marks it contains a certain Bulk of Fluid, and the permanent Vapour may be made to rise within this Vessel previously containing a Fluid, until the Fluid is expelled as low as the Marks.

Two or more permanent Vapours may be *mixt* together by transferring them in the Manner just described into the same inverted Vessel.

By a little Practice it is quite as easy to *transfer* permanent Vapours from one Vessel into another, to *mix* them together, and to *measure* them, as it is to perform the same Things with Fluids.

I have taken the Liberty of employing a few Terms that have been hitherto less frequently in Use than others signifying the same Things ; because I either find those in more general Use are confessedly improper, and
are

are even reckoned so by those who have invented and employed them; or they have been adopted without Consideration, and before the Nature of the Substances they were appropriated to express were well understood. I flatter myself I shall give no Offence by this Procedure. As soon as I find the Public, for good Reasons, disapprove of the Terms here made use of, I shall upon any future Occasion relinquish them,

OBSERVATIONS
AND
EXPERIMENTS,

For investigating the
CHYMICAL HISTORY

OF THE
TEPID SPRINGS of BUXTON, &c.

PART I.

SECTION I.

A chronological Account of the Use of BUXTON-WATER, for Pleasure or Health, from the earliest Records to the present Time.

AT BUXTON (*a*), a small Town or Village in the Peake of Derbyshire, there are tepid Springs, which, on account of their medicinal

(*a*) The following are Conjectures concerning the Etymology of the Word Buxton, formerly written Buckstone, or Buckstones.

“ It is not unlikely that the Stagges or Buckes wounded, would take Soyl ther, and there the Fosters of the Forrest called it Buckstand; but in my Judgment the former Supposition is more likely;” viz. that it derives its Name from *Buck*, the Name of the Owner of the Town.—See a Book,

medicinal Qualities have been treated by different

entitled, “ The Benefit of the ancient Bathes of Buckstones, which cureth most grievous Sickneses, never before published, compiled by *John Jones*, Physition, at the King’s Medenagh Derby, Anno Salutis, 1572, London, 4to.”

“ The Etymology of Buxton, I take to be from *Boc*, *Fagus*, or *Bocca*, Caper, and *ŕēan*, a Stone.” See Mr. Pegge’s Account of the Roman Roads through the Country of the Coritani, or County of Derby, 1779.

“ The Name of Buxton, or Buckstone, as perhaps it should be more correctly written, according to the Truth of the Etymology, is however, but modern, in Comparison of the Antiquity of the Place; for this can rise no higher than the *Saxon* Age, neither do I find it occurring in any very old Author.”—Mr. Pegge’s Account, &c.

If these Baths were used by the Saxons as by the Name of *Batham Gate*, a Road leading to the Bath, so named by Way of Eminence, it should seem they did, one may deduce the Name *Boc*, *Coxit*, q. d. the warm Stones or Rocks, or warm Springs among the Rocks; also from *Boc*, or *Buc*, a Beech-Tree, if we were certain this Kind of Tree ever grew there. *Skinner* derives the Name of Buxton from *Beocce*, *Bocce*, and *tun*, a Town. The Name of this Town seems to occur under the Name of *Bectune* in *Doomsday-Book*.

For these last observations I am indebted to the learned R. Gough, Esq; and I shall add, that it is very certain the Beech-Tree will grow at Buxton, because several of this Species were planted some Years ago near the Hall at Buxton, and are now in a flourishing State.

I have conjectured that Buxton is derived from *Bock-Stein*, or *Stein-Bock*, which is a German Word, and signifies that Animal, which the English call the *Stein-Buck*, or the wild Goat; the French, *Bouquetin*, formerly *Bouc estain*, or *Boucstein*, i. e. *Bouc de Rocher*; and the Latins, *Ibex*.

Whether

Whether it be probable, that this Animal might formerly inhabit such a Climate as the Peake of Derbyshire, I leave the Reader to determine for himself. To assist his Judgment, I shall quote the following Part of the Natural History of the Wild Goat, from Mr. *Buffon*.—" Le Bouquetin & le Chamois, que je regarde, l'un comme la Tige mâle, & l'autre comme la Tige femelle de l'espece des Chèvres, ne se trouvent, ainsi que le Mouflon, qui est la souche des Brebis, que dans les Déserts, & surtout dans les Lieux escarpés des plus hautes Montagnes; les Alpes, les Pyrénées, les Montagnes de la Grèce & celles des Iles de l'Archipel sont presque les seuls Endroits où l'on trouve le Bouquetin & le Chamois: quoique tous deux craignent la Chaleur, & n'habitent que la Region des Neiges & des Glaces, ils craignent aussi la Rigueur du Froid excessif; l'Été ils demeurent au Nord de leurs Montagnes, l'Hiver ils cherchent la Face du Midi, & descendent des Sommets jusques dans les Vallons: ni l'un ni l'autre ne peuvent se soutenir sur les Glaces unies, &c. p. 14. Histoire Naturelle Générale & Particulière, &c. Tome IV. à Paris, 8vo, 1772."

I beg Leave to observe, that although in Summer this Animal might not find in the Peake a Climate agreeable to its Nature, yet in the Winter Season it would be there sufficiently cold, and as the warm Weather approached, it might travel along the Ridge called the Anglo-Appenine, Northward; where, either in England or Scotland, the Air might be of a Temperature suitable to the Constitution of this Creature. There are, indeed, no Animals of this Sort that I have heard of in Derbyshire, but there might be formerly, before the Forests were cut down, as well as other Species of Animals that now no longer exist there: for we are told by *Camden* (see his *Britannia* by *Gibson*) that there were Wolves anciently in the North of Derbyshire, "for the Hunting of which, Lands were held at *Wormhill*, or Worme-hill, from whence those Persons were called *Wolveshunt*, as is manifest from the Records of the Tower," and *Wormhill* had its Name from *Wolf-haunt*.

ent Author's (b), and mentioned in various Kinds of historical Writings, for more than two hundred Years past (c).

Ruins, Remains, and Vestiges of Art (d), which were allowed to be of Roman Workmanship.

(b) The Benefit of the ancient Bathes of Buckstones, &c. by John Jones, 1572.

Several Observations relating to Buxton Wells, MSS.—This Book is in the List of Writings relating to Derbyshire, given by Gibson in his Edition of Camden's *Britannia*.

Lister de Thermis & Fontibus medicatis Angliæ, p. 36.

Short's natural, experimental, and medicinal History of the Mineral Waters of Buxton, and other warm Waters in the Peak of Derbyshire, 4to.

Hunter on the Nature and Virtues of Buxton-Waters, 1761.

Experiments and Observations on Buxton-Waters, &c. by Dr. Percival, Vol. 62. Phil. Transf.

(c) Camden's *Britannia*, first published about 1607.

Leland's Itinerary, Vol. 7. P. I. p. 65.

The Theatre of Great Britain, &c. by John Speed, 1676.

Childrey's *Britannia Baconica*, p. 112.

Leigh's natural and artificial Wonders of the Peak, 1700.

Salmon's New Survey.

De Mirabilibus Pecci, Carmen Thomæ Hobbes.

Wonders of the Peak, by Cotton, in English Verse.

Mr. Bray's Tour.

A great Number of other Books published within these last 30 Years.

(d) "That these Baths were anciently known the Cart Road, or *Roman Causey*, called *Bathgate*, which continues seven Miles from hence to the little Village *Burgh*, does plainly testify; and much more plainly the Roman Wall cemented with red Roman Plaister, close by Saint Anne's Well, where

ship, that have been discovered at different Times in the Neighbourhood, and adjoining to these celebrated Waters, are the Records from which it is collected, that the Romans made Use of the tepid Waters of Buxton as Baths. Independently

where are the Ruins of the ancient Bath." See Bishop Gibson's Edition of Camden's *Britannia*.

Stukeley's *Itinerarium curiosum*, p. 52, 53. and Salmon's Survey of England, Vol. II. p. 543.

" This ancient Roman Wall about Saint Anne's Well was, together with its Basin, totally razed in 1709, when Sir Thomas Delves, of Cheshire, erected the present beautiful Arch over that noble tepid Fountain."—Short's Works, before cited, p. 23.

" Sir Thomas Delves, of Cheshire, in Memory of a Cure he received here, caused an Arch to be erected, in digging the Foundation for which they came to the Remains of a solid and magnificent Structure of Roman Workmanship; and in other Places in the Neighbourhood very capacious leaden Cisterns, and a Variety of other Utensils, which evidently appear to be also of Roman Workmanship, have been discovered.—See Campbell's Political Survey of Great-Britain, 1774, Vol. I. p. 99.

" Here too (viz. thirty-three Yards north-east from the Bath at Buxton arises Saint Anne's Well,) the Romans had erected their noble Works, and here was the ancient Chapel dedicated to Saint Anne, by which Buxton was preserved in Reputation."—See Leeland and Jones, cited in Campbell's Political Survey.

" *Saint Anne's Well* formerly rose up into a Stone Basin, shut up within an ancient Roman Brick Wall a Yard square within, and a Yard high on three Sides, till Sir Thomas Delves built the present Arch over it, which is twelve Feet

pendently of these Testimonies, it is extremely improbable, that for the Space of near five Centuries, during which Period England was provinciated to a Nation with whom warm Bathing was the most usual Luxury, the celebrated Fountains

long, and twelve Feet broad, set round with Stone Seats on the Inside; it has a strong Iron Bar running across its East End, or Entry, instead of a Wall, to keep the Arch firm. In the Middle of this Dome the Water springs up into the Middle of a Stone Bason two Feet square above, but three Feet wide below on the Side next the Bridge from the shelving Stone laid over on the North Side above the main Spring. The lesser Spring rises up in the west End of this Bason, it bubbles up constantly all over. This Well is twenty-four Yards north of the outer Bath."—Short, p. 44.

"The most extensive and the most remarkable of the Roman Remains, in the County of *Derby*, are, I presume, the two Roads, which that People formed there; whereof the former and the greater, extended in a Manner the whole Length of the County, from South-west to North-east: and the other, which I call the less, crossed a Part of the *Peak*, to wit, from Buxton, where the Bath is, to the Station or City at *Brough*, near *Hope*."—Mr. Pegge's Account of the lesser Roman Road in the County of *Derby*, called the *Bathway*.

"Buxton is undoubtedly a very ancient Place, the warm Spring there being discovered very early, and no Doubt in the Roman Times. This I infer, not so much from the vulgar Name above-mentioned, which can be no older than the Saxon *Æra*, as from the Existence of a Roman Road pointing directly to it, and the Saxons having that Reason for denominating this artificial Road the *Bapon-gate*."—Mr. Pegge's Account, &c.

tains of Buxton should not be employed; the Heat of which, although, most probably, not so great as that of their artificial Baths, was capable of producing agreeable Sensations upon Immersion, and to the Employment of which, they would

“ I do not find any Traces of the Road in Question (Bathway) to the North or North-east of Brough, whence it may be reasonable to conclude, that as it extended no farther that Way, it was merely intended for a commodious Communication between this Place and *Buxton* Bath. *Brough* was certainly once a Place of Consequence, and probably very populous. But now from hence to Buxton the Road is very capable of being traced, as we found by Experience, for the Materials of which the Stratum is composed are totally different from the natural Ground on each Side. The Stratum, or Causey, is not much raised any where, (indeed there was but little Occasion for that, the Ground being in general hard and sound) but is the most so at the first setting out; however, in several Places upon Tids-well-moor, you may distinguish the Sides of it for many Yards together, so as to form a good Judgment of its Breadth, which we found to be seven or eight Yards.”—Mr. Pegge’s Account.

“ That the Water was of great Reputation in the darkest distant Times is undeniable, from the Chapel here dedicated to Saint Anne, whose Foundation was likewise discovered, and a large Piece of its Wall dug up in driving the foresaid Level, and no Doubt several other valuable Pieces of Antiquity might have been there then, had there been any Persons of Judgment and Curiosity.”—Short, on Mineral Waters.

Speed describes Saint Anne’s Well as “ inclosed with four flat Stones, called Saint Anne’s,” of which he gives a Drawing as well as of the Hall.

would be further invited by the crystalline Appearance, want of Colour, Taste, and Smell of the Water.

Although we have no Records to shew, that these Waters were employed for the Purpose of Health or Pleasure, previously to the Conquest of Part of Britain by the Romans, or for ten or eleven Centuries after it was abandoned by that People (*e*); yet we are not to conclude, that they were not made use of on both these Accounts.

Such

Mr. Watson lately discovered a Roman Station near Buxton.

About four Years ago, in digging the Foundation for the new Building now erecting called the *Crescent*, the Remains apparently of two Baths were found, one had a Plaister Floor, with some Bottles in it, supposed to be Roman Bottles, and was nearly of the Figure of the present Baths, but not so large; the other was smaller, and had a Wall of Stone.

Either at the Time of Sir Thomas Delves's Arch being erected, or a short Time after, was made the Plantation of Fir-Trees, called the *Grove*, which was lately destroyed to make Room for the Foundation of the *Crescent*.

(*e*) Perhaps the Chapel dedicated to *Saint Anne* is a Proof of the Waters being in Repute during the Period here spoken of.

“ It is obvious, that the Bath at Buxton was in greater Request under the *Roman* Emperors, than ever it was in the later Ages; the *Monkish* Historians, as it would seem, knowing little or nothing of it, unless you will suppose it to be included in certain general Expressions relative to the medicinal warm Waters of the whole Island, as where Bede says,” &c.
—See Mr. Pegge's Account of the *Bath Way*.

“ Mr.

Such were the State of the Arts, and the Occupations of Mankind in those Ages, that we can scarcely expect any Relation of the Effects of these Springs, had they been in Request.

In 1572, either upon the very Spot where the present Building, called *The Hall*, has since been erected, or very near it, stood the principal Building for the Reception of Visitors, which was at that Time reckoned a fine Mansion: and there was then also a *Bath* that appears to have been supplied by the same Springs, in the same Place

“ Mr. William Lambarde (Topogr. Dict.), and Dr. John Jones (Benefit of Buckstone's Bath), who both flourished in Queen Elizabeth's Time, are the first, I think, of our printed Authors that mention Buxton and the Bath there; for what may be thought very strange, John Leland never once mentions it in his Itinerary, as if it was a Place but little known, or of small Consequence in his Time. Jones however testifies, that the Place, for many Years before his Time, had been frequented by Thousands, for the Purpose of bathing; but Mr. Lambarde insinuates, that what Character the Place then obtained, was ascribed as much to the miraculous Assistance of St. Anne, the Patroness of the Place, as to any salutary Virtue in the Waters; whence it appears, that though the Place was then much frequented, it was only ranked amongst the *Holy Wells*. Dr. Jones says much the same. However this Gentleman contributes vastly, I apprehend, to raise the Credit of the Place by his Book; for from that Time, to carry this Account no lower, the Waters of Buxton came into a high Degree of Vogue, both for drinking and bathing.”—Mr. Pegge's Account of the *Bath Way*.

as at this Day (*f*). This *Hotel*, or *Hall-House*, and *Bath*, are the same as those spoken of by Camden, about thirty or forty Years after this Date (*g*).

One hundred and twenty Years ago, or about 1670, this Building was destroyed, and a new Edifice

(*f*) “Joining to the chief Spring, between the River and the Bath, is a very goodly House, four-square, four Stories high, so well compact with Houses of Office beneath, and above, and round about, with a great Chamber, and other goodly Lodging, to the Number of Thirty, that it is and will be a Beauty to behold, and very notable for the Right Honourable and Worshipful that shall repair thither, as also for others; yea, and the Poor shall have Lodgings and Beds hard by for their Uses only. The Baths also so bravely beautified with Seats round about, and defended from the ambient Air, and Chimnies for Fire to air your Garments in the Bath Side, and other Necessaries most decent.” See Jones’s Benefit of Buckstone’s Bath.

(*g*) “At the Rise of the River Wye there are nine Springs of hot Water, called at present Buxton Wells, which being found by Experience to be very good for the Stomach, the Nerves, and the whole Body, the Most Honourable George Earl of Shrewsbury adorned them with Buildings, upon which they began to be frequented by great Numbers of the Nobility and Gentry. About this Time the unfortunate and heroic Princess Mary Queen of Scots took her Farewel of Buxton in this Distich, being Cæsar’s Verses upon Feltria, applied to Buxton;

Buxtona, quæ calidæ celebrabere Nomine Lymphæ,
Forte mihi posthac non adeunda, vale.——”

Camden’s Britannia, p. 142.

The

Edifice erected by William the third Earl of Devonshire. This Mansion, with, probably, various Alterations and Additions, is the principal Hotel at Buxton, now called *The Hall*. It is probable, that the Bath remained in exactly the same Situation as before, and where it is at this Day, because the main Spring therein arises from a Fissure in the Stratum of Lime-Stone; but as the House has been said to be between the Baths and River, and as the Bath is now in the back Part of the House, it would seem, that there had been some Alteration in the Spot upon which the Building was erected by the above Earl of Devonshire. Among other subsequent Alterations, appears to have been the Addition of two other Baths, one for the Use of *Female Bathers*, and the other for the *Poor*, adjoining to the *old Bath*, now appropriated for the Men, called *The Gentleman's Bath*.

A Number of other excellent Houses for the Reception of Visitors have been erected within these last 50 Years, and they have of late been increased almost annually. At present there is a superb and spacious Pile building, from its Fi-

The above Princess Mary was many Years in the Custody of the Earl of Shrewsbury at Hardwick. This Nobleman and his Wife, the celebrated *Elizabeth Countess of Shrewsbury*, frequently visited Buxton. Their royal Prisoner, probably, accompanied them in their Excursions to this Place, and during one of these Visits she wrote the above valedictory Lines.

gure,

gure, called *the Crescent*, which is intended to afford various Sorts of Accommodation.

The Arch and Well erected after the Demolition of the Roman Wall and Basin (see Note (*d*), Page 4), were about four Years ago demolished to make Room for the Foundation of the Crescent. The Water had been hitherto conducted from small subterraneous Streams of a tepid Spring, for some Distance, into this Well; so that most probably the Well antiently was not exactly on the Spot where Sir Thomas Delves's Well was made. After the Destruction of the Well a second Time, for the Purpose just mentioned, the Water was conveyed in a small Grit-Stone Channel, 46 Feet long, in a different Direction, viz. about 46 Feet South East, into a neat square Basin of white Marble, inclosed within a Temple in the Style of Grecian Architecture: where it is drank at this Time, without having suffered any Alteration in its Properties, and with some superior Advantages, as we shall shew hereafter.

From the increased and still increasing Buildings for the Accommodation of Visitors on account of Health, or in Pursuit of Pleasure, it is rendered probable, and by the numbering those who resort to Buxton it has been proved, that these Waters have been much more frequented since the first considerable Hôtel erected by the Earl of Shrewsbury, and afterwards rebuilt by the Earl of Devonshire, and that the Use of them is extending.

extending. Among other Causes of the frequent Use of these Springs, must be reckoned the increasing Luxury of the Nation; the more easy Communication by Means of various Turnpike Roads leading on all Sides to and from Buxton; and the Fashion of the Times to visit what are called *Watering Places* during the Summer Season, especially in Countries that abound with delightful and uncommon Scenes of Nature.

The tepid Fountains of Buxton are resorted to now-a-days, almost entirely for the Purpose of removing or relieving Disorders; whereas, in the Time of the Roman Empire in Britain, they were probably more in Request for Pleasure than Health.

SECTION II.

Grounds on which Buxton-Water has been hitherto applied in the Cure of Diseases.

THE most ancient Grounds on which Physicians have employed Buxton-Water, from the Period when the Earl of Shrewsbury provided the first convenient Habitation for sick People more than two hundred Years ago to the present Time, have been,

1. *Traditional Knowledge, or Rumours of its Effects in the Cure of Diseases.*

As the Cases in which Buxton-Water has been used on this Ground were rarely discriminated; as its Effects were only related in the most vague and inaccurate Manner, and as the Cases related were, for the most Part, imaginary, this Principle of Practice has been hitherto little better than Conjecture or random Experiment.

2. *Observations*, it has been alledged, have been made of *the Effects of these Waters in Diseases* by several Observers, and recorded in the Writings of Doctor Jones, Lister, and Allen. The Plan mentioned by Doctor Jones of registering the Effects of the Water on Patients who frequented Buxton was, no Doubt, the very best Foundation of Practice. But as the Effects of this Water have been related inaccurately, and very incompletely, and as the Histories of the *Cases* have not at the same Time been given, the Observations and Conclusions recited are not of more Use than the former Principle in Practice.

3. Physicians have attempted to found their Judgment of the Use of Buxton-Water in Diseases on *the Effects of bathing in common Spring-Water*, supposed to have been already investigated. But as we have only a very imperfect and inaccurate History of the Effects of *cold* and *warm Bathing*, or of Immersion in Water, heated to about 50° and 96°; and as the Temperature of
Buxton-

Buxton-Water is very different from either of these Baths, the Effects of it are not deducible from a Knowledge of those of *cold* and *warm Bathing*, were we even in Possession of that Knowledge, and were the Effects of the *tepid Springs* of *Buxton* the same as those ordinary Spring-Water of the same Temperature; therefore it follows, that Practice grounded upon this Foundation must have been erroneous.

4. From the earliest Records to the present Time we find, that Practitioners have been directed in the Application of these Waters by the Knowledge they possessed of their simple Properties, and of the Kind and Quantity of Substances they conceived them to contain; that is, *by their Knowledge of the Physical and Chymical History of this Substance.*

A Physician instructed in this Knowledge, is no doubt able to form a Judgment, on many Occasions, with tolerable Certainty, concerning the Effects of Substances applied in Diseases; and very generally, by Means of this Knowledge, he is aided in his Practice and Investigations.

But a great Part of the Physico-Chymical History of Buxton-Water, till within even a few Years ago, was not of such Properties as had been observed by the external Senses, but of Properties created by the Imagination, and such as a subsequent Acquaintance with physical Laws, and with the Qualities of Substances, independently
of

of Demonstration by particular Evidences, prove to be absurd or fictitious (*b*).

Physicians have reasoned, and do at present reason, not only upon the Effects of imaginary impregnating Substances and Qualities of these Waters, but account for their Effects in Diseases

(*b*) *Allen* supposes this Water to contain Lead, Iron, and Sulphur; but *Short* observes, that *Jones* “ is much righter where he thinks the Water is too pure, delicious, and fine, for any such Principles as Lead, Copper, or Allum; and contents himself with an *Impalpable Sulphur*.”—*Short*, p. 59.

Lister says, these Springs “ are very clear, and scarcely deposit any Clay or Earth, and though they are not of the *atramentous Kind*, yet they plainly taste of Iron.”—*Short*, p. 74. cites *Lister de Aq. Medicat. Ang. Exercit. prior*, p. 35.

Leigh affirms, that “ these Waters are sulphureous and saline, yet not foetid, very palatable, because the Sulphur of these Waters is not united to Vitriol.”

Again, “ Where sulphureous Waters tinge Copper Colour, it is from the Addition of vitriolic Salt, as *Harrigate*; Other sulphureous Waters tinge Silver of a golden or yellowish Colour, as in the Bath in *Somersetshire*, there is a great Proportion of Sulphur and little Vitriol: But if they tinge none at all, it is all Sulphur and no Vitriol, as *Buxton*.”—*Short*, p. 48. cites *Leigh*, p. 31. Book I.

“ Since this Water washes so many Ingredients, abounding with Sulphur, and we find that even gross Sulphur, by the Mediation of Limestone, communicates some of its Parts to Water, and also as there is constantly such a visible sulphureous *Halitus* as upon the Surface of the Water, then it is reasonable to conclude, that this Water, whilst warm, is impregnated with sulphureous Steams or Vapour, as one Part of its mineral Spirit.”—*Short*, p. 55.

on the Removal of Causes that are the Creatures of Fancy, and the Existence of which are often inconsistent with the known Laws of Nature.

But were this History authenticated by proper Evidence, it would be so very incompleat, that practical Deductions made from it must have been liable to very many Exceptions, and have depended much upon the Part of this History not investigated; therefore it would do little Service to the Physician, although it might be useful to the Philosopher.

Of late Years, a Part of the chymical History of the tepid Waters of Buxton, we have Reason to believe, has been better investigated; but it was not accompanied with the Proofs on which it was established, was too imperfect, and Practitioners were not thereby enabled to make any useful Inferences, or place a practical Dependence on such as might have been drawn.

5. Some of the Professors of the healing Art, have had for their Guide *the Event of such Cases as have fallen under their own Observation*. But the Experience of the Events of Disorders of any one Person, directed solely to this particular Object, without other Aids, would not probably be sufficient to establish any Principles of Practice, that would enable us to produce Effects with any great Degree of Certainty; it would, however, contribute to that End. The few Examples

C

therefore

therefore that any Physician has had in the ordinary Course of his Practice may accidentally apply in particular Cases, but can afford no general Rules of Direction; and consequently, this Ground has been of extremely little Use in Practice.

6. There are many very learned modern Physicians, who being unable to discover any efficient chymical Properties of Buxton Water from the History now in the Possession of the Public, are inclined to account for the Power of this Substance in removing or relieving diseased States, from *its Qualities as simple Water*, and certain *concomitant Agents* that have an acknowledged Influence on human Health, to which the Habit is necessarily exposed during the Use of this Water. These Agents, which necessarily accompany the Use of Buxton Waters, are the Exercise of travelling to these Springs; probably a Difference in the Qualities of the Atmosphere; an Alteration in the Exercise of the mental Functions (*i*), arising from a Suspension of
of

(*i*) Porro Varium Vitæ Genus maximè in Usu fuisse apud Antiquos ad longe Salubriterque Vivendum, vel ex ipso discere licet Seneca meo & Celso. Nihil enim pestilentius est, nihil ad Salutem perniciosius in Hominibus negotiosis, aulicis, Curis publicis, vel privatis tota Die fatigatis, Studio deditis, quam in eadem Intentione Laboreque continue detinere Mentem nullam eidem Laxitatem debitamque Hilari-
tatem concedendo.—*Bagliui*. This Author cites the Authority

of the Attention to domestic Concerns, and other Business of Life, Scenes of Amusement, various Kinds of Society, a Change in the Face of the surrounding Objects of Nature, and the Confidence, or at least Hope, that is cherished of a Restoration of Health by Means of the Water; the usual Change of Food, Drink, Hours of Sleep and Watching; and the Exercise of the Body by riding, walking, &c.

But different Spring Waters of Celebrity are not alike in their Effects on Diseases, and the above concomitant Agents are all pretty nearly the same at different Watering-Places; at least the Difference of these Agents at different Places, is not sufficient to account for the peculiar Effects of each Spaw, if we except the Qualities of the Atmosphere, in which there may be a considerable Difference, and which we conceive to be

rity of Seneca for the good Effects of the *Varium Vitæ Genus*, of sometimes the wisest Men being engaged in childish Amusements; Socrates played with Children, and Cato drank Wine, by Way of Relaxation from mental Labours; concluding, “*Negotiosis itaque Hominibus & Studio deditis, singulis Diebus, debita Hilaritas Animorumque Laxitas juxta Senecæ præceptum concedenda: quod si monitum hoc posthabeant, floccique faciant Mille Morborum Generibus hac Solum de Causa obnoxii erunt; & unde quæso tot Affectiones hypochondriacæ, scorbuticæ, Mortes repentinæ alique innumeri Morbi his Diebus in Negotiosis Hominibus oriuntur, quam à negata Animis Curarum onere pressis debita, commodaque Laxitate?*”

the most powerful of all these Agents. It still then remains, upon this Principle of a Difference in the Atmosphere, to account for the peculiar Efficacy of medicinal Waters; and this I apprehend must be sought for, if not in the Water alone, at least in the Water accompanied with the Influence of the Atmosphere of the Region of Buxton.

In general I apprehend, that these accompanying Agents have not been sufficiently distinguished from each other, nor their Effects, together and separately examined; nor a Difference of Application consequently made in different Cases. The *distinguishing Properties of the Sky*, far from being duly investigated, have scarcely been thought of, excepting, perhaps, in a vague Manner, as to Temperature. Therefore, until a full and accurate History be made of the distinguishing Qualities of the Atmosphere of the Peake of Derbyshire, at and near the Source of Buxton Waters, the Influence of these Springs on human Constitutions cannot be determined; and consequently, admitting this Principle to be founded in Truth, its Application cannot be directed with Precision, or even on probable Grounds.

From the preceding Survey of the various Grounds on which Buxton Water has been used in Diseases, it appears, that Observations have not yet determined the particular Effects of Bux-

ton Water in different diseased States of the Body.

But if we do not know whether any, or what Effects have been produced by this tepid Water, the Question will naturally be proposed, how the continued, and even increased Use of it for several hundred Years, can be accounted for?

Various Motives may be conceived, to have induced a Number of diseased Persons to make the *first Trials* of Buxton Water; such as vague Experiment, by those who had found no Relief from Means already employed; the natural Propensity of the human Mind to make Trial in Diseases of any *new* Substance, or of a Substance possessing *extraordinary* Qualities, &c. A Number of sick People being thus induced to make Trial of this Water, if as great a Number, or nearly as great, found Relief and experienced Cures in Consequence of its Use, as after any other Means already known, it may be reasonably inferred, that this Spring would in future be as frequently employed as those Means; provided, however, that it had equal Advantages on other Accounts.

The Rumour of the good Effects, may be conceived to have first induced sick People to make repeated Trials in Cases supposed to be similar to those relieved; and in which it was, from reasoning on erroneous Principles, supposed to be helpful. As Mankind have continued the Use of this Water for a Period of several hundred Years,

and as the Frequency of its Application hath increased, as the Means necessary to, or of promoting its Employment have increased, it may be fairly inferred, that the Cure and Relief of Diseases have, at least, in some of the numerous Cases which have followed the Use of Buxton Water, been effected by this Substance. For although the Restoration of Health, and Relief in Diseases, have been known to follow, and, as is deducible from the Properties of the human Frame, may happen, in almost every Disease, *after the Application of any Substance whatever*; and although the Disposition of the human Mind inclines us to apply, as Medicines, any *new Substances*, or any Thing possess of *extraordinary Properties*; yet, if the salutary Effects, on Repetition, be discovered to ensue as frequently without their Application, or after the Application of almost any other Substance, such Substances, after a few Trials fall into Disuse; provided, however, that other Substances have, by the Test of repeated Experiments, been found to produce the salutary Effects expected from the Substance of which the Trials had been made without salutary Consequences following. But if no such Substances be known, any *Thing* whatever may, from the Nature of the human Passions, and from professional Motives, continue in Use, and that in Frequency, in Proportion to its Agreeableness and Conveniency of Application. Considering, however, the present
very

very improved State of Natural History, it is scarcely probable, that a Substance entirely *non-efficient*, will continue so long in Practice as a Period of several successive Centuries.—Such a long and uniform Use can only be accounted for, on the Supposition of its being productive of salutary Effects, as frequently as other Means known, although the Manner, and particular Diseases in which these Effects are operated, be not discriminated.

In this Manner we account for the continued Use of Buxton Water for several successive Centuries; and if we do not demonstrate, it is hereby rendered extremely probable, that this Substance possesses the Power of curing and relieving Diseases. But such has hitherto been the Negligence of Mankind, that we neither know the particular diseased States it is capable of removing or amending, nor on what its Power of producing these Effects depends.

The Consequences of this State of Ignorance are,

1. That this Substance is liable to be applied in Cases where it has no Effect, or is variously hurtful.

2. That probably it cannot be applied, even where it is salutary, in so efficacious a Manner as it otherwise might be.

3. That its Use cannot be so extensive as it must naturally be, were the Properties of the Water, or the Impregnations understood, in which its medicinal Qualities reside.

S E C T I O N I I I .

A PLAN for the Investigation of the medicinal Properties of BUXTON WATER.

THE Method of investigating the peculiar Effects of Buxton Water in particular diseased States, and in what its several Powers of producing these Effects reside, appears to be,

First, To enquire into *the Properties of the Atmosphere of the Peake*: For this, as we have before observed, is the only peculiar *efficient Agent*, or *Means*, capable of operating any considerable Changes on the human Frame in Diseases, *accompanying* the Use of Buxton Water; the other concomitant Agents being common to the Use of medicinal Waters in general.

This Enquiry is necessary, in order to discriminate the Effects of this tepid Water, from those of other Means of amending or restoring Health, to the Influence of which, the human System is necessarily

necessarily exposed during the Application of Buxton Water.

Secondly, *To investigate the Properties of Buxton Water*; which are comprehended under the following Heads:

I. ITS CHYMICAL HISTORY;

1. As a simple or elementary Substance.
2. As impregnated with extraneous Matter.

II. THE HISTORY OF ITS EFFECTS ON LIVING SUBSTANCES;

1. On Vegetables,
 _____ in Health.
 _____ Disease.
2. On Animals,
 _____ in healthy States.
 _____ diseased States.

Besides the Utility of the preceding Histories, for the Purposes of natural Science, and Arts in general, they are each of them of special Use for the Attainment of the Object of our Enquiry. Being instructed by the *chymical History* in the principal Properties of this Water, and in the Sort and Proportion of Substances it contains; among various other practical Inferences, we

1. May frequently form a Judgment, if not with Certainty, at least with Probability, of its Effects on Health and Disease; provided the Properties and Substances be such as those
 Pro-

Properties and Substances with whose Effects we are acquainted. Or, if the Properties and Substances be such whose Effects are not already known; this Circumstance suggests efficient Causes, or at least probable or possible efficient Causes, of Effects before or without it unaccountable, and also new Sources of Knowledge and Enquiry.

2. If we know the efficient Properties or Substances contained in Waters, we are enabled to direct their Application, upon many Occasions, with greater Certainty of Effect. Suppose, for Instance, the peculiar Efficacy of a Water to reside in its Temperature, or in a Substance that is a Vapour, in the Heat of the Water and that of the Atmosphere, and is so mixt with it, that it readily escapes spontaneously upon Exposure to the open Air: This suggests, that this Water must be of the same Heat as at the Spring-Head, when employed at a Distance from it, in the first Case; and in the latter, that Attention should be paid to apply the Water, under such Circumstances, as that the Vapour it contains be not previously detached.

3. If different Properties and Substances in the Water have, separately, and variously conjoined, distinct Effects, according to the diseased States in which they are applied; this Knowledge may enable us to apply the efficacious Qualities and Substances with much greater Effect, by making

ing a Separation of the efficient from the non-efficient Parts and Properties; and by applying the former in a larger Portion, or Dose, than can be exhibited by Means of the Water.

4. If the efficacious Substances be procurable by Art, or found elsewhere in Nature, although we may not exactly imitate the natural Compound, I mean the Water, we may have it in our Power at any Place, and upon any Occasion, to procure and administer those Parts which are efficacious; where, either the Water could not be at all, or not without Difficulty obtained. The Pymont Water, and Sea Water, are the most frequently composed by Art, and the artificial are apparently in all Respects equal to the natural Compounds. The Manner of imitating Waters, that owe their Efficacy to Gas (*k*), hath been shewn some Time ago, by *Venel*, *Shaw*, and some others; and a more complete, accurate, and easy Method has been discovered of late Years by Dr. *Priestley*.

The Chymical History of Water, therefore, in Part, supplies the Place of the History of its Effects in diseased States, may be more readily attained, and also renders this History much more useful and complete.

The History of the Effects of this Water on living Vegetables, in their different States of

(*k*) By Gas, I mean that permanent Vapour, which is frequently called fixed Air or fixable Air, and calcareous Gas.

Health and Disease, may advance us in the Acquisition of the Knowledge we aim at, as the End of our Labours : For such is the Analogy between Animal and Vegetable Life, that certain Principles may frequently be applicable to both. Such Deductions, however, should not be received and applied in Practice without Caution, and considering, that they are liable to Differences and Exceptions.

Farther, the Effects of Substances on Vegetables, upon some Occasions, are their distinguishing Properties, and furnish Lights in the Course of other Investigations.

The Mind, being in Possession of the Knowledge of the *Effects produced by the tepid Water of Buxton on various Classes of Animals in Health*, is thereby enabled to make many practical Inferences. For the Cure or Relief of Diseases, is oftentimes effected by Changes operated on certain Functions *not* affected by the Disease to be removed or palliated.

Secondly, The Effects produced, in Consequence of which Diseases are cured or relieved, are frequently of the same Kind in Health and Disease, only differing, perhaps, in Degree. In either of these Cases, being acquainted with the Effects of Buxton Water on healthy Animals, we deduce the Cases in which this or any other Agent is medicinal or hurtful.

But there are very many Cases in which Diseases are changed for Health, or variously altered,
by

by Agents that do not produce Effects on healthy Functions, of the same Kind as those by which they cure or palliate Diseases. For Instance, the Changes produced by the Peruvian Bark in healthy Bodies, are not those by which it cures intermittent Fevers. The same may be said of Quicksilver, in the Cure of the Lues Venerea; of Opium in the Tetanos; of Antimony in continued Fevers, &c.

We see then the Extent of the Application of this Substance in Practice, on the Ground of the foregoing History; that it supplies the Place of the History of the Effects of Buxton Water on *diseased States*, only imperfectly; but being much more readily obtained than this History, in the Order of Subjects to be investigated, it should have the Precedency, for the Sake of present Use: It also throws Light on the other Histories, by ascertaining the Kind and Differences of Things, and points out on what the peculiar Efficacy, in Diseases, of compound Substances, depends.

The most interesting of all Knowledge on this Subject is, that of the *Effects of Buxton Water on all the various Classes of Animals in diseased States*.

Being possess of a compleat and accurate History of the Effects of this tepid Water in all the various Diseases incident to the human Frame, we shall be able to distinguish the Cases in which

it is helpful, hurtful, or inefficacious ; and therefore to apply it so, as to produce the Effects required with Certainty and Precision.

The other Histories enable us to produce Effects in a few Diseases with tolerable Certainty ; in some others on the Grounds of Probability ; in very many Cases, indeed, they bestow not any Power of commanding Events ; but they all accelerate the Acquisition of the Knowledge of the Effects operated by this Substance in Diseases.

The Attainment of this Knowledge is a Work of immense Labour, and the Result of a long Space of Time. The Industry of any one Person directed wholly or principally thereto, for the usual Period of human Life, would be able to investigate only a small Part of this History, and that Part imperfectly. It is a work that requires the co-operating Labours of many Observers, and the successive Observations of Numbers, at different Times, to render this History tolerably complete. The Extensiveness of this History, however, should not deter any one from exerting his Endeavours towards the Attainment of it ; because, it is only by the united Labours of many Persons that it can be obtained ; and every one who contributes but a small Portion towards it, although that Portion of itself should be of little Use, is a Benefactor to Mankind. And this History ought to be considered as the most important of the Histories proposed, because it is by this alone that

we

we can become thorough Masters of the Powers of Buxton Water for the Purposes of Physic.

Considering, however, the Length of Time and Labour requisite to cultivate this History, so as to render it useful to any considerable Extent, it may not be improper to recommend first, the Acquisition of the other Histories; because they are more readily attained, and also expedite the Attainment of this History: Although it must be remembered, they can supply the Place thereof only partially; and human Industry must not cease till it is obtained, if a compleat Knowledge of the Powers of Buxton Water be desired.

This History of the Effects of Substances on other Animals in a State of Disease besides Man, for the Use of Physic, has scarcely been thought of; but where attainable, it may be of considerable Use, by the Inferences that may be drawn from it with Respect to the Practice of Medicine, and the Lights derived from it for the general Promotion of Science, and the Investigation of the other Histories.

SECTION

SECTION IV.

PLAN of the present Work.

HAVING presented to the Reader a View of the present State of Knowledge of Buxton Waters, and of the Application of that Knowledge, and also the Foundations on which we conceive the Use of this Substance might be better established, we shall proceed to lay before the Public a small Part of two of the preceding Histories, although imperfectly executed, with the View of contributing to the Attainment of the grand End proposed, the Knowledge of the Powers of Buxton Water in relieving and curing Disorders, namely the

History of the PECULIAR QUALITIES of the ATMOSPHERE of the Peake of Derbyshire; and the

History of the CHYMICAL QUALITIES of the TEPID WATERS of Buxton.

From these Histories we shall make such practical Deductions as appear naturally to arise from them, and which may establish the Application of Buxton Water in Diseases, upon a better Foundation than that on which it now stands.

We hope too, that these Observations may contribute towards the Possession of even more important Knowledge than that of any particular Art—that of the *Causes of Things*; because this empowers

empowers the human Mind to produce with Certainty Numbers of Effects; the Knowledge of Arts, only particular Effects, and these upon some Occasions. This Knowledge of Causes of Things, is what constitutes the Empire of the human Mind over Nature; in Consequence of which, we are enabled to explain natural Phænomena, and to direct at Will, natural Substances to the Uses, Conveniencies, and Delight of common Life. Hence the naturally calamitous Situation of Man, is rendered as safe and happy as is competent to his natural Condition.

In order to investigate the Properties of Buxton Water, necessary or assisting Lights may be borrowed from a Contemplation of the *internal Structure and Contents* of the Region of the Earth from whence it springs. And to assist us in this Enquiry, as well as that into the Properties of the Atmosphere, we shall describe *the external Form and Appearance* of the mountainous Land of Derbyshire.

The Atmosphere of the Peake, and the external and internal Structure of the Earth of this Region being naturally connected, they shall be the Subject of the three subsequent Sections.

D

SECTION

SECTION V.

Of the external Form of the mountainous Land of Derbyshire.

BUXTON is situated on the Western Side of the North Part of the County of Derby, in a Tract of elevated, uneven, and hilly *Moor-Land*, called therefore the *High-Peake*, or the *Peake-Hundred*.

The *Peake* is about fourteen or sixteen Miles broad from the South-west to the North-east Side; its whole Length from the North-west to the South-east may be twenty Miles, and it is supposed to contain one fourth Part of the whole County, or 170,000 Acres.

This Region of high Land is the Southern Extremity of the Ridge or Chain of Mountains and Hills, that extends from the Cheviot Hills in Scotland nearly through the Middle of the Island, and terminates in the North Part of Derbyshire. As this Range of eminent Land runs through the Middle of the North of England, as the Appennine does through Italy, it has been called *the English Appennine* (1).

The

(1) “ The north Part of the County (Derbyshire) rises gently into small Hills which begin here, and like the Appennine in Italy, run through the Middle of England in one continued Ridge, rising higher and higher as far as Scotland,

The British Appennine may be reckoned, for the Sake of forming a general Conception of it, from fifteen to twenty Miles broad. Near Scotland it is much broader, and as the Island to the North of Derbyshire contracts itself considerably in Breadth, this Tract of high Land bears no small Proportion to the Breadth of the North Part of England.

The whole Length of this Ridge of Land appears to be about an hundred and twenty to an hundred and forty Miles.

The Elevation of different Parts of the Anglo-Appennine above the Sea in the German Ocean to the East, and in the Irish Channel to the West, and above the Lands interposed between it and the Seas to the East and West, and also above the Land to the South of the Peake, cannot be stated for want of Geometrical or Barometrical Observations ascertaining this Fact; but a tole-

land, under several Names. For here they are called Moorland, after this *Peake*, then *Blackstone Edge*, anon *Craven*, and last of all *Chewiot*, when they branch out into Horns." *Camden's Britannia*.

"The large Country of the Brigantes runs out narrower and narrower, and is cut in the Middle (as Italy is with the Appennine) by a continued Ridge of Mountains, and these separate the Counties into which it is divided. For under these Mountains to the East and the German Ocean lie Yorkshire and the Bishopric of Durham, and to the West, Lancashire, Westmoreland, and Cumberland." *Camden's Britannia*.

able Judgment may be formed of this Matter from the *Rise, Manner of flowing, and Course of Rivers*; from the *apparent Elevation of Land*; from the *Climate, Soil, State of Vegetation, &c.* (m).

All the Rivers between the North of Derbyshire and Scotland have their Origin in the *English Appennine*, and flow either Eastward to the German Ocean, or Westward to the Irish Sea; but at the Termination of this high Ridge in the North of Derbyshire, they not only run to the East and West, but a pretty considerable River, the *Derwent*, has here its Origin, and passes from the North of Derbyshire directly to the South of the same County (receiving in its Course the *Wye*, and other Rivulets that have their Origin in the most Northern Parts of the County of Derby), where it falls into the Trent. Moreover the *Dove*, and several small Rivers flow from, or nearly from, the North of Derbyshire, and run Southward through or near the County of Derby to join the Trent in the South of Derbyshire.

(m) The Height of some of these Mountains is as follows: *Pendle Hill, Pennygant, and Ingleboro*, have been estimated at 600 to 750 Yards above the Plane of the Vales between them. *Helwellin* and *Skidda* are, according to a Plan of Mr. *Smeaton's*, elevated 1000 Yards above the intermediate Valley. Phil. Trans. Vol. LXV. P. II. p. 498.

Axedge, a large Mountain a few Miles from Buxton, as I am informed, is about 2100 Feet higher than *Derby*, and 1100 Feet above the Vale in which is *Buxton-Hall*.

In Yorkshire there is an apparent Exception to this Direction of the Rivers above-mentioned; for there are several Rivers or Rivulets which rise principally in the Northern Part of this County between the Sea, and the great Ridge of high Land already spoken of, that run directly South, and Southward to join the *Humber*.

The above-related general Source of Rivers and their subsequent Courses, denote the superior Elevation of the Land in the Middle of this Part of England, where they rise, to that of the Countries between it and the Sea; and that this superior Elevation terminates in the North Part of Derbyshire.

The Southern Course of some Waters in Yorkshire above-mentioned will be understood, by observing, that there is a Kind of inferior Ridge of high Land which goes off nearly at right Angles from the great Ridge, and extends over the North of the County of York to *Whitby* and *Scarborough*.

The obvious Ascent or Rising of Land, which is in many Parts considerable and sudden, experienced in travelling into the North Part of Derbyshire from the Southern Parts of the same County, from Yorkshire on the East Side, and from Cheshire on the West, is an *ocular Proof* that the Peake Hundred is considerably more elevated Land than that of the adjoining Countries.

The general external Appearance of this Region, viewed from the Summits of the Hills is,

when the Atmosphere is tolerably transparent, a more or less extensive Prospect of woodless (*n*) or naked Moor-Land that is either hilly, or has an undulatory Appearance resembling the Form of the Waves of the Sea, and is for the most Part without, or with but few, Tokens of Inhabitants.

This Tract of Country is intersected in various Parts by Vales, *Ravines*, and Clefts among Rocks. Among the Vales is especially that extensive, and frequently fertile and beautiful Vale along which the *Derwent* winds its Course. Sometimes the Vallies are deep, broad, and fertile, without Cliffs or any romantic Appearances; at other Times they have Rocks on each Side, of various Magnitudes, Shapes, and Appearances, forming high and stupendous Precipices, some of which are as if cut smooth; others are rough, craggy, angular, and frightfully impendent: Sometimes

(*n*) Not very long ago, this Region was covered with Forest Trees, at which Time it was inhabited by Wolves, Deer, and Goats. The Wood of this Country has been cut down, and consumed principally in smelting the Lead Ore, and used for Fuel.

“ Stags Horns have been found buried deep below the Surface of the Ground, of a considerable Size. The Skeleton of a Man was found at the same Time. The Interment of this Man and a Stag, were supposed to have been occasioned by their falling into a Chasm, or wide Cleft, in very early Times, which was afterwards filled up.”—See Mr. Gale’s Letter, May 19, 1744.

there

there are Rocks of the same Kind on the opposite Sides of a *Ravine*, corresponding in Height and Appearance; so that if they were brought into Contact, they would close the Chasm or Cleft entirely, without the Stratum on one Side of the Chasm closed up being higher than that of the other. At other Times the Rocks on one Side are much higher than those of the other, and the Direction of the Stratum of one Side is different from that of the other.

The Vales and *Ravines* are commonly watered by the Rivers *Wye* and *Derwent*, as well as by several small Rivulets, but in some Parts they are dry; and I believe, they sometimes have the Windings and Angles resembling those formed by Rivers in their Course; at others, they are without any regular Windings or Angles.

The Land upon the Hills is, in general, uninclosed, and produces little else but Heath (*o*), if we except a few cultivated Spots adjoining to the humble Habitations of the Shepherds of the Peake. Large shapeless Ledges or Blocks of

(*o*) The Soil of this Region has a most remarkably antiseptic Quality. We have, apparently, a well authenticated Instance of two human Bodies, buried a Yard deep in moist Soil of Peat-Moss, which were not at all putrified after 28 Years and 9 Months; but which became putrid, as animal Bodies usually do, after they were interred in common Earth, in Hope Church.—See Phil. Transf. No. 434.

Stone lie in many Parts upon the Surface of the Ground, as if casually scattered there, in all imaginable Disorder (*p*).

In the Vales Nature is oftentimes very agreeable to the Eye of the Beholder; for here there are Marks of Fertility of Soil, of Culture, and of Inhabitants. Here is produced Plenty of Grass, and sometimes Grain, but in general the Land is employed for Pasturage, and it is well supplied with Water by the Rivers and Rivulets that pass through it.

“ Non liquidi gregibus Fontes, non Gramina defunt,”

VIRG.

The Vales are adorned by a Variety of Forest Trees and Shrubs, which, being intermixed with

(*p*) “ At the South End of Stanton Moor, close to the Village of Birchover, is a very singular Mass of large Rocks, called *Roultor*, *Rowter*, or *Roo-Tor*; whence Rowter means a moving Rock, since in the provincial Dialect, they will say, a Thing *roos* backward and forward, &c. These Rocks stand on the Top of a Hill, commanding an extensive View over the Moor, and seems to have been a Place much frequented by the Druids.

By the Number of druidical Remains on Stanton Moor, we may reasonably suppose this Place to have been inhabited by the Druids. Here are Temples, Caves, Rock Basins, rocking Stones, gorsed daus, Rock Idols, and Cairns. Their sacred Groves have long since given Way to Cultivation; but their more durable Monuments have stood the Ravages of Time, and remain as Helps to illustrate their History.”—— Hayman Rooke’s, Esq; Account of some Druidical Remains on Stanton and Huffle Moor, in the Peake, Derbyshire, 1780.

Rocks

Rocks and Precipices, produce many romantically grand and picturesque Scenes.

There are some remarkably large Grottos, or Caverns, which are popularly known, such as that at Castleton, and one near Buxton: And also a Hole, or Chasm, called *Elden-Hole*, of a very great Depth, which leads to a considerable subterraneous Cavern. This Hole has been occasioned by some natural Operation, as a Current of Water (*q*). The whole Anglo-Appenine abounds with Caves, Chasms, and deep Holes, (See *Tour to the Caves*.) Many of the Hills composing this Ridge of Land, appear to contain large Cavities, which have no Apertures by which they communicate with the Surface of the Earth; but which have been accidentally discovered by Miners, in sinking Shafts for the Purpose of finding Ores. Near the Summit of the Hill, on the West Side of the Vale of Matlock Bath, situated nearly West from Matlock new Bath, is a Shaft about twenty-four Yards deep, which was made by some Miners, who were in Pursuit of Lead Ore. This Shaft leads to a subterraneous Cavern called *Cumberland-Mine*. The Extent of this Cavity, from North to South, I imagine, is at least half a Mile. The Passage down the Shaft is, first through several Yards of the first Toad-

(*q*) See a Description of Elden-Hole, Phil. Transf. Vol. LXI. p. 250.

Stone, and through Part of the second Lime-Stone; in this second Lime-Stone is the Cavern I am describing. It is of very various Dimensions in different Parts, being from the Size that is just sufficient to admit a Man to creep through it, to the Height of twenty, and Width of fifteen Yards. Upon the Floor appear scattered large Masses of Lime-Stone; its Sides and Roof are variously fissured; many of the Fissures are filled up with *Carwk*, *rhomboidal Spar*, *pyramidal Spar*, *Kebble*, *Clay*, and *Tuff-Stone*; also sometimes with a small Quantity of *Galena Plumbi*, or common Lead Ore of this Country. It is covered, in many Places, with *calcareous Earth crystalized* into various Shapes, which make a very pleasing Appearance. These Crystals are *Dog-Tooth Spar*, *Stalactites*, small *cubic Crystals*, *white opaque spherical Crystals*, and a most delicate Crystal which, from its Whiteness, the Figure of it, and its resembling exactly Snow, is called *Snow-Fossil*. This last Form of crystalized Lime-Stone, is said to be peculiar to this Cavern; and the Value of this Cavern entirely arises from its furnishing Specimens of this Substance for Cabinets, and *Water-Icicle*, for polishing and making various Trinkets. The Difficulty of descending into this Cavern has, probably, occasioned it to be seldom visited; but as it is capable of affording Entertainment, by the Novelty, Variety, and frequently by the Beauty of its Appearance, it would undoubtedly

be often noticed by inquisitive Travellers, were the Descent into it more easy.

Most of the Springs in this Cavern, I should have said, are petrifying; and were of the Temperature of 49° , when the Air of the Cave was 52° , and the external Air 56° , in the Month of September 1783.

SECTION VI.

Of the internal Structure and Substances of the mountainous Land of Derbyshire.

THE Number of Shafts that have been sunk, and Holes made in the Earth, for the Purpose of procuring Metals, as well as for Fuel, Stone, and Water; and likewise the steep Rocks of the Vales and *Ravines*; and the natural subterraneous Passages or Caves, have afforded an Opportunity of observing, that the external Part of the interior Substance of the Earth, consists of distinct Beds or Strata of different Kinds of Matter, disposed in an orderly Manner, and not of a Heap of Substances thrown irregularly together.

Our Knowledge of the Structure and component Parts of the Earth, in the Moor-Land of Derbyshire, extends to the perpendicular Depth
of

of about two hundred and fifty Yards below the Surface of the Ground, reckoning from the Top of the Mountains; and by Observations and Reasoning we can, with great Probability, infer what is its Structure at present, or what it has been originally, to the Depth of about five hundred Yards.

The principal Beds of which the Earth is composed, are from twenty to one hundred and twenty Yards in Thickness; they are all placed parallel, or nearly so, to each other, but in various Situations with Regard to the Horizon: Sometimes the Set of Beds, to the Depth with which we are acquainted, being placed parallel to, or in a Plane with the Horizon, but commonly inclined to it, forming therewith Angles of twenty-five Degrees or upwards.

The Beds of which the Earth consists, to the Depth with which we are acquainted, are distinguished from each other by the Species of Matter of which they consist, which is of four Kinds, viz. *Grit-Stone*, a Substance readily converted into Glass by Heat and Mixture; *Shale*, an argillaceous Sort of Earth; *Lime-Stone*, or calcareous Earth, a Compound of Gas and Quick-Lime; and *Toad-Stone*, otherwise called *Channel* and *Cat-Dirt*, which, by some, is considered to be *Lava*, like that of Iceland or Vesuvius in its Appearance and in its chymical Qualities, as far as hath been investigated; by others it is called Argillaceous Earth.

Toad-

Toad-Stone is a blackish Substance, very hard, scratches Glass, but does not strike Fire with Steel; has Bladder-Holes like the *Scoria* of Metals or Iceland Lava, or at least of Clay hardened by the Volcano in Iceland; breaks alike in all Directions; and contains within it no animal or vegetable Bodies, or Impressions. Its specific Gravity is nearly that of Vesuvian Lava; and it is so compact in its Bed, as to intercept the passing of Water from its upper Surface to the subjacent Stratum. When fused it gives Glass of the same Kind as melted *Vesuvian Lava*; and melts under the Blow-Pipe, with and without Tartar, to a black Slag. According to the Analysis lately made, it is composed principally of Silicious Earth, with a large Proportion of Clay and Calx of Iron, and a smaller Quantity of calcareous Earth (*r*). It is variable in its Thickness in the

(*r*) Phil. Transf. Vol. LXXII. p. 327. Art. xx.—“An Analysis of two mineral Substances, viz. the Rowley-Rag-Stone and the Toad-Stone, by William Withering, M. D.”

Toad-Stone, when fused, appears to resemble some of the Species of Lava.

Rowley-Rag, when fused, appears to resemble Scotch Basaltes.

One hundred Parts of Toad-Stone contain,

Silicious Earth	—	63 $\frac{5}{10}$
Calci form Iron	—	16
Calcareous Earth	—	7 $\frac{5}{10}$
Earth of Alum	—	14 $\frac{8}{10}$
		<hr/>
		101 $\frac{8}{10}$

“ Nullam

the same Bed; and this Property makes an Exception to the Beds that compose the Earth of the Thickness with which we are acquainted, being all parallel to each other. This Substance is in Thickness from one to six hundred Feet, and even of a greater Thickness than yet cut through; and, considered as a Part of the natural Structure of the Earth in this Region, is sometimes wanting. Fissures in the Stratum subjacent to the Toad-Stone Bed, are often filled up by this Substance. It has no Fissures or Veins, corresponding to those of the incumbent and subjacent Strata.

Acids without Heat, and in their ordinary State, have no Effect upon this Substance.

“Nullam examinavi Argillam quæ non magnam foveat Silicis Quantitatem, plerumque ultra dimidium.”—Bergman. *Sciagraphia Regni Mineralis*, p. 81.

I have lately seen Specimens of Scoria of Lead, Toad-Stone, and either Lava or Clay hardened, from Iceland, which could not be distinguished, by their external Appearance, from each other.

Mr. Ferber (See his *Oryctographie von Derbyshire*) calls Toad-Stone an Argillaceous Stone.

The common People who work in the Mines in Derbyshire, consider Toad-Stone to be Clay in an indurated State.

I have seen, a few Days ago, Specimens of the Stone, composing the Summit of the Rock of the Giant's Causeway, in Ireland, which resembled exactly the Derbyshire Toad-Stone; excepting, that the Bladder-holes of the latter were filled with calcareous Spar, those of the former contained Fluor.

Air

Air soon renders it soft, and converts it into a vegetable Mould, which is said by some to be a Property of Vesuvian Lava and other Slags, as instanced in the Decay and Conversion into Earth of old Heaps of Slags from Iron Furnaces; but others will not admit this Change of Slags and Vesuvian Lava to be founded in Fact.

Beds of Earth are formed of the Matter rejected by Volcanos.—When a Volcano overflows, the Surface of the Earth is overspread with liquid Fire to the Extent of many Miles around the Chimney of the subterraneous Fire; and in cooling, it forms horizontal or inclined Beds, which, in their Position are similar to those formed by Depositions from Water; but they are otherwise very different from those Depositions. 1. They are not of an equal Thickness. 2. They contain Matter that has been evidently calcined, vitrified, or melted. 3. They do not extend to a very considerable Distance (s).

A Stone from Scotland, which some call *Lava*, others *Granite*, is used for paving the Streets of London; and *Lava* from volcanic Hills in Hesse is employed for building Houses, repairing Roads, &c. as I observed a few Years ago at Hesse Cassel.

(s) We are indebted, principally, to Mr. Whitehurst, (See his Enquiry into the original State of the Earth.) And also to the Bishop of Llandaff (See his *Chymical Essays*), for this Account of the Properties of Toad-Stone.

The above-mentioned Strata are disposed upon each other according to a certain Rule or Order; for *Grit-Stone* is always, when present, *incumbent on Shale*; and *Shale*, when present, is *placed upon Lime-Stone*; and *this last Stratum is incumbent on Toad-Stone*, if present.

And, as there are very generally several Beds of Toad-Stone and Lime-Stone, the first Bed of Toad-Stone is superincumbent on a second Bed of Lime-Stone; and this second Stratum of Lime-Stone on a second Bed of Toad-Stone; then is placed under this last Stratum a third Stratum of Lime-Stone; and under this last Bed lies a third Stratum of Toad-Stone, which is incumbent on a fourth Bed of Lime-Stone. Of the fourth Stratum of Lime-Stone we have very little Knowledge, and that only in a few Places; and as it has never been cut through, we are altogether ignorant of the Beds and Substances of which the subjacent Earth is composed.

The Strata of Grit-Stone and Shale are frequently wanting, and oftentimes also the first Bed of Lime-Stone; and, when this happens, I believe likewise the first Toad-Stone Stratum is always missing, and then the second Bed of Lime-Stone becomes the uppermost Stratum.

Interposed between the Lime-Stone and Toad-Stone Strata are smaller Beds from four to six Feet thick: They are of Clay, of a lightish blue Colour, with a Tinge of Green, and contain Pyrites and Spar in Nodules.

The

The Springs flowing from these Clays, have been found to be warm, according to the Observation of the late Mr. George Tiffington of Winster. I was told, that a few Years ago, at Matlock, in digging for the Purpose of laying the Foundation of some Building, the Workmen came to this Kind of blue Clay, between the second Lime-Stone and second Toad-Stone; and from this blue Clay, warm Springs flowed. It is said, that all the warm Springs arise from the blue Clay between the second Lime-Stone and second Toad-Stone; for that all the Springs flowing from between the first Lime-Stone and first Toad-Stone are cold.

There is one Instance of this Clay being burnt one Foot thick, by the accidental Inflammation of a Bed of Pit-coal.

The above described Strata, it is thought, were the original and naturally constituent Parts of the *Crust of the Earth* in this Part of Derbyshire; but some of them have been, by some Means or other, removed.

Besides these original Strata, there are some Beds which are looked upon as not essential to the natural Constitution of the Earth, and are therefore called *accidental ones*. These are principally Beds of Clay in various States of Induration, and of inflammable Matter, disposed alternately upon each other; both which are incumbent always on Grit-Stone, Shale, Lime-Stone,

&c. They are called Beds of *Argillaceous Stone* or *Clay Beds*, and *Coal*.

These *Argillaceous Beds* contain a Variety of *vegetable* Impressions, but *no animal Remains* whatever; and Iron-Stone, with such a Quantity of Calx of this Metal, as to be named Iron Ore. I lately, however, saw the Impression of Cockles most distinctly, in a Piece of Coal found near Wakefield.

These Beds of Argillaceous Matter, and Coal, principally exist in the lower *Moor-Lands*, and more *Southern* Part of Derbyshire.

There are also, incumbent upon the above Strata, in various Parts of the Country, in the Vales especially, and also in the High-Lands, *Beds of Sand and Gravel*, which are rounded Grit or Lime-Stone, according to the Stratum on which they are incumbent; and have the same Appearance as Stones deposited by Rivers or the Sea, and rounded by Attrition; like those upon the Sea-Shores, or composing the Beds of Rivers. Moreover, we frequently meet with other Substances, forming the *highest Beds*, or Parts of Beds, incumbent on the large and general Strata; such as *Marle*, *Creta fusca*, or *Rotten-Stone*, &c. In the Beds of *Marle*, which are sometimes deep, we find great Quantities of *vitriolic Selenites*, known better by the Name of *Gyps*, *Plaster*, or *Alabaster*; but these
Substances

Substances are only found in the Southern Part of Derbyshire.

The Beds of stony Matter, formed by the Deposition of calcareous Earth upon animal, vegetable, and fossil Substances, called *Petrifications*, are found, especially at Matlock; being the Productions of the tepid Springs of that Place (*t*), and other petrifying Waters.

Tuff-Stone is not, I believe, a separate Bed; or, if a distinct Bed, it is contained in the general Strata of the Peake. It is calcareous Earth in a soft State, and of a porous Texture.

It must not be conceived, that the above *vitreſcible* or *ſcilicious Earth*, called *Grit-Stone*, *argillaceous Earth* or *Shale*, and *calcareous Earth*, are all uniformly of the ſame Appearance, as to Colour, Texture, &c. or unmixed with other Substances.

The *Toad-Stone* Stratum, is a tolerably uniform Substance, and does not contain any different Maſſes of Matter, that I know of, excepting ſome inconfiderable Cavities that are filled up with calcareous Earth, which is there cryſtalized. Theſe Cavities, or ſmall Holes, thus filled up, are called, when empty, *Bladder-Holes*, and give it a ſpeckled Appearance. By Expoſure to the Weather, I am told, the Bladder-Holes filled

(*t*) See a particular Deſcription of the petrified Stratum, formed by the tepid Waters of Matlock, by Dr. Dobſon, Phil. Tranſ. Vol. LXIV. Part I. p. 124. and many Years before this laſt Paper, Phil. Tranſ. No. 456.

with Spar, are frequently robbed of this Substance, and left empty, in which State they are frequently found.

The *Sand-Stone* Strata are also tolerably uniform, and contains only quartz Pebbles; which are, I believe, sometimes in Fissures that are filled up with them, variegate them, and seem to have the same Relation to the Strata of Sand-Stone, that Spar has to Lime-Stone.

Shale, called also *Sbiver*, an argillaceous Earth, contains *Iron-Stone* in Nodules, and sometimes, according to Mr. Whitehurst, stratified. Many Springs issuing from this Stratum contain Iron; as that of the Bridge at Buxton, another at Quarndon, one beyond Matlock Bridge, towards Chatsworth, and also one at Heage, which contains a very great Quantity of vitriol of Iron. In this Stratum the Miners frequently meet with the *Fire-Damp*, or *Oil of Metals* (*u*); also with a Substance of the Consistence of *Molasses*, which is highly inflammable.

I am not certain, whether this Stratum does not contain so much inflammable Matter as to burn,

(*u*) It is necessary to observe, that we shall employ the Term *Oil of Metals*, to express that permanent Vapor, which has been commonly called *inflammable Air*, and *inflammable Gas*; because neither of these Names could be admitted, consistently with the Phraseology adopted in this Work. Our Authority for the Use of this Term, is that of *Stahl* and Dr. *Fordyce*.

burn, when once heated sufficiently by other Substances; as happens with the aluminous Shale near Whitby; and there is a great Resemblance between the common Stone-Coal and many Sorts of Shale. The Earth of Pit-Coal is also believed to be argillaceous.

The *Strata* of *calcareous Matter* are composed of *Laminæ*, more or less separated by Shale, or Shiver, of the same Kind as the Stratum of that Substance incumbent on Lime-Stone. In many Parts, the calcareous Earth contains much phlogistic Matter, as appears from the fœtid Smell emitted on rubbing many Pieces of Lime-Stone, and which is then called *Stink-Stone*, or *Swine-Stone*. Within this Stratum are contained numerous Masses of *figured Stones*, which are evidently of *marine Origin*; some have the entire Shape of Sea Animals, others have only their Impressions. This Stratum has been, in many Parts, evidently fractured. Hence Chasins have been formed, that are now filled up with Fragments of Stone; of which there is a remarkable Instance in the

“ A Metal in its metallic Form, is a Compound of a pure Calx, and a Substance which has been called inflammable Air; but which is an Oil, found out by Stahl, to exist in Metals, and which we would call *Oil of Metals*.”—Phil. Trans.—Dr. Fordyce’s Method of assaying Copper Ores.

Mr. *Scheele*, also, calls inflammable Air, a *subtle Oil*.—*Treatise on Fire*, p. 158.

Vale at Matlock, where the Chasm is filled with what is called *Rubble*.

Smaller *Cracks* and *Cavities* have been also made in this Stratum, which are filled up, and commonly called *Veins*; in Derbyshire, *Pipes* and *Rakes*, according to their Directions.

These *Pipes* and *Rakes* contain various *Metals*, *inflammable Substances*, and *Earths*.

Some of these *Veins* contain a *flinty Substance* only, called *Chort*, or *Chert*, which has been denominated organic silicious Earth, because it has the Impressions of various Species of *Helmintholithi*, especially of *Entrochi*.

Other *Veins*, from one to seven Yards thick, contain *calcareous Earth*, variously crystallized; viz. Spar, of a rhomboidal, cubical, prismatical, and other Figures: Likewise the following Substances are found in, or upon these Strata.

Gypseous Spar, a Compound of vitriolic Acid and Quick-Lime.

Cubic Spar, or *Fluor Spatofus*, a Compound of Quick-Lime and Acid of Spar.

Amethystine, *Violet Spar*, or *Derbyshire Spar*, popularly known by the Name of *Blue John*, of which ornamental Vases, Columns, Pyramids, &c. are formed, whose chymical Properties have not been enquired into, is only found in the Soil, in Nodules, upon the second Lime-Stone at Castleton. This spar is phosphoric.

A Substance named *Cauk*, or *Calk*, called *Gypseous*, but improperly; for it is of late, I am told,

told, found to be composed of *ponderous Earth* and *vitriolic Acid*. It is well known not to be fusible, or not without a very great Heat.

Cawk, *Chert*, and *Dog-Tooth Spar*, have been noticed by the oldest Writers of the Natural History of Derbyshire. See *Woodward's Method of Fossils*, and *Phil. Tr. Abr.* Vol. VI. p. 291.

Kebble is different from, although frequently confounded with, *Cawk*; for I am told it melts without any considerable Heat.

Quartz Crystals in single and double Parymids,

We find, a few Miles from Buxton, in loose Masses, a little below the Surface of the Earth, some small *Quartz Crystals*, vulgarly called *Buxton-Diamonds*; which are nothing more than *Quartz* coloured red by Iron (x).

Stalactites, or *Drop-Stone*, which is formed by a Deposition from petrifying Waters in Caverns, and crystallized. It is much employed for making ornamental Vases, &c.

The Properties of many of the Spars are not understood.

But, the principal End for which Men descend into the interior Parts of the Earth in Derbyshire, is to procure *Ores of Lead* that are here contained especially in calcareous Spar and Fluor, sometimes in Cawk. The Lead is combined, or mineralized, as it is termed, with Sulphur and Regulus of Arsenic. It is also mixed or united with other

(x) "Color omnis à Ferro."—Dr. Fordyce and Bergman.

Substances, as with a small Proportion of *Silver*; and, perhaps, with *Antimony*, but this is uncertain. No Specimens of native Lead have been found in the Moor-Land of Derbyshire. These Ores are variously crystallized, and are of various Forms, when they are called *Steel-Grain-Ore*, *Bleyschweiff* of the Germans; *Galena Plumbi*, *Bley-Grantz* of the Germans; and a particular Ore named *Slickensides*, which has the Property of exploding, upon being scratched with a hard and sharp-pointed Instrument, as it lies in the Vein. And there is also, I believe, *Lead Spar*, *Bley Spath*, which is Calx of Lead indurated, and crystallized.

Another Ore is likewise procured in the interior Part of the Earth of this Country in considerable Quantity, that is, Ore of *Zinc*; which is contained there in the State of a Calx, and known by the Name of *Calamine* and *Lapis Calaminaris*, *Gallmey* of the Germans; also *Zinc* mineralized with Sulphur, when it is denominated *Blende*, *Mock Lead*, *Pseudo-Galena*; which, when mixed with a small Porportion of Iron, is named *Black Jack*.

Iron mineralized with Sulphur, called *Iron Pyrites*, is here found in Abundance; and sometimes also *Copper-Liver-Ore*, which, from exhibiting small Stars, is called *Starry Malachites*; and that I believe is a Compound of Copper, Sulphur, and a small Portion of Iron.

Antimony has been said by ancient Writers to be found in the Mines of Derbyshire; but I apprehend

prehend it was mistaken for *Steel-grained Lead-Ore*.

It is not known, that any other Metals or Semi-Metals are contained in the Strata of Derbyshire; *Cobalt* has been mentioned; but not upon such Evidence as I could depend on.

The cold Springs in the calcareous Strata are many of them petrifying Waters; and those near Buxton and Matlock are of the Temperature of about 48° to 50° of Fahrenheit's Thermometer. One of the Springs in this Region ebbs and flows. In other Parts of the Tract of high Land called the English Appennine, are more Instances of Springs of this Kind.

The preceding Account of the Structure and Contents of the internal State of the Earth of Derbyshire, has been chiefly collected from Mr. *Whitehurst's Enquiry into the original State of the Earth*, to which excellent Work I refer the Reader for further Information; and also from *Ferber's Versuch einer Oryctographie von Derbyshire*; which, however, contains nothing relating to subterraneous Geography but what was liberally communicated by Mr. Whitehurst previously to the Publication of his *Enquiry*, and to whom Mr. *Ferber* acknowledges his Obligations.

We shall conclude the two foregoing Sections with a few Inferences and Observations.

Those

Those Persons who are accustomed to reason concerning the original Formation and Composition of the exterior Part or Crust of the Earth, and concerning the Changes it is liable to undergo by subsequent natural Operations, from their Knowledge of the Natural History of the Earth, and of the Effects of Nature, will, I apprehend, after reading the preceding Description of the external Appearance, and internal Structure of the Earth in the Northern Part of Derbyshire, allow the following Inferences to have been fairly drawn.

1. That the principal Part of the Substance which composes the Earth in this Region, has been formed by Matter deposited from the Sea; for the Lime-Stone Beds that are supposed, with the greatest Degree of Probability, to be of marine Origin, constitute by far the greatest Portion of the Earth, of the Thickness with which we are acquainted.

2. That the Anglo-Appennine appeared first as a Ridge of Land above the Sea, while the other Parts of England were under Water; because, it is presumed, that this Region is the most elevated Land in England.

3. That many of the present Vales and Ravines with their Rocks and Cliffs, as well as the Holes and Caverns, have been formed by Torrents of Water, while the Sea was retiring, or the
antient

antient Rivers contracting, and the dry Land was increasing (y).

4. That subsequently to the Formation of the British Appennine, Beds of Lava were produced between the Strata formed by Depositions from Water, either by the Inflammation and Fusion of inflammable Strata originally existing in the present Situation of the Toad-Stone Beds; or by liquid subterraneous Fires raised from Depths lower than the Parts in which they are now situated, and insinuated and cooled between the Beds of Lime-Stone, leaving Beds of a Slag or Scoria, known by the Term of Toad-Stone; the Properties of which Substance, so far as hitherto known, we have above related (z).

The Strata of Lime-Stone incumbent on, or subjacent to, the Beds of combustible Matter in a State of Fusion, would be partially at least decomposed, or converted into Quick-Lime; but as the Gas detached by the Heat of the melted

(y) ————— “ Vidi factas ex æquore Terras;
 “ Et procul à Pelago conchæ jacuere Marinæ,
 “ Et vetus inventa est in Montibus Anchora summis;
 “ Quodque fuit Campus, Vallem decursus Aquarum
 “ Fecit.”

OVID METAM. Lib. xv. Fab. 4.

(z) The first of these Opinions was suggested to me by a learned and ingenious Gentleman, to whom Philosophy is under great Obligations for his Researches, whose Name I am not at Liberty to mention. The latter Opinion is well known to be that of Mr. Whitehurst.

Earths

Earths would be contained in the Fissures and Cavities of the Earth communicating with the decomposed Lime-Stone, from the strong Attraction between Quick-Lime and Gas, the Lime-Stone Strata decomposed would soon be restored to their original State of calcareous Earth; but by the Action of Fire would probably have the Figures of the Sea Animals of which they were formed wholly destroyed. One might also expect, that the Beds of Clay interposed between the Strata would be changed into Brick by the subterraneous Fires; and in this State they have been in some Places actually found; but as the Instances of this Change are few, it is probable, that some Causes, operating for several hundred thousand Years, have totally altered the Form, and changed the Properties of the Clay so burnt; or, that the Beds of that Substance have been produced by Causes acting subsequently to the Formation of the Strata of Lava.

5. That the most considerable and evident Alterations in the external Form and Position of the Strata of the Peake, with which we are acquainted, have arisen from Fractures of the Beds of Earth, in many Parts of the Country. In Consequence of these, the horizontal or original Situation of the Strata is changed to that of being variously inclined to the Plane of the Horizon. In some Parts, one End of the fractured Stratum is elevated much above the other

End, and forms, perhaps, a Vale with stupendously abrupt Precipices on the one Side, and on the other inclining much below the Level of the opposite Side. Sometimes merely the fractured Ends are separated, and form a Chasm; at other Times the fractured Ends are concealed, by the Openings being filled up with Fragments of broken Strata, and covered with Soil: In some Instances, there is Reason to believe, the Strata have been burst and opened, so as to entomb a great Part of the superior Beds, previously shivered into Millions of Pieces, which are now in a great Measure missing; and from the inclined Position of the Strata, instead of finding the uppermost of one Kind, which must have been primitively the Case from their horizontal Direction, we find it consists of all the various Strata we know. Whether throughout the whole Country, there existed *originally* the whole Set of Strata above described, of which, in particular Tracts, the uppermost are now missing, (either because they have been swallowed up by subsequent Openings of the Earth, or because they were originally wanting in those Parts) is not clearly determined by any Monuments of Nature. We have no human Records of the preceding Events of Nature, nor could we have any from the Date at which they happened; but yet we conclude with Certainty, that they have occurred,

1. From

1. From the Order of Nature, observed with Regard to the Structure of the Crust of the Earth, which is composed principally of Strata, disposed horizontally (*a*).

2. From comparing the Appearances of these Strata, with those of other Countries in which we know they have been effected by the efficient Cause assigned. Here we deduce the efficient Cause from the Effects with the same Confidence that we do so in many Instances in common Life, where we have no Evidence excepting Effects: But these Causes and Effects being more familiar, are not questioned. Should I be acquainted with any Structure of human Workmanship, for Instance, that of a Grecian Temple, and should I, thus informed, find the several Parts that composed that Structure detached from each other by being variously fractured, as the Columns in one Place, the Arch in another, and so on, I should not conclude this was the original artificial State of these Parts; but that they are the several Pieces which once were joined in a certain Order, and formed that Structure called a Grecian Temple, although I have no other Evidence of this being the Fact, but that of my previous Knowledge of the Composition of this Piece of Architecture.

(*a*) “ Par tout où il n’y à pas eu de Bouleversment on trouve les Couches horizontales.” — Buffon.

The same Conclusion is made, on other Occasions, concerning efficient Causes, which we only deduce from the Ruins of Art, or Remains and Effects of Nature.

As an Example of ruptured Strata, and of the immediate Effects, and subsequent Changes in the external Form and Appearance of the Earth, which have gradually succeeded, we shall give a short Description of one of the most remarkable, and best known Fractures of any, in the hilly Part of Derbyshire, viz. The Vale, or more properly Ravine, in which is Matlock Bath.

This *Ravine* is more than two Miles in Length, bounded on each Side by Rocks, some of which are awful and majestic Precipices, now partly concealed, in many Places, by Trees and Shrubs, that grow upon their Sides; and the River Derwent, of a respectable Magnitude, runs through the Middle of it. A Fracture of the Earth, to a considerable Depth below the Surface thereof, appears to have been the Occasion of this romantic Scene. For at Matlock Bath, on the East Side of the Vale, there is a Cliff, or steep Precipice, about one hundred and twenty Yards in perpendicular Height above the River, wherein are exposed to View the whole Thickness of the first Bed of Lime-Stone, the first Stratum of Toad-Stone, and the second Stratum of Lime-Stone. A Stratum of Grit-Stone and another of Shale, one hundred and twenty Yards each, are incumbent on these

these Strata, yet they do not appear or make a Part of this Precipice, but are thereto wanting; as if they had originally appeared as the uppermost Part of the Cliff, but at a short Distance from it had been cut down to the first Lime-Stone, and the whole Portion of Stratum of Grit-Stone and Shale between this Section and the Precipice had been afterwards removed.

At the Foot of this Precipice, composed of the above Strata, is interposed the River Derwent, and a Dyke or vast Gulph filled up with Fragments or broken Pieces of the superior Strata, between the inferior or rest of the Strata, viz. the second Toad-Stone, the third Lime-Stone, the third Toad-Stone, and fourth Lime-Stone, and the Strata of the opposite Side of the Vale.

These Strata on the East Side are rather elevated, so as to form a small Angle with the Plane of the Horizon.

On the West Side of this Vale, the Strata of Grit-Stone and Shale are entirely wanting, as well as a great Part of the first Lime-Stone; and the Set of Strata which correspond in Quality and Thickness with those on the opposite Side, are not only separated or detached from them by the Dyke filled with Fragments under the River, but by their being much depressed towards the Part where the Rupture happened, beneath the Level of the corresponding Strata on the opposite Side, and so as to form a greater Angle with the Plane
of

of the Horizon. For if the Space between the broken Ends of the fractured Strata were filled up, by making them touch each other, the first Lime-Stone and first Toad-Stone on the West Side, would join the second Toad-Stone on the opposite Side, and the second Lime-Stone of the West Side would join the third Lime-Stone of the East Side, and so on of the inferior Beds. The Depression of the Strata on the West Side is so great at the River, that they are there one hundred Yards below the Foot of Matlock-high-Torr; and form, by their Elevation above the Plane of the Horizon, so great an Angle, as that the Strata which compose the Top of Masson Mountain, are elevated two hundred Yards, or one hundred Fathoms above the Summit of Matlock-high-Torr.

The Gulph, or Dyke, now filled up with Fragments of Stone, is supposed to be the Part where the Earth opened during the Convulsion or Earthquake, that rent asunder the whole Set of Strata, and swallowed up the two superior Strata, and Part of the third Stratum, now missing on the West Side of the Vale.

Here then, must have been the Theatre of an inconceivably grand and tremendous Operation, that burst immense Beds of compact and stony Matter; shivered into Millions of Fragments two of the uppermost Strata, of the Thickness of two

F hundred

hundred and forty Yards; opened the Earth, and formed a Gulph, that swallowed up the shivered Beds, and whatever else was at that Time upon the Surface; perhaps, a large Town or City, together with many Thousands of the ancient Inhabitants of the Island, and left the Strata in their present deranged State.

The Progress of Nature, during an immense Space of Time, amidst the Ruins of Nature, produced by this destructive Convulsion of the Earth, and upon the Sepulchre, perhaps, of many Thousands of our own Species, hath created Scenes that delight by their romantic and picturesque Grandeur;—such natural Compositions as would be deemed worthy of Representation on the Canvas of *Lorrain*. In like Manner, doth the casual Operation of Nature, amongst the Ruins of ancient Edifices, frequently produce the most agreeable and affecting Pieces of Scenery; and which are selected as Examples of Compositions of Nature, that are capable of affording the highest Enjoyment to Men of Taste, by their Beauty, or venerable Grandeur.

Another Effect of the bursting of the Strata is, the Appearance of the large Blocks or Ledges of Stone that are scattered upon the Surface of the Ground; for which we can assign no other Reason, but the Fracture of the Strata by subterraneous Blasts.

6. As the Heat of the Springs issuing from the blue Clays, exceeds considerably that of ordinary Springs, and of the Earth in general, we conclude, that there still exist either subterraneous Fires, or that the Heat of those Fires which occasioned the Derangement and Fracture of the external Substance of the Earth, is not yet extinguished.

SECTION VII.

Of the Properties of the Atmosphere of the Peake of Derbyshire.

THE Difference observed in the Atmosphere of different Regions, arises from

1. Their Weight.
2. Their Temperature.
3. The Kind, and Quantity of Substances *combined* with the respirable Air of the Atmosphere.
4. The Kind and Quantity of Substances contained therein, in a State of *Diffusion* and *Mixture*.
5. The Quantity, Frequency, and Form of Water, passing through them to the Surface of the Earth.
6. Their Motion.

C H A P. I.

Of the Pressure of the Atmosphere in the Peake of Derbyshire.

THE Column of Atmosphere incumbent on the British Appennine, is shorter than that of any other Part of England, because the Land is more elevated above the Level of the Sea, or is farther removed from the Center of the Earth than any other Region of England; and therefore, the human System sustains a less Weight of Atmosphere in this Tract of Country, than in other Parts of the Island less elevated.

As the Atmosphere has never been weighed at different Times and Seasons, by Means of the Barometer, or statically, we cannot state the usual Variations of Gravity in the Course of a Year or any given Time, the Duration of particular Degrees of Pressure, and the Order in which these Variations have been observed to succeed each other; nor, consequently, the precise Difference of Pressure between this Atmosphere, and that of other Regions.

However, from our Experience of greater Differences of Pressure of the Atmosphere than exist between that incumbent on the high Land of Derbyshire, and that of any other Regions of the whole island, we are not disposed to infer, that any Effects, or any considerable Effects, happen
in

in the human Frame, *in a State of Health*, by even a sudden Transition from any of these Regions to that of the Peake of Derbyshire; but from our Experience of the Effects of lesser Differences of vertical Pressure than that subsisting between the Atmosphere of the Peake-Hundred, and the less elevated Regions of the Island, we conclude, that a sudden Transition from many of the latter into the former, *in a State of Disease*, may induce considerable Changes.

Here, therefore, is a Principle for directing the Application, and explaining the Effects of this Atmosphere in Cases of Disease.

C H A P. II.

Of the Temperature of the Atmosphere of the Peake.

NATURAL History does not furnish us with an Account of the Heat of this Climate, of its Variations, of the Succession and Duration of various Degrees by the best Means of ascertaining Degrees of Heat, the Dimensions of Fluids, or thermometrical Observations; we therefore judge of the Temperature, by the Effects of this Atmosphere on *the State of Vegetation*, the *State of Water as to Solidity and Fluidity*, and on *the Sensations*.—From these we learn,

That there is here considerably less Heat in the Course of a whole Year, certainly one fourth less

Heat than in the less eminent Parts of England. The highest Degree of Heat does not, perhaps, exceed that of the less mountainous Countries of the Island; but, perhaps, the Cold is of greater Degrees than in less elevated Parts. The Duration of the lesser Degrees of Heat, too, is longer, and the Transition or Changes of the Degrees of Heat succeed in a different Order from those of other Regions adjacent. The Degrees of Heat too, are very different from each other at the same Time, in this Tract of high Land.

For it is well known, that the Winters here, as well as upon the rest of the English Appennine, are far more rigorous, and longer than that of the Lands adjacent, excepting a few Places in the Vales. The Ground is covered with Snow in greater Quantity, and much longer; and the Frosts continue much longer than in other Parts of England.

According to my Information, there is no Spring Season in this County on Account of the Length of the Winter.

In a News-Paper for May 13, 1783, there is this Paragraph: "It appears from several People, who have come from the high Peake of Derbyshire, and South-west Parts of Yorkshire, that there is a great deal of Snow in those Parts. It lay half a Foot thick in several Parts." It was at this Time mild, fine, and very warm Weather about Doncaster, and there had been there no
Rain

Rain for more than two Months. Dec. 27, 1731, says Dr. Short, "there was a strong North Wind at Buxton, and a clear Frost, which in seven Hours Time bore Horse and Rider, though it rained and snowed the Night before till two o'Clock in the Morning." Nat. Exp. History, p. 46.

It is not till the Month of June, or Middle of this Month, I am told, that there are any Signs of Summer, or rather of warm Weather.

The Summer continues, commonly, till the Middle, or latter End of September; and during this Season the Warmth is alternated frequently by cold or very cool Blasts in the Day-Time for an Hour or two; and in the Night-Time it is, I believe, cooler than in the less hilly Countries. But, in some of the Vales, or Situations particularly favourable for the Action of the Sun's Rays upon the Sides of Hills, there is a more uniform and greater Heat than upon the Summits, and Places not sheltered by Hills; so that, at the same Time, it frequently happens, that it is warm and agreeable in the former Situation, and cold, or disagreeably cool, in the latter.

Vegetation, excepting a few cultivated Spots, or in some Vales and Situations favourably exposed to the Beams of the Sun, does not manifest any Signs of Progress, or but a very slow Progress, till about the Month of June; and during the Summer, it is not more rapid, or not so rapid, as in less mountainous Countries in the

same Latitude, or even in more northern Latitudes. So that, commonly many Vegetables produced in Gardens, do not grow, or do not thrive well, or not till late in the Summer; and, there are very few, or no Fruits that are well matured.

The high Land, cultivated for Hay, produces but slender Crops, and is reaped the Beginning or Middle of September. The Hay-Harvest in the Vales is earlier. The Corn that is grown in a few Spots only, is almost entirely Oats, and some Barley, which are reaped in October or November. There is not then Heat to a sufficient Degree, or of sufficient Duration, for the Vegetation of Plants that require but moderate and long continued Heat; as *Grasses* for Fodder, and for Grain. *Ceres* and *Pomona* therefore, do not preside in this Region:—It is the Seat of *Hygeia*.

Many Forest-Trees flourish here (*b*), and afford a most agreeable Screen against the piercing cold Northern Blasts, when placed near the Habitations of the Moorland Shepherds.

This Account of the Temperature of the Atmosphere, is perfectly like that of other mountainous Countries, and the Explanation is easy of the Occasions of its peculiar Qualities.

There is a less Quantity of Heat produced in the Course of a whole Year, or indeed in any

(*b*) “*Amat Colles Pinifer Appenninus.*”——*Sil. Ital.*

given Portion of Time, in this Region of Derbyshire, because the Air is here less dense than in most other Parts of England; whence the Rays of the Sun acting upon it being less refracted, produce less Heat: And there are no *local* Causes of Heat, to balance the Difference of the Degrees between this and less eminent Regions of Land, arising from this general efficient Cause, the Action of the Rays of the Sun upon the Air of the Atmosphere.

Add to this general and principal efficient Cause, the greater Distance from the Seas than the Countries interposed between the Anglo-Appennine and the Irish Sea on the one Side, and the German Ocean on the other; in Consequence of which, the Heat communicated from the Sea to the Atmosphere in Winter, is too much diffused before it reaches the Middle of the Island, to make any considerable Addition to the Heat of the Atmosphere occasioned by other Means. During the Summer Season, the Atmosphere is rendered colder by the incumbent or adjoining Air imparting Heat to the Sea. This therefore is a Circumstance that occasions more Heat, all other Circumstances being equal, in the Middle Parts of the Island, than in those nearer the Sea; but this Circumstance alone, is by no Means sufficient to render the Temperature of this Region equal to that of less eminent Countries.

As

As there is a greater Degree of Cold in this Region in Winter, the Earth is cooled to a much greater Degree than in less elevated Countries, and consequently requires a longer Time to be brought to the same Temperature, by the same Causes, than such Countries. Here then is another Reason for the greater Length of the Winter Season in the Peake, and one Occasion of there being no Spring in this Region.

In the Vales, however, the Air being denser, more Rays collected, and those Rays being liable to be reverberated from one Side of the Mountains or Hills to the opposite Sides; the solar Rays too, acting against those dense and opaque Bodies, the Rocks and Cliffs of the Ravines and Vallies; considerably more Heat is there produced, than by the Sun's Beams acting upon the less dense Air on the Summits of the Hills, and in less Number by falling upon less uneven Ground. The warm Air of the Vales carried by the Winds, and diffused through the cooler Air on the hilly Land, and likewise the reflected Heat from the Clouds or foggy Atmosphere in Summer, occasion the Atmosphere of the Peake to be considerably more heated than it would be by the mere Action of the Rays of the Sun upon the Surface of the Ground, and the incumbent Air near the Earth. This Diffusion of the warmed Air of the Vales through the cool Air of the Hills, affords an Explanation of the frequent Alternation
of

of Warmth and Cold in the Course of a single Day, during the Summer Months. We can also now well understand the other Effects of the Atmosphere on *Vegetation, Water, and the Sensations.*

Among the occasional Causes of greater Cold in the Peake, may be reckoned its natural Situation, as the Termination of the Ridge of high Land that communicates with Scotland. In Consequence of this Circumstance, Air blown from the North, must always be considerably cooler than if the Peake were a Tract of elevated Land connected with less eminent Countries to the Northward.

The practical Conclusions that may be drawn from this Description of the Temperature of the Peake are,

1. That, during the Summer Months, which is the Part of the Year that Buxton is most resorted to, Alterations are liable to be effected in the Habits of diseased Persons, if not by the Difference of Heat to which they are exposed from that of the Countries from which they have come, at least by the frequently alternate States of Heat and Cold of the Atmosphere.

2. That, during the other Parts of the Year, Changes may be produced in States of Disease by the greater Degree of Cold of the Peake, than that of most other Regions, during the same Season.

On the Contemplation of the Effects produced by these two Agents, must the Physician ground

his Application of the Temperature of the Atmosphere of the Moor-Land of Derbyshire.

C H A P. III.

Of the Kind, and Quantity of Substances COMBINED with the Air of the Atmosphere.

WE are only certain of two Things that *combine* with the Air of the Atmosphere, viz. *Water* and *Phlogiston* (c); but it is liable to contain a very great Variety of other Substances *suspended* in, or *diffused* through it.

Water is found universally combined with Air; and as we have not been able entirely to deprive any given Mass of Air, of Water, so we do not know the Properties of Air but when Water is a Part of its Constitution. So large a Portion of the Weight of any given Mass of Air, arises from the Water it contains; and, as we discover more effectual Means of decomposing the Compound of Air and Water, the more Water we are able to detach from it; it has been supposed, that Air was nothing but Water modified in a Manner not understood.

It has been lately asserted, that the Atmosphere contained Water sufficient to account for the *Sin-*

(c) *Gas* is also said, by a celebrated *Chemist*, to *combine* with Air, but I am not acquainted with the Proofs of this Assertion. See *Bergman's* Table of Elective Attractions.

Flood, were it all precipitated. This Explanation is not sufficient to account for that Phænomenon; because, let us suppose the whole Atmosphere, instead of a Part only, to be Water in a State of Vapour, of the same Density as the atmospheric Air, the Atmosphere would then balance or be of the same Weight as a Column of fluid Water of about thirty-five Feet in Altitude, or of a perpendicular Column of Quicksilver of about thirty Inches: Change the Atmosphere of Water in a State of Vapour to a State of Fluidity, and the whole Earth will be covered by Water thirty-five Feet in Depth; but this would not be sufficient to deluge the whole Earth, for this Quantity of Water would be contained in a few only of the Cavities and Vales, upon the Surface of the Earth. Such Cavities and Vales most certainly existed before the Deluge, as appears from Scripture; by which we are instructed that the Ark rested upon Mount Ararat; and as may be demonstrated by our Knowledge of the present State of the interior Structure, and external Form of the Earth.

The Quantity of Water that may be *combined* with Air, is in Proportion to the Density and Heat of the Air. It combines in a certain Proportion; after which, Water may be *diffused* through, and *suspended* in, the Compound of Air so saturated with Water; and, from the frequent, and even daily Precipitations of Water, during the Summer Season in the Peake, it is pretty cer-

tain the Air of the Atmosphere must be there constantly saturated with Water: But this Fact has never been of any Application in Practice.

Phlogiston, or the *Principle of Inflammability*, combines with Air, and forms a Substance that, like Air, is a *permanent Vapour*; but in other Properties these two Substances are totally different from each other. Air combined with Phlogiston has been called, perhaps improperly, *phlogisticated Air*.

The Atmosphere, in every Part of the World, contains a larger or smaller Portion of phlogisticated Air; for it is not only found in the Atmosphere near the Surface of the Earth, and in the Air of large Towns, but at the greatest Heights; as upon the Tops of the highest Mountains, and at immense Distances from Towns, or in uninhabited Countries. The compound of Phlogiston and Air, or Air united with Phlogiston, is readily diffused through the Atmosphere; its specific Gravity is very nearly the same as Air, under equal Circumstances of Heat and Pressure.

Animals are suffocated when *the Compound of Air and Phlogiston* is applied to their Lungs instead of Air; and, when included in Receivers of Air containing a certain, but large Portion of this Species of permanent Vapor, namely, Air saturated with Phlogiston, they will live just as long, as I have found by repeated Experiments, as if included in the Portion of Air alone, without the Addition of Air combined with Phlogiston.

giston. From general, but by no Means accurate Observations, it would appear, that the smaller the Portion of *the Compound of Air and Phlogiston* is contained in the Atmosphere of any Region, the more favourable is that Atmosphere to the Duration of human Life, the Continuance of Health, and the Restoration of lost Health. Yet I could relate Observations, demonstrating the Restoration of Health in some Diseases, to be as speedy and compleat in Air containing a large Portion of phlogisticated Air as in purer Air.

The Quantity of *the Compound of Air and Phlogiston* in the Atmosphere of any Region, we should suppose, might be judged of by the Processes in that Region which separate Phlogiston, or which are supposed to separate Phlogiston, or render the Atmosphere impure; and by the Means there subsisting of purifying it. The principal Process that detaches Phlogiston is *Inflammation*. The *putrefactive Fermentation*, and the *Respiration of Animals*, also alter Air, as is supposed, by separating Phlogiston, in the same Manner as it is altered by Inflammation; but the Identity of the Air altered by Respiration or Putrefaction, and Inflammation, has not been proved.

Putrefaction is not so considerable in the high Land of Derbyshire as in many other Countries, because the Quantity of Vegetables is less than in other Countries. The Heat, also, is so unfavourable as to retard, or prevent this Process, a great Part of
the

the Year. The Circumstance of Moisture of Soil is likewise wanting; for although Rains fall almost daily in Summer, yet the Water flows so speedily, on Account of the Declivities of the Land, into the Channels forming Brooks, Rivulets, and Rivers, as to preserve the Ground tolerably dry.

The *Phlogistication*, or some other Change of Air, by the *Respiration* of Animals, and by *Inflammation*, happens, in any considerable Degree, only in large Towns; of which there are none at a less Distance than twenty or thirty Miles from Buxton. The principal *phlogistic* Operation in the Peake, is the *Inflammation* in the Processes for procuring Lead from its Ores; but, *the Air combined with Phlogiston* formed by these Processes, is but a small Quantity, indeed, compared with the general Mass of the Atmosphere: For they are not constantly performing, and in Consequence of the great Agitation of the Atmosphere, the small Quantity thus produced, is diffused throughout the whole Mass of this Atmosphere.

From these Considerations we should be inclined to conclude, that the Atmosphere of the Peake contains a smaller Portion of *the Compound of Air and Phlogiston*, than the Atmosphere of less elevated Regions in the same, or much more Southern Latitudes. But in order to form a proper Judgment of the Quantity of this Impurity in the Atmosphere, we must not only contemplate the Sources of it, but the Means subsisting of removing it.

The

The Means hitherto demonstrated, or supposed to be proved, that are employed by Nature in the Purification of the Atmosphere, are *Vegetation* and *Water*.

Much has been lately said concerning the Influence of *Vegetation* on Air vitiated by phlogistic Operations; but the Effects of it, on the Atmosphere, have not been satisfactorily explained.

The Experiments of Dr. Ingenhouz demonstrate, that Vegetables exposed to the solar Light, during the Performance of their Functions, excrete Air from their Leaves, Branches, and Stems; which Air, to the Test of Respiration and Inflammation, is frequently six or eight Times more pure than common atmospheric Air. The Experiments of this Philosopher also instruct us, that living Vegetables, in the Absence of Light, as in the Night-Time, and in the Shade, render Air noxious; but that the Effect of Plants in deteriorating Air in the Dark, is more than counterbalanced by their Power of meliorating common Air in the Day-time, when they are exposed to the Solar Light (*d*). It is also rendered probable by the Experiments of several Philosophers, especially by those of Dr. Priestley, that Vegetables absorb certain Substances from the Atmosphere, which render it impure.

Now considering the State of *Vegetation* in the Peake, we should be inclined to infer, on the

(*d*) Experiments upon Vegetables, 1780, 8vo. and Phil. Transf. Vol. LXXII. p. 429.

Foundation of the Result of the above Experiments, that the Atmosphere here is, as far as depends upon living Plants, less pure than the adjacent and less eminent Countries; because Vegetables are here less abundant, and grow less luxuriantly than in such less elevated and neighbouring Regions. Moreover, the Quantity of *Solar Light* being much less, in this mountainous Tract of Country, than in most other Parts of England, this Circumstance furnishes another Ground for concluding, that the Vegetable Creation have here less Effect in purifying the Atmosphere, by the *Addition* of pure Air, and *Absorption* of Impurities, than in other Regions where the Quantity of Solar Light is much greater (*e*).

In

(*e*) My Readers will perceive, I have above delivered an Explanation of the Manner in which Vegetables purify the Atmosphere, which is very different from that commonly received; and it therefore appears incumbent upon me, to state the Grounds for my rejecting the Opinion usually adopted on this Subject, and the Reasons that have obliged me to embrace the Theory above proposed.

Since the Publication of Dr. Priestley's Experiments on Air, and other permanent Vapours, the most prevailing, or only Opinion, concerning the Influence of Vegetation on the Atmosphere has been, that Plants purified impure Air by absorbing the noxious Part of it, which was commonly supposed to be phlogistic Matter; or by decomposing it when it was unfit for supporting Life and Flame, by being combined, as was supposed, with Phlogiston, (Pr. Vol. I. p. 49, 52, 87, 88, 93, 137, 141, 179, and other Parts of this Philosopher's Experiments)

In this Enquiry into the State of the Atmosphere of the Peake, with respect to its Impurities from Air rendered unfit for Respiration by Phlogiston, or Substances supposed to vitiate Air by Phlogiston, I shall in the next Place take Notice of the Situation of the Atmosphere of this

periments and Observations.) This Opinion prevails on the Foundation of the Inference drawn by Dr. Priestley from his own Experiments; but as I am confident, according to my Judgment, that this Deduction is unjustifiable, the Opinion founded upon it is also, to my Apprehension, erroneous.

The Experiments of Dr. Priestley and others, sufficiently prove, that *Air altered by Respiration, Inflammation, the putrefactive Fermentation, Volcanos, various Decompositions in the Practice of the Arts, and other Operations, termed "Phlogistic,"* may be restored to its former respirable State, or even be made more pure than before it was *altered* by these Processes; or be *exchanged* for common Air; and that common Air may be rendered more pure, by Vegetables growing therein. This Amelioration of impure Air may, at first View, appear to be equally well accounted for, upon any of the following Grounds: 1. By supposing the impure Part of the foul Air to be *absorbed*, by the Plants to which it is exposed. 2. On the Supposition, that this Sort of noxious Air is *decomposed* by Vegetation. 3. By conceiving, that Vegetables, during the Performance of their Functions, *add* something to the impure Air, which may be either merely *added* thereto, or which may be united with it. 4. By imagining, that this noxious Air may be amended, or impure Air rendered more pure, by several of these natural Means acting together.

However, after contemplating the Nature of the vegetable Powers, and considering more minutely the Experiments made with the View of determining the Influence of Vegeta-

this Country, with Regard to *Exposure to large Bodies of Water*; for an Opinion is entertained by many, founded on an Inference drawn from Experiments, that large Quantities of running Water, as Seas, Lakes, Rivers, &c. purify Atmospheric Air of those Impurities which are occasioned

tion upon impure, or wholly vitiated Air, I could not but draw a very different Conclusion from that of Dr. Priestley, and others, who have reasoned like him; for I could only account for the Result of the whole of the Experiments on this Subject satisfactorily, on one of the above Grounds, on which is founded the Opinion advanced in the Page which refers to this Note; namely, that Vegetables may render noxious or impure Air more proper for Respiration and Inflammation, by an *Addition* of pure Air; which, according to the Idea of Dr. Ingenhouz, (Phil. Trans. Vol. LXXII. p. 427.) is separated as an Excrement from them; and also, probably, in a small Degree, by the Absorption of certain Impurities. It is upon this Principle only, that we can satisfactorily explain all the Experiments made upon this Subject by Mr. Boyle, Dr. Hales, Dr. Priestley, Dr. Ingenhouz, Mr. Scheele, Mr. Bergman, and other Experimenters.

Mr. Boyle and Dr. Hales shewed, that the Vegetable Functions separated a Substance, which was, apparently, a permanent Vapour, and which they supposed to be Air. Dr. Hales (Veg. Statics, Vol. I. p. 24, 30, 148, 153, 324, 358.) found, that Plants excreted, from their Leaves, Air most copiously, or only, at the Time they were exposed to the Sun's Light, at which Time they were in a perspiring State; but that in the Night-time, or Shade, no Air or Fluid, or only a very small Quantity of them were excreted; and that the Plants were then in a State of Imbibition of watery Fluids, and permanent Vapour. As the Quantity of Fluid imbibed and perspired

caſioned by various Proceſſes named Phlogiſtic, viz. Reſpiration, Inflammation, Putrefaction, &c. either *by decompoſing the Compound of Air and Phlogiſton*, or *by abſorbing Subſtances ſuppoſed to be compoſed of theſe two ſimple Bodies*.

Con-

ſpired was very conſiderable, being in twenty-four Hours, (Veg. Stat. p. 13.) ſeventeen Times more, Bulk for Bulk, than the Fluids entering and going off from the Veins of a Man in twenty-four Hours; and as the Quantity of Air ſeparated from Plants, appears to be in Proportion to the Quantity of Perſpiration, the Quantity of Air ſeparated, muſt be alſo conſiderable. “When,” Dr. Hales obſerves, (Veg. Stat. p. 102.) “the Sun ſhined hot upon the Vine, there was always a continued Series of Air-bubbles conſtantly aſcending from the Stem, through the Sap in the Tube, in ſo great Plenty, as to make a large Froth on the Top of the Sap, which ſhews the great Quantity of Air which is drawn in through the Roots and Stem.” The next Paragraph which I ſhall cite from Dr. Hales, inſtructs us, that the Sap roſe moſt copiouſly, only when the Sun’s Light acts upon the Plant, and that it ſubſides upon the Intervention of a Cloud. Above it was ſhewn, by Dr. Hales, that Air was ſeparated moſt copiouſly under the ſame Circumſtance of Sun-ſhine. Theſe Obſervations coincide perfectly with the Reſult of the Experiments lately publiſhed by Dr. Ingenhouz, namely, that Plants, during their Expoſure to Sun-ſhine, ſeparate Air, which he found to be Air much purer than common Air; and in the Dark or Shade, they do not ſeparate Air, or only a ſmall Quantity of it, and in an impure State.

“If in the Morning, while the Sap was in a riſing State, there was a cold Wind, with a Mixture of Sun-ſhine and Cloud, when the Sun was clouded, the Sap would immediately viſibly ſubſide, at the Rate of an Inch in a Mi-

Considering the great Distance of the North Part of Derbyshire from the Seas, and that the Rivers flowing through it do not contain a large Bulk of Water, we might infer, on the
Foundation

nute, for several Inches, if the Sun continued so long clouded; but as soon as the Sun-beams broke out again, the Sap would immediately return to its then rising State, just as any Liquor in a Thermometer rises or falls, with the Alternacies of Heat and Cold. Whence it is probable, that the plentiful Rise of the Sap in the Vine, in the bleeding Season, is affected in the same Manner." Veg. St. p. 115.

Dr. Ingenhouz has lately decisively proved, (Phil. Trans. Vol. LXXII.) that the Bubbles of permanent Vapour, shewn by Dr. Hales to be so copiously excreted along with the perspirable Matter of Plants, during Exposure to the Light of the Sun, are Air much more pure than atmospheric Air; being, upon some Occasions, six or eight Times more pure than common Air: Moreover, this learned Philosopher has shewn, that Vegetables, especially aquatic Plants, while immersed in Water previously deprived of common Air, and with the Communication between this Water and the Atmosphere intercepted by Quicksilver, excreted this pure Air as long as they live therein, in considerable Quantity; viz. about $\frac{1}{28}$ of the Bulk of the Water, besides the Quantity *combined* and *mixed* with this Fluid, which may be reckoned at least to be $\frac{1}{8}$ of the Bulk of it; or 160 Measures of Water will enable Plants to separate 28 Measures of pure Air. And from the Experiments of Dr. Ingenhouz and Dr. Priestley, it appears that the Time Plants live and separate Air, under these Circumstances, is in Proportion to the Quantity of Water in which they are immersed. Hence it may be very probably inferred, that pure Air thus separated, is produced by the Vegetables, independently of the Absorption of any common
Air,

Foundation of the above Deduction, that the Atmosphere was not exposed to this Means of purifying impure Air, under such favourable Circumstances

Air, although they are capable of absorbing common Air with their Food and Water (Hales Veg. Stat. p. 148, 149, 153, 155, 365.) This Inference, however, is decisively proved to be true, by Experiments which shew, that when Plants are immersed in unboiled Water, the common Air therein does not appear to have been absorbed by the Plant, (Dr. Ingenhouz's Experiments. Phil. Transf. Vol. LXXII.) Dr. Priestley, however, deduces, that this pure Air arises from the common Air contained in the Water in which the Plant is immersed, which is "depurated" by the vegetable Powers; which Deduction, however, as far as I am able to judge, if his own Experiments do not prove to be unjust, those of Dr. Ingenhouz, (Phil. Transf. Vol. LXXII.) clearly demonstrate to be so. The Quantity of pure Air, separated by Plants immersed in Water, is in Proportion to the Quantity of Water, not because it affords common Air to be purified by the Plant, but, probably, because it contains more Food to support the Plant for a longer Time; or because the perspirable Matter, or other Excrements of the Plant, are noxious to the Vegetable from which they were excreted, and are rendered less hurtful when mixt with a large than a small Quantity of Water. The Air excreted, although much purer than common Air, is an Excrement of the Plant, as much as its perspirable Matter; and is thrown off as long as the Water can supply it with Food, provided it be not killed by the pure Air, its own Excrement, before this Food is consumed, (Hales, Veg. Stat. p. 324. and Ingenhouz, Phil. Transf. Vol. LXXII.) Upon this Ground, also, may be readily explained those Experiments of Dr. Priestley, which instruct us, that Plants live longer, and separate pure Air, in Proportion to

cumstances as many other Countries in England situated nearer to the Sea or large Rivers; and that consequently the Air of the Moor-Land of Derbyshire, on this Account, is more impure than

the Quantity of Water, and dead animal or vegetable Matter, not exceeding a certain Quantity of these Substances, than in mere Water; because, under this Circumstance, more Food is furnished for the Plant, either by the animal or vegetable Matter commonly contained in Water, as well as the usual Impurities of Water, or by the animal and vegetable Matter added to the Water; which Mucilage, as fast as it advances to the State of Putrefaction, is absorbed by the Plants, as their proper and pure Aliment, (See Dr. Fordyce's Elements of Agriculture.) This Theory, by the Way, explains why Water remains sweet with Plants growing in it, although it contains Mucilage, that would, without the growing of Plants therein, soon render the Water foetid, better than upon the Supposition, that Phlogiston separated by the Mucilage contained in the Water, is absorbed by the Plants.

As a collateral Proof that Plants excrete pure Air from their Constitutions, and do not merely "depurate" or purify common Air contained in Water, may be stated, that some Species of Vegetables have been discovered by Dr. Priestley to contain pure Air in certain Receptacles, where it is found already excreted, as in the Air-Bladders of many Sea-Weeds; whereas Fishes contain in their Air-Bladders, Air totally unfit for Respiration.

It has been said to have been the Result of an Experiment, that Water, exposed to the solar Light, containing an opaque Substance, as Cloth, rendered impure Air as copiously as Water with Plants separated pure Air; from which it was inferred, that the Water, not the Plant, afforded the Air by the Action of Light upon an opaque Body, but that the Plants purified it when thus separated. This Experiment, on Repetition

than that of other Regions more favourably situated for the Operation of Water.

After an attentive Perusal, however, of the Experiments on which the Opinion concerning the Influence

petition several Times, has been found to have produced a very different Result. See Ingenhouz's Exp. Phil. Transf. Vol. LXXII.

Light has been long known to be necessary to the Growth of Plants, but not so necessary as Air, (Dr. Fordyce's Elements of Agriculture.) The Manner in which solar Light operates upon the vegetable Powers, is not understood. It does not operate merely by the Heat it produces, as Dr. Hales supposed, (Veg. St. p. 130.) nor, as we shall explain below, in the Manner Mr. Kirwan ingeniously conjectures, viz. by the Light decomposing the "phlogisticated Air;" upon which Occasion the Light unites with the Air, and the Phlogiston with the Plant. (See Scheele's Treatise on Fire.)

It being decisively proved, by the last Experiments of Dr. Ingenhouz, (Ph. Transf. Vol. LXXII.) that Plants excrete Air of six or eight Times the Purity of common Air, it may be readily conceived how it happened, that impure Air was meliorated in the Experiments of Dr. Priestley, and, after him, of other Experimenters, by Vegetation. For the *Addition* of a small Quantity of this excreted pure Air, would be sufficient to account for the Melioration, independently of any *Absorption* of the impure Air. But as Plants also absorb impure Air and various other Substances, such as Oil of Metals, and Air altered by phlogistic Operations; and do not appear to absorb the pure Air they have separated; it is obvious Vegetables will absorb the whole, or the greatest Part, of the impure Air, and other Substances different from Air, and excrete the pure Air in Place of the Matter absorbed: So that after Plants have grown a certain Time, under proper Circumstances,

Influence of Water in the Purification of the Atmosphere is founded, I could not perceive, that they demonstrated the Power of large Quantities of

Circumstances, in impure Air, Oil of Metals, &c. we find in the Vessels, in which they were confined, a Quantity of pure Air, equal in Bulk, or nearly so, to the permanent Vapours and other Substances absorbed. Dr. Priestley, I believe, first discovered that Plants grew when surrounded with Oil of Metals instead of Air; and that the permanent Vapour contained in the Jar filled with Oil of Metals becomes less and less inflammable, and more and more fit for Respiration; and, that at last the whole of the permanent Vapour found in the Jar is eminently proper for Respiration and Inflammation, and not at all inflammable. Now it is impossible upon this Occasion, that the Plant could have converted the Oil of Metals into respirable Air; because this Air is equal, in Quantity of Matter, to at least ten Times the Bulk of the Oil of Metals subjected to the vegetable Powers in this Experiment; but upon the Principle of the Excretion of Air from, and of Absorption of Oil of Metals by, the Plants, we can readily comprehend the Manner in which this Air was produced, and the Oil of Metals was lost. This pure Air is excreted from the Plant independently of the permanent Vapour with which it was surrounded, excepting in so far as this surrounding permanent Vapour serves for, or is the Vehicle of, Aliment to the Plant. The luxuriant Growth of Plants in Oil of Metals, arises, probably, from this permanent Vapour stimulating the vegetable Functions; for this Substance is either not capable of supporting vegetable Life at all, or only for a short Time.

Dr. Priestley, Dr. Ingenhouz, and other Experimenters found, that foul Air was frequently meliorated by Vegetation during Exposure to the Sun-Shine, in a very short Time, as in the Space of a few Hours, or perhaps a shorter Time. This

speedy

of Water in rendering vitiated Air more fit for Respiration, by decomposing *the Compound of Air and Phlogiston*, and by absorbing those Impurities

speedy Improvement of noxious Air may be easily understood, by ascribing the Alteration to the *Addition* of pure Air, but cannot be explained satisfactorily, by the usual Theory of the Melioration of vitiated Air by Means of Vegetation.

Perhaps it will be objected, that if the Improvement of vitiated Air, and Purification of common Air by Plants, depend upon the Addition of excreted pure Air, the Volume of the confined Air to which they are exposed should be augmented. To this Objection it may be answered, that when Experiments have been made to learn the Effects of Vegetation upon Air, the Bulk of Air has been rarely attended to, or at least not properly ;—that a small Addition of pure Air will, frequently, be sufficient to account for the Result ; and that supposing no Addition of Volume be occasioned, or even a Diminution thereof take place, this Event may be explained upon the Supposition, that the Vegetables absorb either in the Day-Time or in the Dark, some of the impure Air, which Diminution may be about equal to the Bulk of Air added. Upon this Occasion also, we should consider the Effect of the Water upon the confined permanent Vapour to which the Plants are exposed, in uniting or mixing with it, and communicating it to, the external Air ; and again, the Effect of the Water in combining or mixing with the Air of the Atmosphere, and afterwards of separating it in the Receiver containing the Plants and permanent Vapour intended to be made respirable.

Upon this Ground we can explain the Reason of the Failure of Plants in purifying or improving Air, namely, either because there was not Light sufficient, or some other Circumstance was wanting to produce the Excretion of pure Air ; or, because there was present, some Means of deteriorating this

purities called phlogistic Matter; on the contrary, I concluded, that they shewed the Effect of Seas, Lakes, and Rivers on the Atmosphere, to be that of rendering it more impure, in as much as

Air when excreted: We can also understand how it has happened, that at one Time the same Plant amends noxious Air more speedily, and to a greater Degree, than at another; owing to the Circumstance of Light, Health of the Plants, State of the Water in which the Vegetable is confined, &c. Likewise we can readily comprehend how it happens, that the Quantity of pure Air separated, is, to a certain Degree, greater in Proportion to the Bulk of Vegetables growing therein.

Vitiated Air, instead of being amended, is sometimes deteriorated by other Means, besides the Exhalations mentioned by Dr. Ingenhouz to be made in the Night-Time, from the Constitution of Plants in general, and in the Day-Time from their Roots, Flowers, and Fruits; of which we need not here particularly treat.

Common Air does not appear to contribute to the Production of the excreted Air of Plants, excepting, perhaps, in supporting their Life; for, in the Experiments of Dr. Ingenhouz, the common Air of the unboiled Water does not appear to have been absorbed at all by the Plants, although this learned Philosopher seems to have made a Deduction that it was absorbed. Ph. Transf. Vol. LXXII.

We conclude, that although we allow the Inference to be just, that one Office of the vegetable Creation in the System of Nature, is to purify the Atmosphere rendered impure by various Operations of Nature and Art, we cannot embrace the Opinion commonly received, that this Effect is produced by an Absorption of certain Impurities, or by decomposing that Compound, or those Compounds, which consist of Air unfit for Respiration and Inflammation by being combined with Phlogiston, or other Substances.

Water

Water appears to unite and mix with the pure Air of the Atmosphere in larger Quantity, and preferably to those Impurities called phlogisticated Air, and phlogistic Substances (*f*). Pr. IV. p. 52, 158. Fontana, Phil. Transf. 1779, p. 439, 444. Dr. Forster's Translation of Scheele on Fire, p. 163.

Since

(*f*) Having, in the Page which refers to this Note, advanced an Opinion concerning the Influence of Water on the Atmosphere so very opposite to that commonly received, I deem it necessary to state the Grounds on which I have established my Conclusion.

The Result of Dr. Priestley's Experiments, (Pr. Vol. I. p. 67, 68, 96, 97, 98, 100, 131, 161, 200, 201, 203, 246, 261, 269. Vol. II. p. 90, 267, and other Parts of his Works on Air) being, that after *Oil of Metals*, and *Air vitiated* or rendered unfit for Respiration, and decomposing inflammable Bodies, by breathing, Inflammation, Putrefaction, Mixture with nitrous Gas, and a Variety of other Processes, in which Phlogiston either actually is, or is supposed to be, separated and united with Air, has been agitated pretty violently and for a long Time, in wide Jars inverted and sufficiently immersed in a large Quantity of Water exposed to the Atmosphere, the confined permanent Vapours have been found wholly or partially in a State of Purity equal to atmospheric Air; this learned Philosopher deduces, that by this Operation the *Oil of Metals* is changed, and the *vitiated Air* is restored wholly, or partially, to the State of atmospheric Air: And he conceives these Changes to be effected, by the Phlogiston of the *Oil of Metals* being absorbed by the Water, and by the Absorption of the "noxious Effluvia," or Phlogiston of the vitiated Air. This Inference Dr. Priestley employs as a Principle to explain the Purity, long believed to exist, of
Air

Since the farther Discovery of the Nature of that permanent Vapour formed by the Combination of a certain Proportion of nitrous Acid with Phlogiston, hitherto called *nitrous Air*, or *nitrous Gas*, a Term we are under the Necessity of employing, (although it appears exceedingly improper)

Air of the Atmosphere exposed to Seas and other large Quantities of running Water: “ Since, says he, Water in this Experiment must have imbibed and retained a certain Portion of the noxious Effluvia, before they could be transmitted to the external Air, I do not think it improbable, that the Agitation of the Sea and large Lakes may be of some Use for the Purification of the Atmosphere; and the putrid Matter contained in the Water may be imbibed by aquatic Plants, or be deposited in some other Manner.” The Result above related, is sufficiently established by Dr. Priestley’s Experiments, as well as by those of other Experimenters; but the Inference drawn from them is very obviously doubtful, and in this Light it has appeared to the Author of a Treatise on *Gases*, who proposes this Question, p. 19. “ Was the Melioration produced by the Water separating the vitiated Part of the Air from the rest by Absorption, or by the Agitation effecting a Kind of Circulation between the external Air and the vitiated Air included in the Jars; by which Means, much of the former might be received into the Vessels, while Part of the latter might be absorbed by the Water, and thrown out into the open Air.” With the utmost Deference to the Judgment of Dr. Priestley, his Experiments, to my Apprehension, afford not only probable, but decisive Proofs, that the confined permanent Vapours found in the Jars after Agitation in Water, in the Experiments above referred to, were not the permanent Vapours subjected to the Experiment *transmuted to the State of common Air*, by abstracting

proper) because it has not yet obtained a more proper Denomination, and its being applied to determine the Quantity of extraneous Substances or Impurities of the Air of the Atmosphere, it has been customary to estimate the Purity of common by Means of this Substance.

The

abstracting a Portion from them, or by decomposing them, but were conveyed within the Jars from the Atmosphere, while the Oil of Metals and vitiated Air were gradually mixed with the Water, and from thence communicated to the external Air. The Facts in Support of this Conclusion are the following. It appears from Dr. Priestley's Experiments, and those of other Philosophers, that if the permanent Vapours proposed to be changed into respirable Air by Water, be exposed to Water, so that a greater Portion of them be absorbed without Motion, than happens after the Agitation by which respirable Air is produced, the Residuum is not different in Quality from that of the whole of the permanent Vapour before Absorption. 2. That the permanent Vapour absorbed by the Water, and again expelled, was not altered by being thus absorbed. 3. That by agitating the permanent Vapours in a large Quantity of Water, in Vessels with their Orifices closed, or in Vessels with strait Necks and their Mouths open, in a Trough of Water exposed to the external Air, under which Circumstances there was a much more ready Communication from the Inside of the Jar to, than from, the external Air, no Alteration, or but a very partial Change, was effected. 4. That the Facility of the Production of common Air within the inverted Jar, was evidently in Proportion to the Opportunity of the Air of the Atmosphere, when loosened from the Water by Agitation, entering within the inverted Jar, and of the permanent Vapour to be changed, being mixed with the Water, and from
thence

The Principle upon which this *Compound of Phlogiston and nitrous Acid*, called *nitrous Air*, is applied for this Purpose, is this. *This Compound of Phlogiston and nitrous Acid* doth not combine with any permanent Vapour, excepting *Air*; and the Phlogiston combined with nitrous Acid in this

thence mixed with the general Mass of Atmospheric Air; because the Change intended to be made, was expedited by using open Jars with very wide Mouths, and by the Water in which it was agitated being exposed to the Atmosphere; and not by Agitation, and increasing the Quantity of Water independently of the Use of wide Jars, and Exposure of Water to the external Air. 5. That the permanent Vapours confined within the inverted Jar, were to the Testimony of the Smell shook into the Water, and from thence into the open Air. 6. That the Agitation of common or pure Air in Water, or mere Exposure of them to Water, frequently injures them. 7. That merely transferring vitiated Air, or Oil of Metals through boiled Water, or Water free of Air, does not alter them. 8. That agitating permanent Vapours in unboiled Water increases their Bulk, by separating Part of the Air contained in the Water. 9. That whatever Kind of permanent Vapour be agitated in Water, in Vessels, provided it does not readily unite with Water, it may be exchanged for common Air, or Air rather worse than common Air. The above Facts just related, if they do not demonstrate the Truth of our Opinion, certainly render it highly probable. The following Result of an Experiment, however, may be considered as decisive, as if it had been performed purposely to determine the Truth of the Opinions upon this Subject. Mr. Kirwan notices this Experiment, Phil. Trans. Vol. LXXII. P. 204. to shew, that the Experiments of Dr. Priestley do not prove, that the Oil of Metals consists

this Compound, is attracted by and combined with Air, without increasing the Bulk of the Air, until it be saturated by this Phlogiston separated from nitrous Acid ; till it be saturated, so far from increasing, the Phlogiston diminishes the Volume of the Air

consists of respirable Air “ supersaturated with Phlogiston,” 1 Pr. p. 67. After a Quantity of inflammable Air in a Glass Jar, had been agitated in a pretty large Trough of Water about ten Minutes, by which near one-fourth of its Volume had disappeared, the Residuum combined with nitrous Gas, and an Animal lived in it as long as it usually does in an equal Bulk of common Air ; but it was still weakly inflammable. In another Experiment, 1 Pr. p. 68. by continuing the Agitation still longer than in the former Experiment, the Air which had been inflammable, suffered a Candle to burn in it ; and by a still longer Continuance of this Process, it was in the State of Air in which a Candle had burned out. Upon this Experiment Mr. Kirwan remarks, “ that it clearly follows, that if the external respirable Air had no Access to the Inside of the Jar, half nearly of the inflammable Air was converted into, or consisted of, respirable Air, since such Quantity of Air was found in it after the Operation. Now it is impossible, that either could happen ; for inflammable Air could not be converted into half, nor even one-third, or one-fourth of its Volume of respirable Air ; as even one fourth of respirable Air contains more Matter than four Times its Bulk of inflammable Air ; it is then evident, the external Air must have had Access to it.” Having presented the Reader with a summary View of the Facts which, according to my Judgment, demonstrate the Error of the Conclusion, that Oil of Metals and vitiated Air are capable of being changed into respirable Air by Agitation in Water ; and consequently, shown the Opinion found-

Air with which it is united, like other phlogistic Processes in which Phlogiston is separated by the Attraction of Air, as in all Cases of burning. Therefore, if to one Portion of Air without any extraneous Substances diffused through, or mixed with

ed upon such a Deduction to be erroneous, I shall relate the Effects of Water upon the Atmosphere, which appear deducible from the Result of the Experiments and Observations just related, on which is established the Opinion, that *Seas, Lakes, and other large Bodies of Water, tend to render the respirable Air of the Atmosphere more impure.*

Air altered by being united with Phlogiston, or by Processes of Nature and Art called phlogistic Operations, is nearly of the same specific Gravity as common Air, and these two Substances are readily diffusible through each other; so that the ordinary and almost constant Motion of the Atmosphere, is sufficient to diffuse Air vitiated by phlogistic Processes throughout the general Mass of the circumambient Air.

Flowing Water, and Water in a *Still-state*, being generally *saturated* with atmospheric Air, and also containing as much thereof as can be *mixed* with it, can have no Effect, according to any of the foregoing Experiments, excepting, perhaps, in vitiating the incumbent Air immediately in Contact with its Surface. Upon some Occasions indeed by Variations of Temperature, and the Motion of the atmosphere, Water upon the Surface of the Earth may sometimes separate Air, at other Times absorb it.—The Air thus separated, we infer, will at one Time be more pure, at another Time less pure than the common Air of the Atmosphere; and that the Air absorbed will be the most pure Part, or certainly the Water will not absorb the vitiated Air preferably to the more pure Air of the Atmosphere; so that

with it, and to another equal Portion of Air containing a small Quantity of *the Compound of Air and Phlogiston* or other adventitious Substance, be added a Quantity of that *Compound of nitrous Acid and Phlogiston*, called nitrous Gas, just sufficient to

Water in this its usual State, rather tends to vitiate than render the circumambient Air more free of Impurities.

When the largest Bulks of Water upon the Surface of the Earth, as Seas and Lakes, are *agitated* considerably, as in Gales and Storms, it may be concluded from the Event of Experiments, that the Air already mixed with the Water, is by this Agitation detached and thrown into the common Atmosphere, and the same Operation at the same Time mixes therewith common Air of the Atmosphere. But as the principal Part, or indeed almost the whole of the Air separated by this Means, must be obviously the common atmospheric Air, which was mixed with the Water by Agitation; the Influence of these large Quantities of Water, thus agitated, on the Purity of the Atmosphere, we have no Grounds for supposing can be considerable.

We shall conclude this long Note with observing, that although no Experiments hitherto given to the Public, show by what Means, Nature purifies the Atmosphere from Air vitiated by phlogistic Operations, there are good Grounds for believing, that we know of a Means by which the Air, destined for the Support of Life and Inflammation, is deprived of a considerable Source of Impurity, namely, *Gas*; provided, this Substance be only contained in the Atmosphere in a State of *Diffusion*; or, that Water attracts it more strongly than pure Air, if it be *united* therewith. (See *Bergman's Table of Attractions*, and his Essay on the Usefulness of Chymistry.) But of this Impurity we shall treat hereafter, in considering the Substances *diffused* through, and *mixed* with, the pure Air of the Atmosphere.

saturate the *first* of these Portions, and the same Quantity of nitrous Gas to the other Portion of Air and adventitious Substances, the Result will be, that the Volume of the second Mixture of this Compound of nitrous Acid and Phlogiston or nitrous Gas and impure Air, will be *greater* than the first Mixture of this Compound of Phlogiston and nitrous Acid and pure Air.

It is very certain, that this Principle is perfectly just and well founded; but on Account of the Difficulty of obtaining *exact Measures* of the permanent Vapours to be mixed together, and a Variety of other Circumstances, this Method of determining the Purity of Air is either erroneous or impracticable; for it can only enable us to judge, as appears by many Experiments, of greater Differences, and such as rarely exist between the Atmosphere of different Places, arising from extraneous Substances; and from which could we determine this Question by this Means, no practical Deduction of Utility could be made. It has been found, that an Animal lives *longer* in a Receiver containing a given Bulk of pure Air, than in the same Bulk of a Mixture of pure Air and *the Compound of Air and Phlogiston*; from which we can only infer, that an Animal can breathe *longer* in pure Air, than in Air that contains foreign Matters: But the Inference is not just from this Experiment, that pure Air is more conducive to Health; or that impure Air, from the Admixture
of

of the *Compound of Phlogiston and Air*, is an efficient Cause of Disease. Again, extraneous Substances that are certainly known to be the Occasion of Diseases may be contained in Air, but which hitherto have not been, and probably cannot be demonstrated by Means of nitrous Gas.

If, for Instance, I take a Parcel of atmospheric Air in a Region where an epidemic Fever, as the Plague, Intermittents, Small-Pox, &c. prevail; and another Parcel that is a Mixture of the purest atmospheric Air of a mountainous Country, and at the greatest Distance from any Source of Impurity, and $\frac{1}{100}$ or $\frac{1}{200}$ Part of its Bulk of Air saturated with Phlogiston, I should find, after adding the same Bulk of nitrous Gas, and in sufficient Quantity to saturate the Air of each Parcel, that the Bulk of the Mixture composed of the latter Air, or artificial Mixture of pure Air and *the Compound of Air and Phlogiston*, and nitrous Gas, to be greater than the Volume of the Mixture composed of the former Air impregnated with contagious Matter, and nitrous Gas. The Inference from this Experiment must be, according to the preceding Principle, that the latter Parcel of Air being more impure, or containing more extraneous Matter, according to the Test of nitrous Gas, is more injurious to human Health than the former Parcel of Air, which contains indubitably the efficient Cause of Diseases. How erroneous is this Conclusion! I do not know from Experience

any Instance of Disease occasioned by pure Air and a small Proportion, as $\frac{1}{288}$ of its Bulk of *the Compound of Air and Phlogiston*, or phlogisticated Air; but it is needless to observe, that the former Parcel of Air is a most evident efficient Cause of Disease.

Moreover, on actual Trial, in many Instances at least, this Test does not point out the smaller Differences of Climates, if they do exist, so as to be demonstrable, by this Means, with any Kind of Uniformity or Certainty.

The following is the Result of some Experiments made to estimate the relative Purity of Air of the Atmosphere of different Places and Regions, performed with Attention to all the known Circumstances liable to occasion erroneous Conclusions.

Two Measures, each of which contained six Drachms Measure, of Air appertaining to the Places and Regions under-mentioned, were added to one Measure of nitrous Gas: Each of the Measures was expressed by a Scratch upon a Tube, the Bore of which was about one-third of an Inch in Diameter, and each of these Measures was divided first into nine equal Parts, denoted by Marks made with a Flint upon the Glass, and then each of these nine Parts into four equal Parts. The Mixture of Air and nitrous Gas was made in a Phial, and after an equal Agitation and standing for the same Time under equal Circumstances of Heat, Pressure, &c. in all the Trials,

Trials, it was transferred into the Tube just mentioned, and its Dimensions noted.

Two of the above Measures of atmospheric Air, and one Measure of nitrous Gas, which occupied before Combination, a Space equal to 27 Divisions of the above Tube, were, after Combination, reduced in Bulk as follows :

N ^o 1.	Air of the <i>Levels</i> , about fourteen Miles from Doncaster,	—	17 $\frac{1}{8}$
	Ditto, second Trial	— —	16 $\frac{3}{4}$
N ^o 2.	— Of Mosbro-Hall, six Miles from Sheffield	— —	15 $\frac{3}{4}$
	Ditto	— — — —	15 $\frac{1}{2}$
N ^o 3.	— From Sheffield	— —	15 $\frac{3}{4}$
	Ditto	— — — —	15 $\frac{1}{2}$
N ^o 4.	— From the Top of <i>Sir William</i> , a high Mountain, on the Road between Sheffield and Buxton	— — —	15 $\frac{3}{4}$
	Ditto	— — —	16 $\frac{1}{4}$
N ^o 5.	— From the Ashburne Road, a Mile from Buxton	— —	16 $\frac{1}{4}$
	Ditto	— — — —	16

N ^o 6.	— the Macclesfield Road, a				
	Mile from Buxton	—	—		16 $\frac{1}{2}$
	Ditto	—	—	—	16
N ^o 7.	— the Manchester Road, a Mile				
	from Buxton	—	—		16
	Ditto	—	—	—	16 $\frac{3}{4}$
N ^o 8.	— Fairfield, a Mile from Bux-				
	ton	—	—	—	16
	Ditto	—	—	—	15 $\frac{1}{2}$
N ^o 9.	— Doncaster, in Marsh-Gate	—			17 $\frac{1}{2}$
	Ditto	—	—	—	17 $\frac{1}{4}$
N ^o 10.	— Doncaster, French Gate	—			16 $\frac{3}{4}$
	Ditto	—	—	—	16 $\frac{1}{2}$
N ^o 11.	— Doncaster, Hall-Gate	—			16 $\frac{1}{8}$
	Ditto	—	—	—	16
N ^o 12.	— Doncaster, Hob-Cross-Hill				14 $\frac{3}{4}$
	Ditto	—	—	—	15 $\frac{1}{2}$

The three first and four last Numbers of Air put to the Test of nitrous Gas, were collected the 4th of February, 1782, when the Weather was cold and there was a Thaw upon the Ground; the others, the Day following, in Derbyshire, where there was a severe Frost, and Snow lay upon the

the Ground. On the 7th of this Month they were combined with the same Parcel of nitrous Gas.

I was much disappointed in the Result of these, as well as other Experiments, performed with the same View; for, having made no Trials myself, nor having then seen any made by others that contradicted or rendered questionable the Deductions and Opinions generally received, I was impressed with the Idea that I should see considerable Differences, by Means of this Test, in the Air of the above Regions, usually reckoned so different in Purity. I was unable also, after many more Trials besides those above related, to account for the *Want of Uniformity* in the Result on the Repetition of the Trials with the same Parcel of Air, and nitrous Gas. I afterwards ascribed this *Difference in the Result* of the Trials with the same Elements, in Part to the Difficulty, or Impracticability of performing this Experiment with such *Attentions* as should not occasion a Variety in the Result, independent of the State of the Air to be examined. But, I am now inclined to believe, the Varieties of the Atmosphere of different Places as far as concern Health, are in general not demonstrable by this Test; and that, generally, these Varieties only occur occasionally, and that the Occasion of them impregnate but a small Portion of the Atmosphere, when they are productive of Diseases.

Since the above Experiments were performed, I find that Mr. Fontana, Mr. Cavallo, and other Experimenters,

Experimenters, agree with me concerning the nitrous Gas, considered as a Means of determining the Purity of Air of the Atmosphere of different Regions.

C H A P. IV.

Of the Kind and Quantity of Substances, impregnating the Atmosphere of the Peake, in a State of Diffusion and Mixture.

THE most considerable and interesting Effects on the human System produced by the Atmosphere, are occasioned by Substances *suspended* therein.

Air, in all the various Degrees of the Heat of the Atmosphere, is a permanent Vapour of great Rarity, being many hundred Times specifically lighter than any Fluid we know; but, in Consequence of its *Visciditv*, it is capable of containing any Kind of Substances, provided they be divided into sufficiently minute Parts; and we have actually found an infinite Variety of Things in the Atmosphere; *permanent Vapours, Fluids, and Solids* of various Kinds; Animals and Vegetables: So that *Air* is never breathed, any more than Water drank, as a simple or elementary Substance, but as impregnated with various extraneous Matters. Of eleven or twelve Species of permanent Vapours with which we are acquainted, there are two which differ exceedingly in specific Gravity; namely,

Gas,

Gas, an acid permanent Vapour, which is nearly twice the Weight of atmospheric Air; and *Oil of Metals*, which is ten Times or more, lighter than common Air; and they are all readily diffusible through each other.

Of these Vapors, excepting *the compound of Air and Phlogiston*, or phlogisticated Air, above treated of, there are only two yet known that are *native Substances*, in any considerable Quantity, and that are liable to impregnate the Atmosphere; namely, *Gas*, which, according to the present universal Opinion, is the same Thing as the *Mephitis* of the Antients, the *Choke-Damp* of the English Miners, the *Moffette* of the Italians, and the *volatile medicinal Principle of Springs*, especially of the *Acidulæ*; and *Oil of Metals*, which is denominated by Miners, *Fire-Damp*.

Gas is contained in the Atmosphere in Consequence of its being extricated, during the Putrefaction of animal and vegetable Matters, by the chymical Analysis of Substances, the Decomposition of calcareous Earth in making Quick-Lime, from Rents or Fissures of the Earth, and Volcanos; from certain Lakes and Springs, especially in Countries where subterraneous Fires exist; and, perhaps, it is separated from the Lungs of breathing Animals; also it is possibly formed by the Union of Phlogiston with Air in phlogistic Processes.

During

During the putrefactive Fermentation, among other Substances separated and mixt with the Atmosphere, as well as during the chymical Analysis of Substances, the Decomposition of calcareous Earth by Heat, and, either spontaneously or by Means of Heat, from certain Spring-Waters, there is a *permanent Vapour* detached that combines with Quick-Lime, and therewith forms calcareous Earth; with caustic Alkali, and therewith forms mild Alkali; mild Alkali and this permanent Vapour combine and form a peculiar neutral Salt; and this permanent Vapour, unites with Water, and produces an acidulous Fluid; it also suffocates Animals that breathe in it, and it extinguishes Flame. During the Respiration of Animals, there is a *permanent Vapour* endowed with the above Properties, either precipitated from, or added to, the Atmosphere; but a permanent Vapour, possessed of these Properties, is Gas.

It appears from the Writings of the antient Naturalists, and the *Poets*, of which Numbers are cited by *Pliny*, that the Properties of that Substance met with in the Bowels of the Earth, called now-a-days *Choke-Damp*, and that mephitic permanent Vapour denominated Gas, which issues from various Caverns, and Rents or Fissures of the Earth, especially in Italy, where subterraneous Fires have existed for Ages, were as well understood some Centuries ago as at present; for they were known to *extinguish Flame* and *suffocate Animals*,

Animals, and no Person that I know of among the Moderns, hath demonstrated more of their Properties. For who hath ever collected these Substances, questioned, and then discovered their Qualities? Or what Experiments have been made, excepting their Effects on Flame and the Respiration of Animals? Yet all have inferred from the above-mentioned two Qualities, *that the Choke-Damp* and *permanent mephitic Vapour*, arising from Apertures of the Earth, have the Properties above-related of Gas, and were denominated and considered by Experimenters accordingly (g).

As

(g) Fixed Air is the oldest Fluid that hath been noticed by Mankind, since it is naturally found in many subterraneous Places, and from its killing Animals, and from its extinguishing Flame, the Miners call it Choke-Damp; but before Mr. Boyle, the Idea of it was very confused; and it was believed, that its fatal Effects were owing to a Vapour or *Spirit* diffused through the Air in some particular Places, hence it was called *Geist*, i. e. Spirit, whence the Word Gas has been derived, &c. It is found in various Mines, Wells, and Places not ventilated, and where it may be formed by a natural Fermentation and Combustion, as in the Vicinity of Volcanos, &c. People are found dead near Brick-kilns from fixed Air, and other noxious Vapours, during burning. The Grotto del Cane near Naples has been famous for Ages, in Consequence of the Stratum of fixed Air which exists at the Bottom of it, and which is evidently emitted through the Fissures of the Earth. Animals of various Species and even Men have been killed by it, or deprived of their Senses; and Light is commonly extinguished in it. It is often mixed

As then it hath been only demonstrated, that the permanent Vapours above-mentioned, *choke Animals* and *extinguish Flame*; and, as no Experiments or Observations have been made to discover more of their Properties, I submit to my Readers, whether former Deductions be not unwarrantable, and that the just Inference was, that *these permanent Vapours were not Air, or Oil of Metals*; and that, as many other permanent Vapours, besides Gas, suffocate Animals and extinguish Flame, it remains for future Observa-

tions

ed with common Air, phlogisticated Air, and inflammable Air.—*Cavallo* on Air and other permanently elastic Fluids.

“ Dr. *Brownrigg* had the Satisfaction to find these Waters (Spa) pregnant with the *artificial* or *facilitious* Air of Mr. Boyle, the same with that of the suffocating *Grotto* near Naples, and the same with the *Choke-Damp* of our Coal Mines; for as much as this Air instantly extinguished Flame, and the Life of those Animals he had inclosed in it.”—Vide Sir *John Pringle's* Discourse on the different Kinds of Air, p. 11.

1774.

And the same Author says, p. 13. “ I have been well informed, that for several Years past the learned Professor (Dr. *Black*) has taught, that the Air which unites with alkaline Substances is of the same Nature with the *Mephitic*, or suffocating Air of the *Grotto del Cane* and Mines.”

Dr. *Brownrigg's* Arguments (Phil. Transf. Vol. LV.), that the *Choke-Damp* and *fixed Air* are the same Substance, are, 1. because *Choke-Damps* have been found to expire from the Earth in Parts near the *Acidulæ*, and produce the same Effects upon Animals as the *Choke-Damp*, or as the *Grotto del Cane* and other Caverns.

2. These

tions to shew, whether they be Gas, or any of the other known permanent Vapours which stifle Animals, and in which Substances do not burn.

2. These *Acidulae* are really impregnated with a mephitic Exhalation resembling the *Choke-Damp*, because some of these Springs, as those at Pyrmont, do plainly discover it by their deadly Effects upon Ducks swimming upon their Surface. 3. The brisk and pungent Taste of the *Acidulae* shews them to be related to the *Choke-Damp*, and to resemble that from Beer and fermenting Liquors, which kills Animals like the *Choke-Damp*.

“ A noxious Gas is found in many Caverns, as in the famous Grotto del Cane, in Mines, Wells, and other deep Pits. This Gas, which, by English Miners, is called *Choke-Damp*, is heavier than common Air, and therefore lies chiefly at the Bottom of Pits; extinguishes Flame, precipitates the Lime of Lime-water, and is noxious to Animals: From these Properties, which it possesses in common with the Gas obtained from calcareous and alkaline Substances, it has been reckoned to be of the same Kind, as that which has been described under the Name of calcareous Gas,” (Fixed Air). See a Treatise on Gases, Chap. xiii. Pag. 75.

I suspect two Properties are deduced by this last Author from other Properties; namely, that because this Substance kills Animals, and extinguishes Flame, it therefore *precipitates Lime from Lime-water, and is of greater specific Gravity than common Air*. That such an Inference is liable to Error, has been before shewn.

Air of the former Kind, (fixed Air, or *Choke-Damp*) besides having been discovered in various Caverns, particularly the Grotto del Cane in Italy, had been also observed on the Surface of fermenting Liquors, and had been called *Gas* by Van Helmont.—Dr. Priestley’s Experiments and Observations on different Kinds of Air. Vol. I. Introduction, P. 3.

There

There are some Considerations which incline me to believe, that these Vapours are not Gas; at least, that only a Part of them is this Substance: For they appear to be contained very generally in the Bowels of the Earth, in every Part of the Globe, into the interior Part of which we have penetrated; and, in many Countries, as for Instance, in the West Riding of Yorkshire, we can scarcely dig a Hole ten Yards deep, without meeting with the Choke-Damp; and yet the Springs of these Regions do not denote, by their acidulous Taste, that they contain an unusual Quantity of Gas. Now, we should expect, that were this *Damp*, Gas, they would naturally contain a large Quantity, or be even saturated therewith. And, though the Existence of these Vapours be very general throughout the whole interior Substance of the Earth, yet, not one Spring in a thousand appears to be *acidulous*; or perhaps to contain any Gas combined with Water, as will be rendered highly probable, if not demonstrated, hereafter. *Lavoisier* says, “the Wells at Utrecht are from eight to twenty Feet in Depth, and the Water is raised by Pumps. They are covered with a Kind of Arch: When, after a certain Time, the Wells are opened on any Account, it is necessary to leave them uncovered for twelve Hours before any Person descends into them. Whoever should venture to go down into them sooner, would suffer instant Death.” I shall observe up-

on the above Fact, that a Stratum of the Substance composing the *Damp*, must be supposed to be formed upon the Surface of the Water. Now were this Stratum Gas, the Water must be *acidulous*, because, before it could be separated therefrom spontaneously, it must be more than saturated therewith; and whenever Gas exists, as a Stratum upon any Spring, it may be pronounced, that the Water is saturated with this Substance, and that the Gas which is upon its Surface is what is called *superfluous*.

Secondly, These subterraneous Vapours can only be accounted for, by the Fires that have subsisted, or do subsist, in the internal Parts of the Earth; and although the chymical Analysis, produced by this Means, may, probably, separate Gas, as in the burning of Substances upon other Occasions; yet, from Analogy we should suppose, this will not be sufficient to fill the Vacuities of the Bowels of the Earth with Gas, and saturate the Springs that have flowed through Passages communicating with those Cavities for several thousand Years. In Countries where no subterraneous Fires have apparently subsisted, as in the English Appennine, for, perhaps, a hundred thousand Years past, the Springs flowing for this Period, have, in all Probability, carried off all the Gas detached by the subterraneous Heat. Let us even suppose, the whole Strata of calcareous Earth to be decomposed by subterraneous Fires,

it is not likely, that the Gas would remain for many thousand Years in the Crannies and Caverns of the Earth, probably, exposed to the Action of the Strata of quick Lime, by Means of Cavities in which the Gas was contained communicating therewith, though at a considerable Distance, and certainly to subterraneous Streams of Water, without being wholly combined with one or both of these Substances.

Having given the Reasons which incline me to believe, that these mephitic Vapours, or *Damps*, are not Gas, I shall state the Arguments, which, to my Apprehension, render it probable that they are entirely, or principally, *the Compound of Air and Phlogiston*, or Air united with Phlogiston.

The external Part of the Earth, in every Part of the World yet explored, has been infested, or is infested, with subterraneous Fires; as appears by the Derangement of the Strata, the Appearance of Earthquakes, and the Eruption of Volcanos; and, consequently, there must have been an immense Quantity of *the Compound of Air and Phlogiston* formed, far exceeding the Quantity of Gas separated by this Combustion. But *the Compound of Air and Phlogiston*, is absorbed in a small Proportion, by pure or elementary Water, and that very slowly: And, the Rain-Water which forms Springs being saturated, or nearly so, with Air, does not absorb any, or but a small Quantity, of

this

this *Compound of Air and Phlogiston*. (See Part III. Exper. xli, xlii. of this Work.)

Therefore, on the Supposition of these subterraneous permanent Vapours, being *the Compound of Air and Phlogiston*, and not Gas as is commonly supposed, we can account for its Origin and Subsistence on more probable Grounds, than upon any other Supposition.

In Countries where there are frequent Eruptions of Volcanos, the mephitic Vapours expelled by Rents in the Earth, and from Caverns, are probably, a Mixture of various Kinds of permanent Vapour, that are formed or separated during the chymical Analysis of inflammable Substances; namely, *Gas*, *Oil of Metals*, and *common Air*, as well as *the Compound of Air and Phlogiston*; because the Springs have not had Time to combine with, and wash off, the three first permanent Vapours.

We can now account for the Origin of *the Compound of Air and Phlogiston*, in every Part of the Atmosphere, from the Quantity of that Substance exhaled from the Earth in many Countries, and its consequent Diffusion through the general Mass of the Atmosphere; as well as from the Quantity produced, by various Operations, upon the Surface of the Earth, in which Phlogiston is separated.

It hath been demonstrated, that certain Springs emit, either spontaneously, or by the Application

of Heat, Gas, which, like all other permanent Vapour excepting Air, suffocates Animals and extinguishes Flame; and, as several Fountains have been found to kill Animals on drinking them, or approaching near them, it hath been concluded, that they, upon all Occasions, produced this fatal Effect by the Gas they separated. The Lake *Avernus* was, in antient Times, as famous in History for its Power of destroying animal Life, as the *Grotto del Cane* is at present (*b*).

Quam super haud ullæ poterant impunè volantes
Tendere iter Pennis, talis sese Halitus atris
Faucibus effundens supera ad convexa ferebat:
Unde locum Graii dixerunt nomine Avernum.

VIRGIL, Lib. VI. *Æn.*

(*b*) “ There are upon Mount *Ætna* several Springs, some of so deadly a Quality, that Birds and Beasts have been found lying dead on their Banks, from having drank these Waters.” (See Brydone’s Tour through Sicily and Malta, p. 250.)

“ Virgil, and other Authors, say, that Birds cannot fly over the Lake *Avernus*, but that they fall therein; a Circumstance favouring my Opinion, that this was once the Mouth of a Volcano; and I am convinced, that there are still some Remains of this Vapour upon this Lake, as I have observed, there are very seldom any Water-Fowl upon it; and when they do go there, it is only for a short Time, whilst all the other Lakes, in Winter Time, are constantly covered with them.” (Vide Sir William Hamilton’s Account of Volcanos.)

Mr. *Addison*, in his Travels through Italy, says, “ there is nothing now particular in the Lake *Avernus*, formerly famous, according to Virgil, for its Steams of Poison, for it is plentifully stocked with Fish and Fowl.”

It.

It is most probable, that the permanent mephitic Vapour that arises spontaneously from Waters, is more frequently *the Compound of Air and Phlogiston* than Gas; and for the same Reasons that inclined me to believe, that the Choke-Damp, or *Mephitis*, was *the Compound of Air and Phlogiston* rather than Gas; but this Question may readily be determined by the *Taste* of the Water. If it be not *acidulous*, it certainly does not produce fatal Effects by the Gas it separates spontaneously; because, before it could extricate this permanent Vapour, it must be saturated therewith: If it be *acidulous*, it most probably chokes Animals, in Consequence of the Stratum of Gas apt to form upon its Surface. Moreover, if the Water be near any Volcano, or Rents of the Earth emitting *Moffette*, the Probability is, that it abounds with *the Compound of Air and Phlogiston*.

Sir James Lowther collected, many Years ago, a Bladder-full of that subterraneous Vapour, called the *Fire-Damp*; by which Means, this Substance was ascertained to be Oil of Metals. If some Person would be at the Trouble of procuring a Parcel of the Choke-Damp, it might readily be determined whether it be Gas, or *the Compound of Air and Phlogiston*, or some other permanent Vapour.

The Gas contained in the *Acidulae*, and that which is discharged through Rents of the Ground, may sometimes be produced in the Bowels of the

Earth, by the Combination of Acids with absorbent Earth, as by the Combination of calcareous Earth with the vitriolic Acid of Pyrites: But the principal Source we know of, is the Decomposition of calcareous Strata, and the chymical Analysis of inflammable Matters; for it is not yet rendered perfectly clear, that Gas is formed by the Union of Phlogiston and Air, in all Processes in which Phlogiston is separated.

Oil of Metals we infer, is contained in the Atmosphere, because it is produced by the Putrefaction of Vegetables and Animals in large Towns, marshy Grounds, many Ditches, and boggy Places; and is most copiously discharged from the Bowels of the Earth, by Means of Springs, which are well known by the Flame produced near their Surface upon the Approach of a lighted Candle; probably also by Rents in the Earth, and the Eruption of Volcanos.

It is produced in the Earth, during the chymical Analysis of the inflammable Matter of subterraneous Fires; which, therefore, accounts for the Origin of the *Fire-Damp*.

In Derbyshire we have three peculiar Sources of the permanent Vapours here treated of, namely, *the tepid Springs of Buxton*, which separate spontaneously a Substance that is probably *the Compound of Air and Phlogiston*, to be fully described hereafter; the *Decomposition of Lime-Stone* in the making of Lime, in Consequence of which

the Atmosphere is constantly impregnated near Buxton with Gas, and a small Quantity of *the Compound of Air and Phlogiston*; and the Processes for making Lead, that extricate or produce Gas, Oil of Metals, and *the Compound of Air and Phlogiston*. From a Contemplation merely of the Sources of these permanent Vapours, excepting those Sources just mentioned, we should be inclined to infer, that a smaller Quantity of these two Impurities, viz. *the Compound of Air and Phlogiston*, and Gas, is contained in the Atmosphere of the Peake, than in almost any other Part of England. The Quantity of these permanent Vapours does not appear to be so great, as to occasion any Apprehension of bad Effects from breathing the Air at, or in the Neighbourhood of Buxton; excepting upon a near Approach to the Substances separating them, and when the Air is little agitated by Wind.

To form a Judgment of the Quantity of Impurities in any Part of the Atmosphere, we must not only consider their Sources, but whether any Means exist in Nature of removing them. We have already considered the natural Means existing of purifying the Atmosphere of the Peake, from Air vitiated by Inflammation, Respiration, &c. called, perhaps improperly, phlogisticated Air, but we have reserved for this Place the Consideration of the Provisions in Nature for purifying atmospheric Air of Gas: For, as the

Quantity of this Substance continually separated or formed, and mixed with the Atmosphere, is very considerable, the common Air destined for the Support of Life and Inflammation, would probably be rendered incapable of serving for these Purposes, were there no Means provided of freeing the Atmosphere from this Impurity.

Vegetation has no Effect, as far as we know, of purifying the common Air of Gas, whatever may be the Effect of this Operation on other Impurities of the Atmosphere.

Air rendered impure by *Gas*, may be purified by fixt vegetable Alkali, as shown long ago by Dr. Hales; which Effect may be now explained by Mr. Bewly's Experiments (*i*), which demonstrate that mild Alkali, (a Substance composed of caustic Alkali united with Gas,) unites with Gas, and forms a neutral Salt. There have been also various other Substances discovered since the Experiments of Dr. Hales, which free Air of Gas when these two Substances are *diffused* through each other, or perhaps *combined* together. Among these Means of purifying Air of Gas, there is one existing in great Abundance, and which even makes no inconsiderable Part of the Globe itself, which there can be no Doubt in considering to have great Influence on this Impurity, provided these two Substances be placed under

(*i*) See Appendix to Dr. Priestley's Experiments and Observations, Vol. II.

Circumstances in which they exert their Attractions upon each other. This natural Means is the *Water* of Seas, Lakes, Rivers, Brooks, &c. It is upon this Ground only, Dr. Fordyce explains the Office of *Water* in Nature of purifying the Atmosphere; and he makes a most ingenious and original Observation upon this Subject, which enables us to understand clearly the Action of Water upon the common Air intended for Respiration and Inflammation, and to interpret various natural Phænomena. He observes that Gas, being much specifically heavier than Air, and not being united with it, must occupy, or be constantly tending to occupy, the lowest Parts of the Atmosphere, and consequently be more liable to be absorbed by Water upon the Surface of the Earth. This Property, together with the Agitation of the Atmosphere, and the Motion of these Waters, are Circumstances sufficient to produce a Combination of the Gas contained in the Atmosphere with the Water upon the Surface of the Earth.

Now considering that the Quantity of flowing Water upon the Surface of the Land in the Peake is not so great as in many other Countries; and that this Region is nearly in the Middle of the Island, between the German Ocean on one Side, and the Irish Sea on the other, we may infer, that the common Air of the mountainous Part of Derbyshire is, on this Account, liable to contain
a greater

a greater Quantity of Gas than many other Climates of this Island. Whether this be the Fact or not, must depend upon the Result of the Enquiry hereafter to be made, concerning other natural Means of separating Gas from the Atmosphere, or of diminishing its Effects as an Impurity.

There are many Substances in a State of *Fluidity* contained in the Atmosphere, but, of these, *Water* only is there *suspended* frequently and generally in Air that is respired, and by which Effects are known to be produced on the human Frame in every Part of the Earth.

In the Peake of Derbyshire the Atmosphere is more frequently blackish or dark-coloured, misty and foggy, and sensibly humid, or betokens Humidity or Dampness, by altering the Dimensions of Substances, more frequently than in the less eminent Countries adjacent.

Moreover, the Clouds, which are nothing but Portions of Air, with Water suspended in them, in this Tract of high Land, are suspended near the Surface of the Earth, and frequently rest upon the Summits of the Hills, or are intercepted in their Passage from one Part to another by the Mountains, against the Sides, or on the Tops of which they are frequently observed to rest. This humid or hazy Atmosphere, frequently prevails for several Weeks together in Summer. Either this State prevails, or the Transitions from a serene

rene to a cloudy Sky, happen almost daily; so that a Person, judging of the State of the Weather in this Country, according to what he has observed in less mountainous Regions, would be much deceived; for it is very common to have a dark black Morning threatening, according to usual Appearances, a rainy Day, although this Appearance soon changes into a serene Sky. The reverse of this as frequently happens.

It has been humourously said, on Account of the frequent cloudy Weather, “that the Sunshine is justly reckoned one of the Wonders of the Peake.”

I shall premise a few general Observations, after which there will be no Difficulty in explaining these Appearances of the Atmosphere, in the North Part of Derbyshire.

It has been before observed, that Air dissolves Water (*k*), or that Water is possibly a constituent Part of Air. Air containing Water in a State of *Solution*, is perfectly dry; and the most transparent Substance in Nature:—is that Substance which, of all Things, bends or refracts least the Rays of Light in their Passage through them.

The Law relating to Solution in Fluids, obtains with permanent Vapours, in so far as *the Quantity of Water a given Portion of Air can dissolve is, æt. par. in Proportion to its HEAT.* But there

(*k*) Phil. Transf. Vol. LV. Art. xxiii. on Evaporation, by Dr. Hamilton.

is, also, another Law governing Solution in permanent Vapours, which is, *that the Quantity of Fluid an assigned Portion of permanent Vapour can dissolve, is, cæt. par. in Proportion to its DENSITY.*

When a Menstruum is saturated with any Solvend, it may have any Portion of the Solvend diffused, or mixed with it. For Instance, after fixed Alkali is saturated with acetous Acid, any Portion of this Acid may be diffused through the neutral Salt formed of acetous Acid and fixed Alkali.

Dry Air which is saturated, or nearly saturated with Water, and denser, and nearly as warm or warmer than the Atmosphere of the Peake, when blown into this Country, will be pretty certainly rendered less dense, and most probably, be cooled; in Consequence of which, the solvent Powers of this Air being diminished, it will be apt to precipitate Water; and if only such a Diminution of these Powers take Place, as to precipitate a Portion of Water that shall not be able to overcome by its Gravity the Cohesion of the Air, it will remain suspended, and produce a humid, and less transparent or turbid State of the Atmosphere. This rainy or foggy Weather may happen, whenever the Wind blows from any Point of the Compass, excepting that which carries Air from the Northward directly along the Course of the Anglo-Appennine, and continue for several Weeks, provided Air of the Properties, and from the Points
of

of the Compass above-mentioned, be blown during such a Time into the Peake.

The alternate States of transparent and cloudy Skies, that take Place almost daily in Summer, are probably occasioned by the warmer and denser Air of the Vales being blown over the higher Land. The Air from these Places, may be considered as only *Portions* of such Air as were above stated to be blown for a longer Time; and consequently their Effects are only of a short Duration.

The Atmosphere is only able to support Clouds for a certain Height, above the Level of the Sea. In Countries where the Altitude of the Land is considerably above the Level of the Sea, Clouds are apt to creep near, or upon, the Surface of the Ground; and in their Passage through the Atmosphere, are liable to be intercepted and attracted, by the Summits, or Sides of the Mountains; therefore, as the Peake is much higher in the Atmosphere than the Land of the neighbouring Countries, the Hills are frequently observed to have Clouds resting against their Sides, and crowning their Tops. The turbid State of the Atmosphere in this Region, and the Appearances in Consequence of this State, agree with those of the Atmosphere of other elevated Tracts of Land; in which, also, the Water suspended in the Air, hath been observed by hygrometrical Observations.

As it has been long observed, that the human Constitution, both in Health and Disease, is much affected, in many Cases, by Moisture of the Atmosphere, it will be necessary, that the Effects of this humid State of the Air of the Peake, be considered in Practice.

Besides the above-mentioned Substances, which are *diffused* through the Atmosphere, of probably, every Part of the Globe, there are a great Number of fossil Substances; to wit, Acids, Alkalies, Earths, metallic Substances, and Inflammables; also, various Kinds of permanent Vapours, with the Properties of which, we are not acquainted, to be able to refer them to any particular Species of Things; liable to be contained in the Atmosphere, and in that Vehicle to affect human Health.

The great Source of almost all these Substances is *Volcanos*; preceding, and during the Eruption of which, the Air has been so affected as to poison Birds and other Animals, in the Vicinity of these grand and wonderful Appearances of Nature.

The second general Source is, the Practice of various *mechanical Arts*, by which a Variety of Substances, poisonous or hurtful to animal and vegetable Life, are mixed with the Air of the Atmosphere. We have Examples of this Fact in Derbyshire, where the Air is impregnated to so great a Degree, with various fossil Substances, but principally with Calx of Lead, near the Furnaces

naces for smelting the Ores of Lead, that Vegetables are either destroyed, or grow near them in a weak and sickly Manner.

But the Effects of these Agents, in contaminating the Atmosphere, by mixing therewith various Bodies, are not extensive, and only prove noxious to Life and Health near the Place of their Separation; for they are at greater Distances, either deposited by their Gravity upon the Surface of the Earth, or are absorbed by Water; or else they are so diluted, by being diffused through a large Part of the Atmosphere, as to be innocent in their Consequences.

It has been rendered extremely probable, if it be not demonstrable, that there are various Species of *Animals* which have their Birth, and which grow and live *in the Atmosphere* of particular Regions; but the Effects of these animated Beings, Natives and Inhabitants of the Air, on human Systems, are not known.

But, of all the Substances *suspended* in the Atmosphere yet known, the Properties of those Things which are the efficient Cause of epidemic, and many contagious Diseases, *Miasmata*, are of the greatest Importance to be understood. These *Occasions* of Diseases, are Substances *suspended* in the Atmosphere, and generated especially in fenny and marshy Grounds; certain Soils, under particular Circumstances of Moisture; Rivers, when exhausted of a great Part of their natural Quantity
of

of Water ; and by the Putrefaction of animal or vegetable Substances, in which is comprehended foul or confined Air, accompanied with peculiar Circumstances.

These *Miasmata*, which have the above-mentioned Origin, occasion intermittent, and various Species of continued Fevers, the Plague, &c. but we do not know more of the Properties of these Substances, than their *Source* and *Effects in producing Diseases* ; for we are ignorant whether they be Solids, Fluids, or permanent Vapours ; nor are we acquainted with their Taste, Smell, Colour, or, in short, with any Part of their chymical History. It is probable their Bulk is not so great, as that their Existence in any Part of the Atmosphere may be discovered by the Test of nitrous Gas ; and hence, as before observed, Air containing an unusually small Portion of all extraneous Matters, excepting those we are treating of, would not, on that Account, require less nitrous Gas to saturate it, but Air of an Atmosphere innocent in its Effects, containing a larger Quantity of *the Air united with Phlogiston*, and other extraneous Matters, would be saturated by a smaller Quantity of nitrous Gas : Therefore, by the Effects of this Test, as hitherto mentioned by Observers, we should draw false Conclusions.

It doth not appear, that the Moor-Land of Derbyshire begets any efficient Cause of Fevers, or other epidemic Disorders : So that the contagious

gious Diseases which appear in this Country, are either generated by Putrefaction, or they are imported from other Regions. It has been observed, by several Practitioners, that intermittent Fevers in particular, never make their Appearance in the Peake. There is a particular Disease in this Country called *the Derby-Neck*, but by what efficient Cause it is produced, I have not learnt.

It is not improbable, that *Matters separated from Animals and Vegetables in the Performance of their Functions*, may affect the human Frame, when conveyed by the Air of the Atmosphere, as well as the State of *Electricity* of the ambient Air; and also some *phosphoric Vapours*; but the Effects of these Substances on livings Animals have not been investigated, and therefore we can make no practical Inferences.

Moreover *Light*, whether considered as an *Emanation*, or as a *Vibration* of an ethereal Substance excited by the Sun, is not produced in such *Quantity* in the Peake, as in less mountainous Countries in the same Latitude, on Account of the State of the Air of this Region above-described. But of the Effects of this Substance or Property on Health or diseased Habits, we have no Observations.

C H A P. V.

The Quantity, Frequency, and Form of Water passing through the Atmosphere to the Surface of the Earth.

THE uniform Observation of Persons who have resided in the Peake, as well as the Inference that naturally follows concerning mountainous Regions is, *that a much greater Quantity of Rain, and also Snow, falls in this Country, than in the less elevated Lands adjacent.*

About Buxton, and, I imagine, also in the other Parts of the high Peake, in the Summer Months, it is common to have an incessant Fall of *Rain* for many Weeks successively; but about Matlock, where the Moorland is of much less Altitude than the Part just mentioned, I am told, this Appearance never, or very rarely happens. This Fact is worthy of particular Attention. During the Summer Months, if there are not incessant Rains for many Weeks together, there are many rainy Days, and very frequent Showers, in the whole Peake: About Buxton, in particular, there is, in this Season, scarcely a showerless Day. For the most Part, these Showers are sudden in their Appearance, oftentimes scarcely announced by a previous Obscurity of the Heavens, and are as suddenly succeeded by a serene Sky.

Much Water is precipitated also in the Form of *Fogs* or *Mists*. In a Summer-Morning, particularly, the Summits of the Hills are seen to *reek*, as it were, with Fogs, exactly like the Smoke from a large Fire ascending out of a Chimney.

In the Winter and the Spring-Months there is a considerable Quantity of *Snow*, far exceeding both in Quantity and in the Time it remains upon the Earth in that Form, that which falls on the neighbouring less elevated Land.

Water also falls very frequently in the estival and autumnal Months, as well as in other Seasons, in the Form of *Hail*.

The peculiar Occasion of these Appearances may be readily understood, by applying the Principles laid down to explain the Humidity of the Atmosphere of the Peake, p. 123, 144.

When the Water falls in a *fluid State* in continued Rains, or Showers; or in a *solid* and *crystallized State* in Snow and Hail, the humid Air saturated with Water wafted into the Peake, is rarified, and also cooled to such a Degree, as to occasion a more copious Precipitation than happened in order to produce moist Air; so that the Particles of Water unite in Masses capable of passing through the Atmosphere to the Earth by their Gravity, in Opposition to the Attraction of Cohesion, or Viscidity of the Air. If the Temperature of the Atmosphere when the Water is precipitated, and through which it passes, be not

of less Heat than about 32° Degrees of Fah. Ther. it falls in a *fluid State*, or it rains; but in less than that Heat it is a *crystallized Solid*, and is precipitated in the Form of Snow.

Hail is supposed to be Snow rendered partially fluid in its Passage to the Earth, and several Masses of this partially melted Snow, united again, rendered solid, and crystallized in a different Form.

Dew is occasioned by the Earth, heated by the Sun after a Summer's Day, evaporating Water; which from the Coolness of the Evening Air, and in the Night, is only suspended; and in such Quantity as occasions the Particles to unite, and fall to the Earth.

The *Reeking* of the Summits of the Hills, is owing to the Evaporation of Water, from particular moist or wet Spots upon their Tops, into the incumbent cool, and rare Air, by which it is condensed into a Column of Fog, that disappears a few Hours after Sun-rise, by the Air being then sufficiently heated to dissolve the Water that evaporated from the wet Places.

The Reader will not be at a Loss to account for the Manner in which so large a Quantity of Water precipitated from the Atmosphere is disposed of, when he recollects, that it gives Rise in this, and other Parts of the English Appennine, to almost all the Rivers that flow into the Irish Sea on one Side of it, and the German Ocean on the other.

other. *One of the chief Uses of this Ridge of high Land seemingly is, to precipitate Water from the Air blown over the Island, for the Utility of the adjacent less elevated Regions.*

Practitioners in directing Patients to live in certain Climates, will find it necessary to consider the Influence arising from long continued or daily Precipitations of Water. Water contained in the Atmosphere in a *suspended State*, and also Water frequently falling through the Atmosphere in a *fluid Form* to the Surface of the Earth, will have the Effect of uniting with Gas diffused through the common Air; and consequently, from the frequent humid States, and almost daily Precipitations of Water in Rain, we may justly conclude, the atmospheric Air of this Region to be more free of Impurity arising from Gas contained therein in a State of Suspension, than in Countries where contrary States of the Atmosphere prevail. Moreover, Water will combine with or wash off almost every Kind of Substance *suspended* in the Atmosphere, excepting Water; so that, on this Account, we should expect to find *the Moor-Land Air of this Region void of almost all extraneous Substances, excepting Water*; a Circumstance never before, as far as I know, suggested.

C H A P. VI.

The Motion of the Atmosphere.

THE continued Rains, or the rainy and showery Days, and the alternate clear and dark Skies, in the Peake, are commonly preceded and accompanied by *Wind*.

We want Observations to instruct us, from what particular Points of the Compass the Winds blow at particular Times; and what may be their Duration, Succession, and Degree.

Winds accompanying or preceding the continued Rains, and rainy Days, proceed, in all Probability, from the general Causes of Winds of this Island; but the Winds preceding and attending the sudden Precipitations of Water from small Portions of the Atmosphere, probably blow from all Points of the Compass, and arise from local Causes.

The frequent Winds along with Showers, are generally sudden in their Appearance, and blow with great Briskness or Violence; so that they are often *Gusts* and *Storms*, that before, or with, the ceasing of the Showers, are succeeded by Calms, and serene Weather.

The Atmosphere of the Peake then, is with some Degree of Constancy, either well ventilated by Currents of Air, from the subjacent Lands and

and Seas, or by partial Motions of the Air, from Causes subsisting within this Region of high Land.

The Effects of the Winds, or Agitation of the Atmosphere, have been much noticed by the most antient Writers, especially by those who have written upon pestilential Diseases.

Some Winds are observed to excite epidemic and contagious Diseases; others, to interrupt or dispel them. The large Fires in the open Air, employed (1) so frequently in Times of contagious Diseases, to prevent their Progress, appear to have that Effect, by exciting an artificial Wind, rather than by any Thing added to, or destroyed in the Atmosphere, during the burning of Substances.

It may at first Sight appear, that as much Mischief may be done as is removed by blowing Weather; but the Winds, which are the Vehicle of the *Occasions* of Diseases, can scarcely be classed among those brisk Winds, which blow so frequently in mountainous Regions, nor are they accompanied with such Quantities of Rain; therefore it may be inferred, that *the Winds, by diffusing any noxious Substances, whether they be Solids, Fluids, or permanent Vapours, through the general Mass of the*

(1) “ *Hippocrates, cum ab Illyria pestis Græcis immineret, accensis Sylvis eam avertit, qua de Causa Græcia ei statuam pileo capite tecto locavit æqualesque cum Hercule Hippocrati Honores decrevit, quod ceu alter Hercules Monstrorum Dominator, pestem à Græcia averterit.*”—*Sennertus.*

Atmosphere; as well as Rain, by washing them off, combining with, or, perhaps, decomposing them, render the Atmosphere of the Peake more pure or free from extraneous Substances, than the less elevated Countries; and consequently, the Physician will have a Ground for his Conduct in the Treatment of Diseases, founded upon the Consideration of the Purity of the Air of this Region, arising from these Circumstances.

We have now stated the particular Properties of the Atmosphere of *the Southern Extremity of the British Appennine*, or the Moor-Land of Derbyshire, with the View of distinguishing the Effects of Buxton-Water from those of the Atmosphere; and of furnishing Practitioners with a better Foundation for Practice, than mere Conjecture.

Further Grounds of Practice might have been obtained, by a *History of the Health of the Natives of the Peake*, viz. their Form; the peculiar State of the Functions of the Body and Mind; their Fecundity; Diseases; Duration of Life, &c. But a farther Prosecution of this Subject, was not consistent with my other Engagements. I must not omit, that it is a general Opinion, that the Air of this Part of Derbyshire is favourable to long Life; but whether the Fact upon Enquiry would be, an unusual Number of People who have lived to great Ages, I have not been able to learn. If, however, this should prove to be the Truth, the Inference would not be fair, that the

Lives

Lives of Natives of different Regions might be protracted, by transporting themselves into this Country. It is found, that the Atmosphere in which a Person is born, of whatever Nature it be, is often capable of restoring Health, that is, enjoyed indifferently, in what are reckoned more salubrious Climates :

“ ————— Custom moulds
 “ To ev’ry Clime the soft Promethean Clay :
 “ And he who first the Fogs of Essex breath’d,
 “ (So kind is native Air) may in the Fens
 “ Of Essex, from inveterate Ills revive,
 “ At pure Montpelier or Bermuda caught.”

ARMSTRONG.

It is also an Observation made by the Antients, and which has been found by Physicians in subsequent Ages to be perfectly just, that *Change of Climate* (*m*) is favourable to the Restoration of Health, independent of any Considerations with Respect to the different salubrious Qualities of the Atmosphere of various Regions ; and as the Atmosphere of the Peake is, on many Accounts, very different in its Properties from almost all other Countries of this Island, a Removal into it may be, on this Ground, very frequently a Means of removing Diseases.

(*m*) “ Pessimum ægro est Cœlum, quod ægrum fecit ; adeo ut in id quoque Genus, quod Naturâ pejus est, in hoc statu Salubris Mutatio sit.”—*Celsus*.

The

The Inferences I have made from the preceding Histories are but few, because the Limits of this Work did not admit them: and I rather chuse each Physician to make the Application his own Judgment suggests, than to be liberal of my own practical Decisions.

I shall just point out further, that in forming a Judgment of the Application of the Mountain-Air of the Peake, not only *the Effect of its particular Properties should be considered singly, but of the whole in Conjunction.*

Being now instructed in some Knowledge of the external Form, and internal Structure and Properties of the Earth, we shall be better qualified to attempt the second Part of this Work,

P A R T II.

HISTORY OF THE CHYMICAL QUALITIES
OF THE TEPID WATERS OF BUXTON.

S E C T I O N I.

Of the Properties of the tepid Waters of Buxton, that are discovered immediately by the external Senses, and of their Temperature and specific Gravity, as they appear experimentally. To which is premised, a Description of the external Form of the Country, and of the Structure and Contents of the Earth, at and environing Buxton; also, various Particulars relating to the Number and Situation of these tepid Springs.

THE tepid Springs of Buxton arise out of the Earth in a Vale, environed by hilly, or more properly, uneven wavy Land; on the South Side of the Rivulet *Wye*, within the Distance of forty or fifty Yards from each other, and about half a Mile from the Source of this Rivulet; or, perhaps, more accurately speaking, of the Part where it bursts from the natural subterraneous Passage that conveys it from *Ax-Edge* to this Vale.

The uppermost Stratum on the South Side of the above Rivulet is the *first*, or *black Lime-Stone*;

Stone; which has been burnt, Time immemorially, to Quick-Lime, on an adjacent Hill, as appears from the large Groupe of whitish conical Heaps of Lime-Stone-Kilns, and Rubbish, left after burning this Stone to Quick-Lime.

This Stratum is covered in some Parts with Fragments of Shale, of a few Feet in Thickness, and perhaps, also, by the Clay of which Bricks are made in the above Vale.

On the North Side of this Rivulet, the superior Stratum is first *Shale*, but after ascending towards the Summit of the Hill on this Side the *Wye*, it is *Grit-Stone*, incumbent on this Shale and the other Strata before fully described, that constitute "the Crust of the Earth" in the Peake.

The loose Stones in the Rivulet in this Part of the Vale, are chiefly rounded or broken Masses of Iron-Stone, some of which are entitled to the Appellation of Iron-Ores. It appears, that the Earth for a short Distance on each Side, and under the *Wye* at Buxton, does not consist of the above-described Strata on each Side of this Rivulet, but is composed of loose Masses of Stone, which are seemingly Part of the Strata natural to this Region broken to Pieces: So that the Strata on each Side of the *Wye*, or Vale through which it runs, are separated from each other by, apparently, a Chasm that has extended nearly through the Middle of this Vale filled
up

up with fractured or loose Masses of Stone, called *Rubble*; over which Chasm the Rivulet flows, and upon which the new Building, the *Crescent*, and other Houses are erected.

The Deficiency of the Stratum of Grit-Stone and Shale on the South Side of the Wye, and their Appearance on the North Side of this Rivulet, indicate, that a Fracture of the Earth has here happened, which has removed the two superior Strata in one Part. The original or horizontal Position of these Strata has been also changed; for on digging into the Earth, the inclined Position of the Strata has been observed;—on the South Side they are so considerably inclined, that at about a Mile South of Buxton on the Ashburne Road, the first Toad-Stone *bassets* or becomes the most superior Stratum; and were the Rubble that now fills up the Chasm in this Vale removed, and the Strata on each Side of it brought into Contact with each other, the first Lime-Stone on the South Side of the Wye would touch the Stratum of Shale on the opposite Side; and the first Toad-Stone on the South Side, would be in Contact with the first Lime-Stone of the North Side. As Part of the Stratum of Grit-Stone is wanting immediately on the North Side of the Rivulet at Buxton, the uppermost Stratum to a certain Distance from the Rivulet on the North Side is Shale, after which towards the Summit of the Mountain it is Grit-Stone. See Plate I.

The

The Soil of the Land in this Vale is barren, but cultivated for Pasturage and Hay; is woodless, and fenced with Walls of Lime-Stone.

The Aspect of this Region, from the Summits of the surrounding or contiguous Hills, is an extensive Tract of wavy Moor-Land without Trees, Shrubs, or Fences, excepting some blackish Stone Walls in a few Parts; and on any of these eminent Places, it appears to the Beholder as if the Spot on which he is placed were environed with a Chain of hilly Land: So that the Face of Nature is as dreary and joyless in this, as in most other Parts of the Peake.

If we accompany the Rivulet Wye in its winding Course in a pebbled Channel for a few Miles, we pass through Vales, not unfruitful in Herbs for Pasturage, between Cliffs among Lime-Stone Rocks, or through *Ravines* partially cloathed with various Shrubs and Trees of the Forest, so as to afford a Diversity of agreeable and romantic Pieces of Scenery. There is at present no Road through the Tract I am describing, but with no great Labour a Path might be made for two Horses to travel abreast; and, after consulting the Genius of the Place, a Man of Taste might, without considerable Expence, compose natural Scenes far more pleasing than the present State of Nature affords. A Work of this Kind has been in Contemplation, but is not likely to be soon executed, although it would be of obvious

vidous Advantage to those who repair to Buxton for the Restoration of their Health, and also be profitable to the Owners of Estates.

The only Consolation to the Invalid in his Airings at Buxton is, at present, that of breathing pure Air, and travelling on good Roads. The Countenance of Nature here being naturally gloomy, it excites in many Constitutions very unpleasing Sensations. This Climate is, indeed, execrable on this Account to the unhappy Hypochondriac. As it will scarcely be doubted, that the good Effects of Exercise are much increased when accompanied with pleasing Scenes of Nature, it is greatly desiderated to render the Aspect of the Country near Buxton agreeable, or to make it at least less gloomy and uncomfortable. The Means of attaining so desirable an End, are not so difficult as may at first be imagined. — I have purposely said more upon this Subject, on Account of the Cultivation and ornamenting of the neighbouring Grounds, bearing so inconsiderable a Proportion to the various Kinds of convenient and agreeable Accommodation for the Reception of Visitors to Buxton.

The Rise of the River Wye near Buxton, or more properly its first Appearance after flowing through a natural subterraneous Passage from Ax-Edge, its Course to the Derwent at Rowsley, and, in Conjunction with this and other Rivers, to Matlock, denote *the superior Altitude of this*
Part

Part of the Peake to that of Matlock, and the other Traëts of high Land through which it runs (n).

The tepid Springs of Buxton issue out of the Bowels of the Earth, either through Fissures in the Lime-Stone upon the Surface, or from the Rubble covering some Part of this Stratum.

Several of these supply new Saint Anne's Well in the same Manner described Page 9 (o).

On inspecting the Bath, called the *Gentleman's Bath*, when emptied, it appeared that it was supplied, principally, by the Water issuing from one or two Fissures in the Lime-Stone Stratum at the South-East Side of the Bath, where it is not paved. It is also usually reckoned, that several small Springs ooze through the Seams of the flat Stones of the Floor of this Bath.

These Springs are said to fill the Bath to its ordinary Depth, or about five Feet, in 50 Minutes. It was two Hours and 50 Minutes before this Bath

(n) The Mountain Ax-Edge, in which is the Source of the *Dove* and *Wye*, is about 1100 Feet above the Level of the Ground at Buxton-Hall; and Buxton-Hall is 1000 Feet or thereabouts higher than Derby: So that the Column of Quicksilver in the Barometer-Tube is always one Inch lower at Buxton than at Derby, at the same Time and under similar Circumstances. For this Fact I am obliged to my Friend Mr. Whitehurst, who made the Observations which ascertained it.

(o) According to Dr. Short's Observations and Calculation, these Springs throw out 390 Gallons of Water in an Hour. P. 4. of Dr. Short's Work.

was

was filled by its Springs, according to my Observation; but during this Time they flowed also into the two adjoining Baths, neither of which contains so much Water as the Gentleman's Bath. This Bath measured 25 Feet 6 Inches in Length, 12 Feet 8 Inches in Breadth, and the average Depth was 4 Feet 10 Inches, therefore it contained 2,697,696 cubic Inches, and $9,566 \frac{84}{282}$ Ale Gallons of Water.

Some calculate, that these Springs throw out Water at the Rate of 60 Gallons a Minute.

If we suppose two and a half Times the Quantity of Water I found to be contained in the Gentleman's Bath, to have flowed into the three Baths in the two Hours and fifty Minutes I observed it required to fill one of these Baths; then the whole Quantity flowing from these Springs in the above Time, was about 23,916 Ale Gallons, or about 8,440 hourly, and nearly 140 Ale Gallons a Minute. Perhaps, however, I might be as near the Truth, by supposing only twice the Quantity found to be contained in the Gentleman's Bath, to have flowed into the three Baths in two Hours and fifty Minutes, for the above Quantity of two and a half Times its Bulk, is, I suspect, too great.

Besides the Gentleman's Bath, there is a *Bath for the Ladies*, and a *Bath for the Use of the Poor*; which are supplied by small Streams that

L

flow

flow through the Seams of the Pavement of each of them.

These are the only Branches of the tepid Spring now in Use, and many of them are observed to rise *perpendicularly* out of the Earth. The other tepid Streams, which were probably never made use of, are concealed from View naturally, or by Art; and are, chiefly, in the Earth between the *Hall* and the *Crescent*; also, under the South-West End of this last Building, and perhaps to a greater Distance Eastward of the *Hall*.

Tepid Water was raised two or three Years ago, by a Pump placed against the Outside of the Hall, upon the Foot-Road leading from the Hall to the Well, and was drank during the Time of making the Alterations in the Situation of the Well; but it is now disused.

This Water was not from a separate Spring, as some affirmed, but from the Spring which supplies the Bath before it breaks through the Fissure of the Rock in the *Gentleman's Bath*.

Bingham, or *Leigh's Well*, formerly in Use, is now, I believe, covered by some Work-Shops, erected for the Convenience of carrying forward the Building of the *Crescent*.

There are many *cold Springs* on the South Side of the Rivulet *Wye*, in the Vale near where the Streams of the
tepid

tepid Springs rise, and even in the Spaces of Land between them.

Also, about half a Mile South-West of the *Hall*, in the same Vale, there is a Spring of a much greater Heat than that of the cold Springs of this or other Regions in general; and from which a *permanent Vapour* separates itself in the same Manner, and of the same Kind, as that of the tepid Springs near the *Hall* at Buxton; excepting upon one Occasion, when I found it was mixed with Air.

At this Spring-Head in the Summer 1782, not having with me a proper Instrument for measuring permanent Vapours, I mixed about an Ounce Measure of the Bubbles that arise spontaneously from this Spring, with an equal Bulk of nitrous Gas, in a four Ounce Bottle. The Mixture was at first turbid, and, upon Agitation, Water rose evidently above the Mark denoting two of these Measures mixt together; but upon a Repetition of this Experiment with an Eudiometer, no turbid Appearance or Diminution of Bulk of the two Measures were observed. This Spring would very probably be of the same Temperature, and have the same Properties as the other tepid Springs, could they be procured without an Admixture with the contiguous cold Springs.

The above-mentioned cold Springs are all, or most of them, hard Waters; are not petrifying, and are without Taste, Colour, or Smell. I neglected to

enquire whether they deposit Earth, copiously, like the tepid Waters of Buxton, in boiling. Their Temperature, ascertained by two Thermometers, graduated with Fahrenheit's Scale, between the Hours of 8 and 10 A. M. when the Heat of the Atmosphere was 54° to 57° , was as follows.

The Cold Spring near the Angel-Inn	$47^{\circ} \frac{1}{2}$,
— Pump-Water adjoining St. Anne's Well	49° ,
— Cold Springs in the Meadows } South-West of the <i>Hall</i> —	47° to 49° ,
— Rivulet Wye about 50 Yards } from its Source — —	
— Ditto, at Fairfield Bridge —	51° ,
— Cold Spring, adjoining to, and mixed with, the tepid Spring, half a Mile South-West of the <i>Hall</i> at Bux- ton, in a Meadow belonging to Dr. Norton, of Macclesfield; Tempera- ture according to the Part examined	50° to 55° ,
— <i>Tepid Spring</i> , into which a Part } of the last mentioned Spring flowed	
— Cold Springs and petrifying Springs } a few Miles from Buxton —	48° to 49° .

On the North Side of the Rivulet, near the Bridge at Buxton, there is a cold Spring, which contains *Iron* dissolved by *vitriolic Acid*, that decomposes spontaneously upon Exposure to the Air, and therefore it tinges the Bason in which it is received of a brownish Colour. The Temperature of this Spring was various, according to
the

the State of the Air, because a Quantity of it is exposed to the Influence of the Heat of the Atmosphere, after it springs out of the Ground: Its Heat varied from 52° to 55° . This Spring issues from the Stratum of Shale, and has been already mentioned in a former Part of this Work, as an Instance of this Stratum abounding with chalybeate Springs.

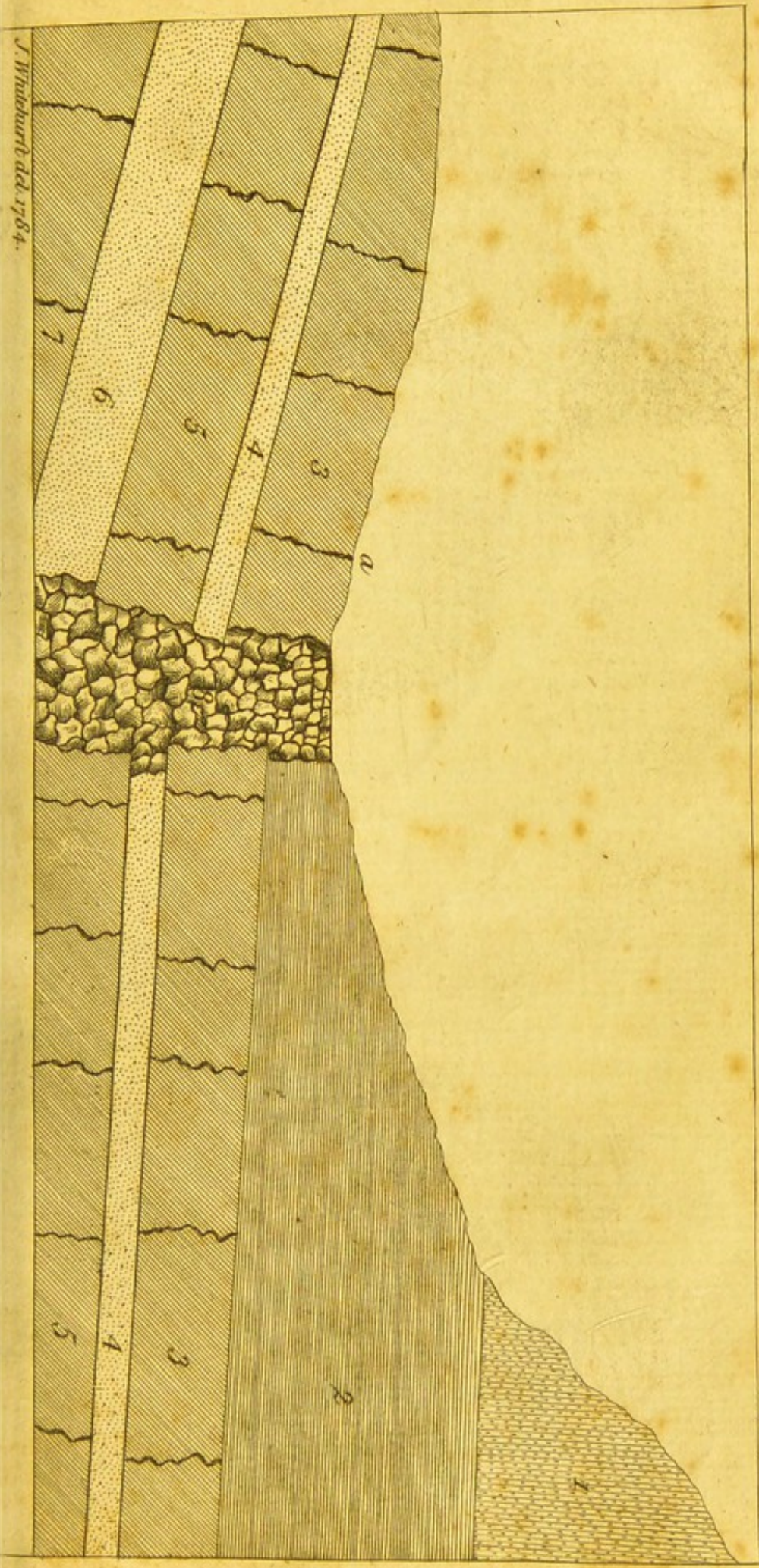
In order to convey to my Readers more fully and clearly the Knowledge of the internal Structure and Contents of the Earth at Buxton whence the tepid Springs rise, I have inserted the following accurate Representation of the Strata at this Place, engraved from a Drawing with which I was favoured by my ingenious and worthy Friend Mr. Whitehurst, for which I acknowledge myself greatly beholden to him. I experience great Satisfaction in giving this Plate to the Public, not only because it is capable of communicating more just and compleat Ideas of the subterraneous Geography of this Country than could be conveyed by Words, but because it affords an Example of the interior State of the Earth throughout the whole Peake, and perhaps throughout the whole Anglo-Appennine; and which will therefore be an excellent Illustration of the Description of the Structure and Contents of the Earth of the Peake, given Sect. V. p. 34. and Sect. VI. p. 43. of this Work.

EXPLANATION OF PLATE I.

1. Grit-Stone, 120 Yards in Thickness.
2. Shale, 120 Yards thick.
3. First Lime-Stone, 50 Yards in Thickness.
4. First Toad-Stone, 16 Yards thick.
5. Second Lime-Stone, in Thickness 50 Yards.
6. Second Toad-Stone, 46 Yards thick.
7. Third Lime-Stone, 60 Yards.
8. The Part of the Earth that consists of *Rubble*, which appears to be Fragments of the Strata 1, 2, 3, 4, &c. on each Side of it. In this Part the Earth has probably been rent, and a Chasm formed, which has been filled up with Pieces of the Strata broken to Pieces.
- a. The Situation of the tepid Springs, and Manner in which they may be conceived to rise out of the Earth from the Toad-Stone Strata, perpendicularly through the Lime-Stone Beds.

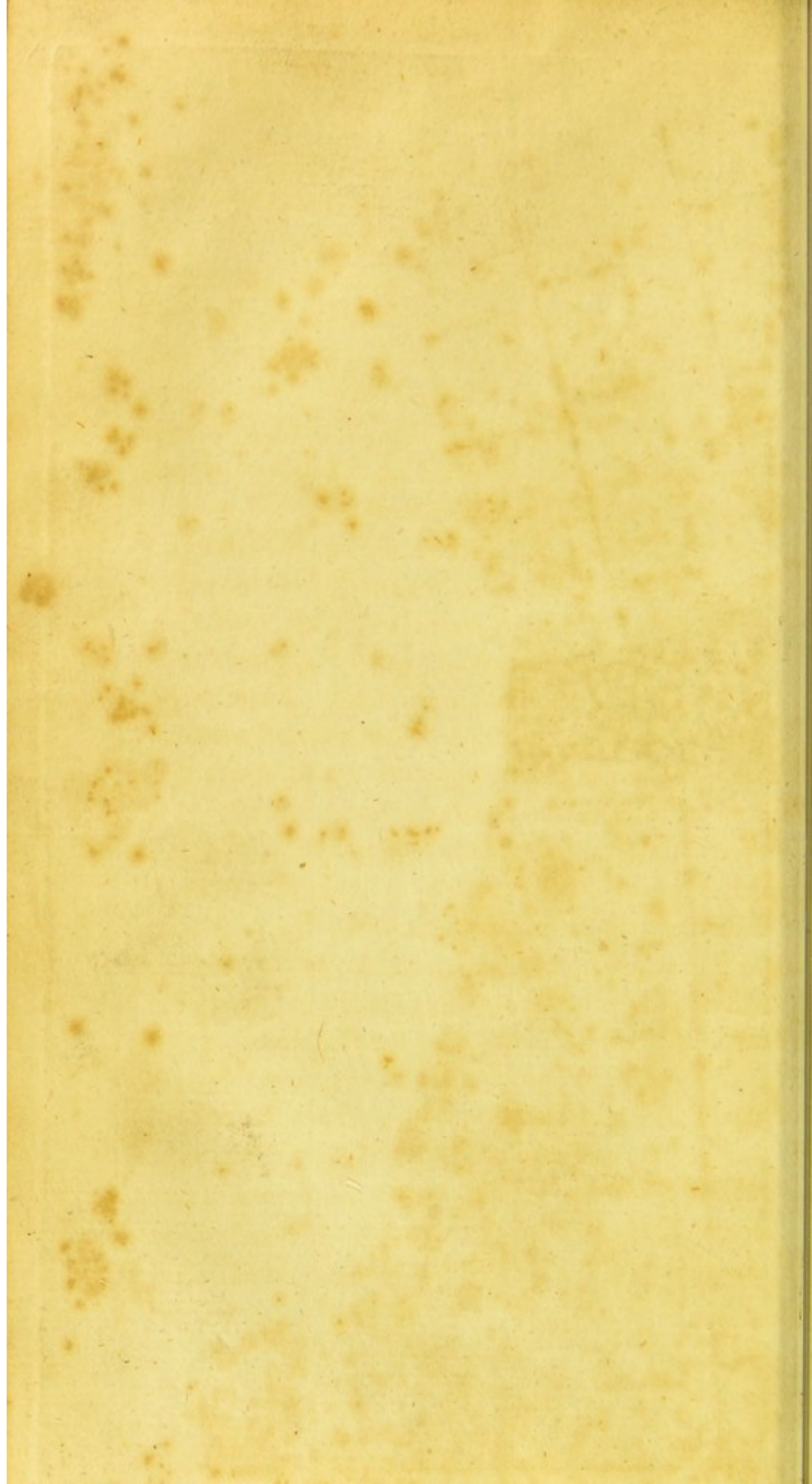
As the Properties of the tepid Springs of Buxton are all, apparently, precisely the same, the History of one of them may be considered as an Example of any of the rest.

When this tepid Water is taken fresh from the Spring, and viewed in a Glass-Vessel, it is of a *crystalline Transparency* and *colourless*: Also when a large Bulk of it is viewed together, as that contained in the Baths, where it is four or five Feet in Depth, it is *colourless*, and refracts the Rays



J. Whitehurst del. 1784.

to Front p. 150 Vol. I.



Rays of Light so little that Objects may be seen through it of their customary Appearance, provided it be in a State of Rest.

However, when the Bath is agitated, as by the plunging of Bathers, it is instantly changed from a State of Transparency to that of *Turbidness*; but as soon as the Commotion subsides, it becomes instantly clear as before. This turbid Appearance has been mistaken for Filth deposited on the Pavement of the Bath, and stirred up and mixed with the Water; but it certainly is not occasioned by this Circumstance, because it may be produced at all Times, even immediately after the Bath has been washed clean, and when there is no Sediment to be observed in the Bath. Moreover, Glass Vessels were filled with this seemingly muddy Water, and it appeared perfectly clear; nor did it deposit any Sediment on standing.

A little Attention readily suggested an Explanation of this Phenomenon. The Rays of Light enter the Bath Room through a Window near the Top of it, and pass through the Air of the Room, and also through the Water, when in a State of Rest, without suffering any considerable Inflection in their Passage from the rarer into the denser Medium, therefore produce no Colour: But when the Water is agitated, and its Parts or Portions of it are moved with Rapidity against each other in a Variety of Directions, the Rays are broken into numberless Parts, and variously inflected up-

on the Surface of, and within the Water; by which Means Rays of all Colours are occasioned, viz. red, yellow, and blue; which, being blended together, reflect the whitish or grey Colour of the Water; as soon as the Commotion subsides, the Rays of Light pass through the Water as before, without any considerable Refraction, and therefore the Bath resumes its Transparency. This Phenomenon is then a mere *Deceptio Visus*.

Some have asserted in Conversation, that this tepid Water is of a bluish Cast; and have mentioned this Property to show, that it contained Copper; but I am confident, there is no Substance in this Water occasioning any Colour; and whenever it has reflected any coloured Rays, they have depended upon some Circumstances variously refracting them, independent of any Impregnation of this Fluid.

This crystalline Fluid contained in Vessels, commonly immediately after being drawn from the Spring, and always on standing in a temperate Heat of the Atmosphere, exhibits *bright Bubbles*, apparently of some permanent Vapour, of the Size of the smallest Pin's Head, adhering to the Sides of the Vessel, or whatever is immersed in it.

The Baths contain these Bubbles in every Part of them, especially upon a little Agitation. Moreover, *Streams* or *Clusters* of these Bubbles, of various Sizes, from the Magnitude of the smallest Pin's Head to the Bulk of a Cherry, or even
sometimes

sometimes of a Billiard Ball, every now and then break out from the small Holes and Vacuities between the Stones that compose the Pavement of the Baths, and dart perpendicularly upwards through the whole Thickness of the Water to its Surface, where they burst and vanish in the Atmosphere.

These Bubbles also adhere frequently to the Skin of Persons bathing, where they excite a prurient Sensation.

If the Bubbles that adhere to Vessels containing this Water after standing, be shook off, a fresh set of them will collect on further standing; which may be detached as the former, and in this Manner do they collect for several Times: But after a certain Number of these Particles have thus separated themselves, the Portion of Water that yielded them will manifest them no further, however long it be left to stand in the same Temperature of the Atmosphere as on its first Exposure.

But in a Portion of Water that has ceased to manifest Bubbles in a temperate Heat, by exposing it to greater Degrees of Heat, they will again appear; and after detaching a certain Quantity, however long the Heat be applied, no more can be procured.

I am not certain, if this Water does not become *less transparent* by standing in open or closed Vessels, in temperate Degrees of Heat of the Atmosphere; but no Sediment can be perceived to be
thereby

thereby deposited; nor does it deposit any Earth, where it runs in its accustomed Channels upon the Surface of the Ground.

The Bath-Rooms are observed, I believe, at all Seasons, to be filled with *Steam*, provided the Doors have been shut some Time before, but in greater Quantity in cold than warm Weather.

Frequently a Stratum of *Steam* is incumbent upon the Well; which Appearance is observed commonly at all Seasons early in the Morning, or late in the Evening; generally at all Times of the Day and Night when the Weather is cool; and always when the Air feels cold, or when very moist; but most copiously when Cold and Moisture of the Atmosphere are conjoined, and when the Air is sufficiently cold to congeal Water. When the Steam is observed to sit upon the Well in the Day-Time in temperate Weather, it has been found to be a pretty certain Forerunner of Rain at Buxton, or in its Neighbourhood.

I have never perceived any *Smell* from this Fluid; nor will it become fetid by standing, as some have asserted, in any Degree of Heat, provided the Vessels in which it is preserved be perfectly free from extraneous Substances; but if a minute Portion of animal or vegetable Matter, as a Portion of Cork or Shred of Bladder, be mixed therewith, it will, like other Spring-Water, acquire a fetid Smell after a certain Time. Water is a fermentable Substance with $\frac{1}{360}$ of its Weight
of

of animal or vegetable Matter ; and on this Account the Thames, and some other River-Waters, undergo the putrefactive Fermentation.

Buxton-Water is perfectly *insipid* ; in particular, it has not the slightest *acidulous Taste*, but it is rather *warm* to the Palate ; at least it is much *less cool* than ordinary Spring-Water.

This Water feels rather *hard* or rough when rubbed between the Hands and Fingers, like ordinary hard Waters that decompose Soap. When the human Body is immersed in Buxton-Water, it commonly excites a gentle Shock by the *Sensation of Cold* it produces, which, in a few Seconds, is succeeded by a Feeling of agreeable Coolness, or of a slight Degree of Warmth. It feels warmer in cold Weather, as in Winter, than in warm Seasons.

It is not more *sonorous* than common Spring-Water ; as appears by pouring it from one Vessel into another at a Distance below it.

The Heat of those Springs of Buxton-Water, as denoted by the Expansion of Quicksilver in several Thermometers graduated according to Fahrenheit's Scale, which supply the *Gentleman's Bath*, has been observed to be $81^{\circ} \frac{3}{4}$ to 82° ; and of the *new Saint Anne's Well* 81° to $81^{\circ} \frac{1}{4}$.

There is good Reason to believe, that this Water has been of precisely the same Temperature for many hundred, perhaps many thousand Years. It has certainly been of the same Heat, since
this

this Property was ascertained by the Use of Thermometers more than thirty Years ago. There has been indeed a Variation of about one Degree of Fahrenheit's Scale, in the Accounts given by different Persons of sufficient Accuracy for ascertaining this Point; but that Difference was not occasioned by the Variation of the Heat of the Water, but was owing to the Difference of the Thermometers employed: For there is liable to be a Want of precise Conformity in the Degrees of Expansion, as denoted by the Scale, between different Instruments exposed at the same Time to the same Temperature; if not in all the Degrees, at least in some of them.

The small Difference between the Heat of the *Well* and the *Bath*, is occasioned by the former being exposed to the Atmosphere, which being always much colder than the Water, receives some of its Heat; but the latter, being exposed to the Air of the Bath-Room, the Temperature of which is only six or eight Degrees colder than the Water, receives less Heat from it than the open Air does from the Well.

For some Time after the Alteration in the Situation of the Basin, or of the *Well*, as it is commonly called, already mentioned, p. 11, the Water was found to be colder than it was in the former Basin, named *old St. Anne's Well*; it was at first several Degrees and afterwards about
one

one Degree, of Fahrenheit's Thermometer, of less Heat than at the *old* Well. A satisfactory Reason might be assigned for this Alteration in the Temperature of the Water in the new Basin, made for the Convenience of drinking this tepid Spring. In order to make my Readers acquainted with the *Occasion* of this Diminution of the Heat of Buxton-Water, and with the Means by which it was restored to the same Temperature as in the *old* St. Anne's Well, as well as to enable them to form a Judgment of the Effect of the late Alterations at Buxton upon the Water, I shall state,

Some Facts relative to, with Remarks upon the Circumstances of, the NEW and old St. Anne's Well.

There was no Spring in the old St. Anne's Well, p. 11, as was commonly supposed. The Receptacle containing the Water was supplied from subterraneous Streams of the tepid Spring that issued from Fissures in the Stratum of Lime-Stone, at the Distance of many Feet from the Well. When this Well was demolished about four Years ago, for the Purpose mentioned in a former Part of this Work, p. 11, the Water was conveyed in a Grit-Stone Channel from the very same Streams as before, but in much larger Quantity, perhaps to a greater Distance, and in a different Direction.

The Water was conveyed at least forty Feet, in a North-East Direction, to the *old* Well; and
it

it is now conducted forty-six Feet Distance, South-East, in a covered Channel of Grit-Stone, which is of a semi-cylindrical Form; the Stones composing which lie on their convex Side. The Diameter of the Cylinder, of which this Channel is nearly a Semi-cylinder, is about four Inches and a half.

The Basin of the new St. Anne's Well is hewn out of one entire Mass of Grit-Stone, and it is covered with a massy Stone of the same Kind, placed in Contact with the Water, and cemented down. An Aperture is made in the Side of the Basin, through which the Water perpetually flows, as from a Pump-spout, at the Rate of half a Pint in a Second of Time.

A neat Basin of white Marble is placed under the Stream that flows through this Aperture, for the Convenience of filling Glasses and other Vessels with this Water.

The Basin of the *old* St. Anne's Well, being always open, was exposed to the Danger of being made foul and impure. The Temperature of the Water therein was $81\frac{1}{2}$ or 81° .

The Occasion of the Diminution of the Heat of the Water in the *new* Basin, soon after the same Streams were conducted into it that supplied the *old* Well, will now readily be apprehended. The new Channel and the Earth near it being much colder than Buxton-Water, Heat would be communicated to these surrounding Bodies from
this

this Water, until they acquired nearly the same Temperature as this tepid Spring; consequently, for some Time, it was found of less Heat in the *new* Basin than in the *old* Well. It is obvious, that this Water flowing for a sufficient Time through this new Channel, would be alone sufficient to restore it to its pristine Degree of Heat: but to produce this increased Degree of Heat sooner, the Basin was covered with the Stone Cover; in consequence of which the Communication of Heat from the Water in the Basin to the Atmosphere, was prevented.

The Effect of further Time, and thus intercepting the Communication between the external Air and the Water in the Basin, was the Appearance of this Spring-Water of its former Heat, namely, $81\frac{1}{4}$ or 81° of Fahrenheit's Thermometer.

From this State of Facts, and the above Remarks, it appears extremely improbable, that the Buxton-Water has suffered any Change or Diminution of its medicinal Qualities by the late Alteration in the Situation of the *Basin*; on the contrary, it is now used accompanied with some decisive Advantages, both with Respect to its salubrious Qualities, and its Mode of Application; which have been produced by the Construction of the new Well.

For, 1. As the medicinal Qualities of this Water chiefly depend upon a *permanent Vapour*,

as

as I shall shew fully in the Course of this Work, of which a great Part is liable to escape upon Exposure to the open Air, the present Mode of drinking it, prevents in the most effectual Manner the Flight of this Substance, which it was liable to in the former Well.

2. The Method now in Use, of receiving the Water from a Hole in the Side of the large Grit-Stone Basin, is far more agreeable than the former Method of immersing the Hand and Glasses, or other Vessels, in the Well, in order to fill them.

3. The present Contrivance of the Channel which conveys the Water to the Basin, is far more compleat than the former one; and by Means of the Stone Cover over the Basin, the Water is preserved free from accidental Impurities, to which it was heretofore liable.

It may be proper to add a few Observations, in Order to render the preceding Account of the Circumstances of the new, and old Well, and of the Manner in which the Water was conducted into them, more compleat and intelligible, as well as to shew further the Advantages obtained in consequence of the late Alterations, with Respect to the Manner of conveying the Water to the new Basin, and the Preservation of its medicinal Qualities.

Several small subterraneous Streams of a tepid Spring are received into a Sort of Reservoir, in the Earth, at the North-West End of the Grit-Stone

Stone Channel which conveys the Water into the *new* Well. The same Streams flow into this subterraneous Receptacle as those which were formerly conducted into the *old* Well.

The Streams which are thus collected, have been erroneously considered to be the Sources of distinct Springs, but they are truly Currents or Branches of, probably, only one tepid Spring, with the Source of which we are unacquainted. All the tepid Streams which have been met with in the Vale under or near the *Crescent* at Buxton, appear to take a northern Course; and, perhaps, they are all Streams from the same Spring, which is, seemingly, in the Bowels of the adjoining Hill, to the South of the *Hall*.

Having made these *Remarks*, I shall resume the Account of the Properties of Buxton-Water.

Matlock, Buxton, and common Spring-Water, were exposed to a freezing Cold of the Atmosphere under similar Circumstances:—They all became Ice in the same Time; all detached Bubbles which were retained in the Mass of solid Water; thereby increasing the Bulk of the Water, so as to rise over the Surface, and burst the Sides of the Phials in which they were contained. These Masses of solid Water being exposed to a Temperature of 54° of Fahrenheit's Thermometer became fluid, and, in returning to a State of Fluidity, the Bubbles of Vapour escaped. These Waters had not suffered any Change, apparently, after being frozen and again

M

rendered

rendered fluid, excepting having lost a Part, at least, of their Vapour; for they have the same sensible Properties, and precipitated Lime from Lime-Water as copiously as before. In one Instance, some Earth was found deposited in Matlock-Water, as there appeared a Precipitation in Consequence of freezing; which is accounted for in general, by saying the Water was robbed of Gas, the Menstruum of the Earth, on being rendered solid by Cold, and therefore was precipitated. But no Gas was separated, and it may be accounted for, if this should prove a Fact on Repetition of the Experiment, by supposing the Water contained more Earth than it could dissolve in Degrees of Heat in which it was fluid near the freezing Point, and therefore deposited Part of its Earth. These Waters rendered solid, in Consequence of the surrounding Temperature, had, like all other Spring-Water, the Properties of Glass, and might be employed for all the Purposes of this Substance, excepting the Property of being fluid in less Degrees of Heat than the Glass produced by fusing certain solid Substances, viz. for Microscopes, Burning-Glasses, &c.

The *Effects of Heat* on this Water will be related in a different Part of this Work.

The *comparative Gravity* of the Water of these tepid Springs, and of ordinary cold Spring-Waters, also of Rain and distilled Water, was attempted to be found, by weighing each of them with a fine
Balance

Balance in the same Florence Flask, with a narrow Neck, upon the straitest Part of which was made a Mark with a Diamond; and by the Vessel being so filled, that the most concave Part of the Surface of the Water should be even with the Mark upon the Flask, when viewed, as often as filled, exactly in the same Position, at the same Distance from, and directly opposite to, the Organs of Sight.

The Water was thus weighed in two Flasks of different Capacities; one of them contained one Pint and about an Ounce Measure, the other two Pints and about four Ounces Measure.

The Event of many Trials with Waters of the Heat of 46° , 48° , and 54° , of Fahrenheit's Thermometer, and of the same Heat as that of the surrounding Medium, was, that

Distilled-Water was lighter than any of the other Waters examined; a Pint of each of which exceeded the Weight of this Bulk of distilled Water in the following Proportions.

Rain-Water was two or three Grains,

Buxton-Water, seven different Parcels, was from six to eight Grains,

Pump-Water, which was a hard Water, was from eight to ten Grains,

Another hard *Pump-Water*, was fourteen to sixteen Grains,

A petrifying Spring-Water, near *Chee Torr*, four Miles from Buxton, was six Grains,

Matlock-Water was eight Grains,

The *Mixture of the tepid and cold Spring* spoken of p. 147, 148. was six Grains; and

The Water from the *Bath in Middleton Dale* was six Grains heavier than distilled Water.

In January 1782, a Pint Florence Flask filled with *Buxton-Water* weighed, as above-described, immediately after taking it from the Well in the new Grecian Temple, during a hard Frost, ℥ j. ʒ iiij. ʒ v. Gr. iiij.

The same Bulk of the *cold Spring* from the Pump adjoining the Well, weighed, ℥ j. ʒ iiij. ʒ v. Gr. xxij.

Buxton-Water, heated to 86° of Fahrenheit's Thermometer, after being cooled to 44° of the same Scale, weighed twenty-five Grains less than when heated to 44°; and

Pump-Water, heated to the same Temperature as the last-mentioned Water, was twenty-two Grains lighter than when of the Temperature of 44°.

Also, a cubic Inch of *Buxton-Water*, was found to be half a Grain heavier than this Bulk of distilled Water;

— — of *Pump-Water*, was one Grain heavier than this Bulk of distilled Water.

— — of *River-Water*, was the same Weight as *Buxton-Water*.

Although

Although the Balance employed upon this Occasion was much more sensible than ordinary Beams, yet it was not so fine as some that might have been obtained purposely for Experiments of this delicate Nature.

I wish, therefore, the Reader to consider the preceding State of specific Gravity of these Waters, as representing in a general Way the Difference of Weight between each; for the exact proportional Differences of Gravity of many of these Substances are very different from those found by other Experimenters. So that, where important Conclusions are to be founded upon the Fact of the precise specific Gravity of these Waters, it will be necessary to ascertain it in a more exact Manner with finer Instruments than those here employed.

From the above Account it appears, that by the simple Exercise of the external Senses, we are not able to perceive any Substance suspended or dissolved in this tepid Water, excepting a Substance that is apparently a permanent Vapour in the Form of Bubbles; for this Water has no Colour, Taste, or Smell, no uncommonly soft or hard Feel, and is not sonorous. The not being sonorous, indicates this Water not to be highly impregnated with Gas, or any other Species of permanent Vapour.

Buxton-Water, then, as it appears immediately to the external Senses, is a simple or elementary Substance, with which is mixed a permanent Vapour.

The Appearance of this permanent Vapour, is different from that of ordinary Springs; which in general, or always, only detach small Masses of Air, by standing in a warm Exposure. Sometimes I have seen Bubbles arising frequently from between the Seams of a Stone Pavement of a cold Bath, and also from the Surface of Moss growing in Water; but in no Instance so copiously, and contained in a State of Suspension in such Quantities, as in the tepid Waters of Buxton.

This permanent Vapour is probably not Air, or it is a Compound of which Air is only a Part; because the Bubbles of Air of common Spring-Water, are *brighter* and *larger* than those of this tepid Water.

The Bubbles that are contained so copiously in Buxton-Water, are not those of that acidulous permanent Vapour called Gas; because Spring-Waters that detach Gas spontaneously, from the Laws of Chymistry, must be, and actually are, saturated with this Vapour, and consequently *taste acidulous*; but these tepid Waters, although they separate a permanent Vapour, probably different from Air, are *insipid*.

Moreover, I venture to propose, that Gas may be distinguished, when suspended in little Masses or Particles in transparent and colourless Fluids, from this permanent Vapour of Buxton-Water and Air, suspended in such Fluids. The Particles of Gas seen in Fluids, are much smaller than those of
Air;

Air; they are almost opaque, and gray or whitish, not much unlike exceedingly minute Particles of white Sand in Fluids, as in Water already saturated with Gas, and in fermenting Liquors; whereas, the Bubbles of Air in Fluids, as in Water, are larger and much brighter than those of Gas; they are transparent and sparkle like Stars, and are apparently more viscid than Gas; as appears by their being so apt to adhere to the Sides of Vessels. The distinguishing Properties here related, may be most clearly observed by filling a Decanter with fresh Spring-Water, and setting it in a warm Room; on standing, Air-Bubbles will manifest themselves by adhering to the Sides of the Glass, where they sparkle and are bright as Stars. Compare these Appearances of Air in Water with those of Gas in Water, by pouring Pyrmont-Water from one Vessel into another Glass-Vessel, or by decanting a Bottle of brisk domestic Wine or Champagne: The Pyrmont-Water and Wines will appear replete with exceedingly small whitish Particles, without the Transparency or Splendour of the Air-Bubbles in the Vessel of Water.

This permanent Vapour of Buxton-Water, is not hepatic Air, or any other phlogistic Vapour, because it is inodorous.

Oil of Metals is contained in some Springs, and the Appearances of the permanent Vapour of Buxton-Water do not, that I know of, discover it to be a different Substance; or that this Sub-

stance is not a Part of the permanent Vapour of this Water.

A permanent Vapour has been lately discovered in some Waters, as those of Bath, that separates itself spontaneously, perhaps, with nearly the same Appearances as that of Buxton-Water, of which we shall take Notice hereafter, called *phlogisticated Air*, but without Proof of its being *the Compound of Air and Phlogiston*; and we have endeavoured (Page 112 to 116) to render it probable, that the Vapour, called *Choke-Damp*, *Mephitic*, or *Mofette*, is *the Compound of Air and Phlogiston*, and very generally contained in the Cavities of the Earth, all over the Globe.

Therefore, the permanent Vapour of this tepid Spring, may, for any Thing we know to the contrary, be partly, or entirely, *the subterraneous Compound of Air and Phlogiston*. But as human Industry has been employed only lately to discover the Properties of Substances in the State of permanent Vapour; and, as we at present distinguish only a few Species of Things in the Form of permanent Vapour, it is probable, there exist in Nature, as great a Number of Kinds of Substances in the State of *Vapour*, as in that of *Fluidity* or *Solidity*. On the Discovery of any permanent Vapour with new Appearances, we should therefore recollect, how very little we know of the History of Substances in this Form, and the Probability of its Difference from Substances already known.

The

The external Senses, simply applied, and the Thermometer with greater Precision, inform us, that these tepid Springs much exceed the Heat of ordinary Fountains.

Common Springs taste cold, and feel cold, when the Body, or Part of it, is immersed in them; and steam when the Atmosphere is extremely cold, or less cold but moist. They expand the Quicksilver in Fahrenheit's Thermometer, in general, from 48° to 54° , in the South Part of England; about Edinburgh, from 46° to 48° ; and in the middle Part of England, the Temperature of cold Springs is, perhaps, from 48° to 50° .

I found the Heat of above thirty Springs in the Neighbourhood of Doncaster, in the Winter Season, flowing from Lime-Stone and Sand-Beds, to be included between 48° and 50° of Fahrenheit's Thermometer; and two or three others of only 47° of this Thermometer.

The Heat of cold Springs about Buxton, is between 47° and 49° ; and those at Matlock 49° to 50° .

It will require many more Observations, fully to determine the Heat of Springs in the different Regions of this Island, and is a most useful Part of natural History (q).

The

(q) The mean Heat of the Springs near Edinburgh seems to be about 47° , and at London 51° ; and it is probable, the
mean

The tepid Water of Buxton *tastes rather warm, feels tepid, or agreeably cool*, and expands the Mercury in Fahrenheit's Thermometer about 30° more than ordinary cold Springs, i. e. to 81° or 82° .

It feels warmer, like all cold Springs, but is not actually warmer, in Winter than Summer. *Pliny*, and some other antient Writers, say, Springs are colder in Summer than in Winter; they should have said, *feel* colder in Summer than in Winter.

A Spring of such a tepid Temperature as the Water of Buxton, is a singular Degree of Heat: For those Springs called warm Waters, *Thermæ*, greatly exceed the Heat of these tepid Waters, and are not uncommon; but excepting the Matlock-Water, which is 68° or 69° of Heat, I know of none of the same Degree, or of intermediate Degrees of Heat, between the Heat of cold Springs and that of warm Waters.

mean Heat of good Springs in any Country, is very nearly the mean Heat of the Country.—Ph. Transf. Vol. LXV. P. II. p. 60.

Dr. Heberden observes, “ we should have an easy Method of finding the mean Heat of any Place, if it be always nearly equal to that of its Springs. This Matter may be ascertained by a proper Number of Observations, and it is therefore very desirable to have an Account taken of the Heat of the Springs wherever a Register is kept of the Heat of the Air.”

Cold Springs steam only in very cold, or cold and moist Weather; because at other Times, the Air dissolves the Water as fast as it is evaporated.

The tepid Springs of Buxton, on Account of their superior Heat, evaporate more Water than the cold Springs; and so much, that unless the Atmosphere be warm, or dry and of a temperate Heat, the whole of it cannot be dissolved; therefore it is suspended in the Form of *Steam*.

The Reader will comprehend this Explanation, by referring to the Principles of Solution, stated Page 123, 124.

Buxton-Water steams in the Bath-Room, although the Air be from 72° to 76° , which far exceeds the greatest general Heat of Summer; because the Air of the Bath-Room is kept constantly almost compleatly saturated with Water, and therefore can dissolve but a small Part of that which continues to be evaporated.

The Heat communicated by the Bath of Buxton to the Air being uniform, might be employed for many useful Purposes, in various Arts, in domestic Economy, Vegetation, and Physick; by making a Communication between the Bath-Room and other close Rooms, and excluding more perfectly the external Air.

The Occasion of this Heat, being so much superior to that of other Springs in general, will be considered hereafter.

The specific Gravity of Water is, *cet. par.* in Proportion to the Quantity and specific Weight
of

of the Substances dissolved therein; hence, by this Property, we judge of the Purity of Springs.

Celsus, when he asserts, that Ice and Snow-Water are heavier, according to the Balance, than Rain, Fountain, Well, or River-Water, is in an Error. His Words are, "Aqua levissima pluviatilis est, deinde fontana, tum ex Flumine, tum ex Puteo; post hæc ex nive aut Glacie."

It appears, that Buxton-Water does not differ considerably in specific Gravity from various cold Springs, when they are of the same Temperature; in general it is lighter, and always as light as these Waters.

But an equal Bulk of Buxton-Water, immediately after being taken from the Spring, weighs much less, 20 Grains in a Pint less, than cold Spring-Water. For this there are two Reasons; first, the superior Heat of the Water; and secondly, the *permanent Vapour* suspended in it.

To the Vulgar it is wonderful, that Springs of different Qualities should be near each other; that a cold and warm Water; a hard and soft Water; a pure and a chalybeate Spring, should be found within the Compass of a few Yards, as happens at Buxton: But to a Person tolerably acquainted with the Structure of the Earth, these Differences may be readily accounted for; without which Knowledge, however, they must be acknowledged to be rather extraordinary Appearances.

This

This is the Instruction we have received concerning the Properties of Buxton-Water by the immediate Perception of the external Senses, and by the Aid of Instruments for the Purpose of discovering its simple Qualities; but as the Properties of Things are frequently not manifest to the Senses, either on Account of the Minuteness of the Quantity of them presented to the external Senses, or from their Nature, we call in to their Aid Instruments and Experiments.

SECTION II.

Containing Experiments to shew, by Means of Mixture of Substances with the tepid Water of Buxton, whether any or what Things are contained therein.

I. SALTS.

A. Acids.

Exper. I. **I**NTO a two Ounce new Flint Phial with a Glass-Stopper, previously rinsed repeatedly with distilled Snow-Water, was introduced a Shred of dry Paper dyed by immersing it in Infusion of *Archill*. This Phial was filled with the tepid Spring-Water at the Well, and while under the Water closed with the Stopper; and out of it preserved inverted.

A clear

A clear and new Flint Phial, containing about two Ounce Measures, first well cleaned with distilled Snow-Water, was filled with this distilled Water, into which was introduced a Shred of Paper dyed with Infusion of Archill of the same Parcel as that last used, and closed with a sound Cork; and

A third Phial of the same Kind, and rinsed in the same Manner as the former, was filled with distilled Snow-Water nearly saturated with Gas separated from Marble by vitriolic Acid, and a Piece of Paper stained with Archill, of the same Parcel as the former, was introduced therein. After these three Phials of Water and dyed Paper had stood two or three Hours, and also twenty-four Hours in the same Temperature, the Water of the *first mentioned* Phial was of a *dilute purple Colour*, and the Paper of a *deep Purple*. On adding to this Water a few Drops of a Mixture of a thousand Parts of Water and one Part of vitriolic Acid, the Water and Paper immediately turned *pale red*.

In the second named Phial the Water was scarcely tinged of a *pale purple Colour*, and the Paper was of a *paler Purple* considerably than in the first-mentioned Bottle, and even had rather a *reddish Cast*.

In the third Phial the Paper was *reddish*, and the Water just tinged of a *reddish Hue*.

The

The Buxton-Water did not change the purple Colour of the Archill red, applied under Circumstances that must have exposed this Substance to the Action of the most volatile Acid had it been contained in the Water; but the dyed Paper became of a deeper Purple than that in distilled Water, and as some of the same Parcel of stained Paper was turned *redish* by the Application of the weakest Acid, Gas, and by an extremely diluted and almost insipid Solution of vitriolic Acid in Water, we cannot from this delicate Test of Acidity discover any Appearance that indicates an Acid contained in this tepid Water.

Exper. II. Two Ounces of *Lime-Water* were added to a Jar containing about six Ounces of Buxton-Water immediately after being taken from the Spring. A Pearl-coloured Mixture was instantly produced, from which by standing a woolly Sediment in a colourless transparent Fluid was deposited.

To another Jar of the same Kind as the last, with the same Quantity of the Pump-Water near the Well as the former Jar contained of Buxton-Water, were added two Ounces of Lime-Water; a Mixture of the same Kind, and Sediment in the same Quantity as the former appeared on the Addition of the Lime-Water.

This Experiment was intended to shew, whether that particular acidulous permanent Vapour called Gas was combined with Buxton-Water,
which

which is well known, when dissolved in Water by Nature or Art, to combine with Quicklime dissolved in Water; thereby producing a calcareous Earth or earthy Salt soluble in a very small Proportion in Water, that occasions the Water to become turbid, and on standing to deposit a white Sediment. These Appearances denoting Gas were observed in this Experiment in Buxton-Water, and common Pump-Water; and they are visible in by far the greatest Number of Spring-Waters, perhaps, in the whole Kingdom. We should therefore be apt to conclude, that Buxton-Water, as well as many other Springs, contains Gas; especially as the Precipitation here made, may be proved by Observations and Experiments to be Quicklime and Gas. I apprehend, however, that such a Conclusion drawn from this Experiment is false, and we shall hereafter relate the Proofs, *that there is no Gas in Buxton-Water combined with the Water*; and that the Appearances above related hitherto supposed to demonstrate its Existence in Water, probably depend upon a different Cause, viz. *Gas united with the Compound of Gas, and Quicklime combining with the Quicklime dissolved in the Lime-Water added; as I shall show, that calcareous Earth, perhaps, is not Quicklime united with Gas, but a Compound of Quicklime and Gas combined with Gas.*

An additional Proof of the Truth of this Conclusion may be found in Experiment I. which shews,

shews, that this tepid Water does not contain a sufficient Quantity of Gas, if any Portion of this Substance, to diminish or change the purple Colour of Archill; on the contrary, it renders this Substance of a deeper Purple, which is an Effect of Alkali. To these Observations add those of Pages 155 and 165, and this Conclusion will be more fully established.

Exper. III. A small Quantity of *Iron-Filings* was, several Times, added to a Phial of Buxton-Water, at the Well, and there corked closely and agitated. To this Water poured off and filtered, about half an Hour after being thus mixed with Iron-Filings, was added *Powder of Galls*. In one Case, the Water was by this Addition turned of a purple Colour; but in three other Cases no Colour was produced, either immediately, or after standing several Hours.

To Buxton-Water deprived of its *permanent Vapour which separates spontaneously*, and of its *respirable Air*, in which had been mixed Iron-Filings, and the Mixture afterwards filtered as above-related, was added Powder of Galls. In one Instance it became, by the Addition of Galls, immediately brown, but in three other Cases, not until after several Hours.

Buxton-Water was deprived, by Lime-Water, of the Gas it contains, perhaps united with *the Compound of Gas and Quick-Lime*; and Buxton-Water was also deprived of the whole of the three Kinds of

permanent Vapour it contains, viz. *The permanent Vapour that separates in great Quantities spontaneously, respirable Air*, (both which are combined with, and suspended in, this tepid Spring,) and the Gas combined with *the Compound of Gas and Quicklime*. Iron-Filings were mixed and agitated with Water thus deprived of its *permanent Vapours*; and to these Mixtures filtered, after *standing a few Hours*, were added Powder of Galls; by which no Colour was produced in less than two Hours, and then only a brown Colour, apparently from the Galls merely infused in the Water, independent of Iron. With some of these Mixtures, filtered, after *standing several Days*, the Galls produced a *reddish, purple, pink, or dark blue, and black Colour*, either immediately or on standing.

The various Shades of blue, red, and black, produced by Galls mixed with filtered fresh Spring-Water, and with Water artificially impregnated with Gas, in which Iron-Filings had been agitated, has been the Result from which it was concluded, and generally believed, that a Spring contained Gas combined with, or suspended in, the Water: Also, that in common chalybeate Springs, Gas was the Solvent of the Iron. But, as it is shown in this Experiment, that not only Buxton-Water apparently containing Gas, but certainly deprived of this, or any, or all of its permanent Vapours, sometimes produces, and at other Times does not
produce

produce Colours with Galls, under equal Circumstances, it may be inferred, *that Gas is not the Solvent, or not the only Solvent of Iron in Water, but, perhaps, that Water alone will dissolve Iron.* And it will be shewn hereafter, by the most decisive Experiments, that Gas is not the only, or not by much the most usual Solvent of this, or other Metals in Mineral-Waters.

I recollect that Dr. Fordyce, in his chymical Lectures mentioned, that the Water of a Smith's Shop, in which red hot Iron is cooled, contains Iron dissolved therein; which Solution, however, I apprehend, frequently does not take place, because only the Ashes (r) upon the Surface of the red

(r) The Scales beat off from red hot Iron, are as much mere Ashes, as the Ashes of Pit-Coal, or other Inflammables. Like Ashes of other Substances, they are the Product of Inflammation; for Iron is decisively an inflammable Substance, or will burn, as well as Oil, Alcohol, or dried Vegetables: But the burning or Inflammation of Iron, is not obvious in the ordinary Way, namely, the rusting of it in the Air, and the Calcination of it by Heat: However, under particular Circumstances, it burns as distinctly as a Tallow Candle. When I was a Student of Chymistry at Edinburgh, about nine Years ago, I made a Bar of Iron, that had been exposed to the Heat of a large Kitchen Fire for many Years, evidently burn; by first heating it red hot, or perhaps, white hot, and in this State, exposing it to the Blast of Air from the large Bellows of an Iron Furnace; it then became fluid, emitted Flame, and as the Flame extended, little fluid Masses dropped off from the End of it, which, when collected, were exactly like a common Pit-Coal Cinder. Neither this appa-

red hot Metal are, in general, exposed to the Action of the Water; and, upon mixing Galls with this Water, I found that it sometimes produced a purplish Colour, but in general no Colour, excepting that of Infusion of Galls in Water.

Common River, and Pump-Water, which had Iron-Filings infused in them and filtered, sometimes produced Colours with Galls, but at other Times did not produce any Colours, or only a *grey-coloured turbid Fluid*. Mr. Boyle found, that Water in which Iron-Filings had been infused, produced an inky Colour with Galls; but some-

rent Cinder, nor the Scales above-mentioned, are reducible to a metallic State; nor, if I recollect rightly, are the Ashes called Flowers of Zinc, left, after burning Zinc, capable of being restored to the State of a Semi-Metal.

All the Metals and Semi-Metals, are, perhaps, *inflammable*, although we may not know the Circumstances necessary to make them burn.

Cramer, in the last and German Edition of his *Anfangs-Gründe der Metallurgie*, Fol. 1776, shews *Antimony* to be capable of burning.

I do not know, whether the inflammable Property of Antimony be much known; that of Iron is, I imagine, a Thing with which many Readers are acquainted.

Arsenic also burns distinctly, provided it be exposed to a proper Degree of Heat.—See *Bergman's Sciagraphia Regni Min.*

We have a familiar Example of the burning of Iron, so as to produce *Heat, Light*, and *chymical Analysis*, in the Instance of striking Fire with a Flint and Steel; the Particles produced by the Stroke, are nothing more than Particles of Steel separated by the hard Flint, and set on Fire by the Violence of the Stroke.

times

times no Colour. He also relates, that Infusion of Galls poured upon Steel-Filings of which Needles were made, produced an opaque Liquor, and of a dark inky Colour; which Colour it retained upon Filtration. I do not, however, mean to infer, that Gas alone, and also Water saturated with this Substance, may not dissolve or suspend Iron in greater Quantity than simple Water; but that the Inference is fallacious, that Buxton-Water contains Gas, because, after Iron-Filings have been exposed therein, a Colour is produced, on the Addition of Galls, peculiar to Solutions of this Metal.

Iron-Rods, or Rails, and Iron Chains, are continually suspended over the Surface of the Bath at Buxton, yet it does not appear that this Metal here rusts faster than in common Water or moist Air. Were this tepid Water saturated with Gas so as to detach it spontaneously, from the Property of Water so impregnated of dissolving or suspending Iron, a more speedy Solution might be expected.

B. *Alkalies.*

Exper. IV. A Phial with a Glass-Stopper, of the same Kind as that employed *Exper. I.*, containing half an Ounce of *Syrup of Violets*, was filled with the Buxton tepid Water, by immersing it in the Well, and being there closed with the Stopper, was withdrawn, agitated, and preserved

inverted. This Mixture was at the same Time compared with Syrup of Violets, of the same Parcel as the former, and distilled Water; and with a third Mixture of the same Syrup and common Pump-Water; both of which Mixtures, contained the same Proportion of Syrup and Water as the first Mixture.

The Mixture containing Buxton, and that with Pump-Water, appeared of a *bluish-green Cast*, pretty much alike; which Colour became, commonly, a pale green on standing; but the other Mixture was of a *pale blue Colour*.

In other Instances, with a different Parcel of Syrup of Violets, the Mixture with the tepid Water, recently taken from the Well, and that with the Pump-Water, were of a *bluish Colour*: And with Buxton-Water that had been preserved corked some Time in Bottles it was generally *bluish*. From various Trials it appeared, that Buxton-Water, recently taken from the Spring, and Syrup of Violets, generally formed a *green Mixture*; and Buxton-Water, which had been some Time kept in Bottles, and Syrup of Violets, generally made a *bluish Mixture*.

A few Drops of an almost insipid Solution of fixed Alkali in distilled Water, turned all the above Mixtures of a *pale green Colour* immediately.

Exper. V. A Drachm of *Nitre of Magnesia* (without the smallest Portion of superfluous Acid) was added to four Ounces of Buxton tepid Water

ter at the Well. This Mixture remained clear after standing twenty-four Hours. The same Quantity of Nitre of Magnesia was added to eight Ounces of Buxton-Water, and the Mixture was clear after standing some Time. Two Drachms of Nitre of Magnesia were added to a Jar containing a Pint of this tepid Spring, and not the least Precipitation occurred during two Days.

The greenish Colour commonly produced by Buxton-Water and the blue Juices of Vegetables, is reckoned a certain Proof of the Presence of an Alkali; but, many other Substances besides Alkali produce this Colour, and several of these are commonly contained in Spring-Water, viz. calcareous Earth, and earthy Salts in general, as vitriolic Selenites. Also, Nitre of Magnesia, nitrous Acid so saturated with Lead as to form Crystals, changed the Syrup employed in Experiment IV. green, &c. This Appearance, therefore, alone is but an equivocal Sign; however, in Conjunction with other Observations and Experiments, it is pretty decisive.

Exper. V. shews clearly and decisively, that the green Colour produced in the IVth Experiment, was not occasioned by Alkali in this tepid Water; because Nitre of Magnesia is decomposed by the smallest Portion of Alkali in Water, and no other Substance in Water is known to decompose this earthy Salt.

C. *Vitriolic Acid combined with Alkalies, Earths, and Metals.*

Exper. VI. To a Wine-Glass full of this tepid Water, immediately after being taken from the Well, were added ten Drops of nitrous Acid, upon which Mixture, were poured thirty Drops of *Solution of Lead* in nitrous Acid. The Addition of this Solution, occasioned a turbid Appearance immediately. On standing, there was a copious Deposition of close grey Sediment, adhering closely to the Sides of the Glass.

The same Appearances happened with a like Mixture, and a hard Pump-Water, instead of Buxton-Water.

Also the same Mixture was made, precisely as the last, with distilled Water instead of this tepid Spring, and the Mixture was neither turbid, nor had it any Sediment on standing.

From the preceding Experiment it may be concluded, that *vitriolic Acid* in the Water, combined with the Lead dissolved in nitrous Acid; and, as the Compound of Lead and vitriolic Acid is a Salt very sparingly, or not at all, soluble in Water, it is upon this Occasion precipitated. As a Decomposition may be produced on adding Solution of Lead in nitrous Acid to Water containing Alkali, absorbent Earths, or Metals, or in Consequence of *mere Dilution*; nitrous Acid was previously added, sufficient to saturate

saturate any such Substances in Buxton-Water, and to prevent Decomposition by Dilution : And it is proved by this Experiment of the Mixture of distilled Water instead of Buxton-Water, that *mere Dilution* did not decompose this Solution of Lead ; therefore it may be fairly inferred, that *the Precipitation arises from vitriolic Acid* ; but whether this Acid be combined with Water, or other Substances, cannot be determined by this Experiment.

D. *Muriatic Acid combined with
Alkali, Earths, or any other Substances.*

Exper. VII. To a Wine-Glass filled with this *tepid Water* were added at the Well, first, five Drops of nitrous Acid, and then ten Drops of *Solution of Silver* in nitrous Acid. Upon this Solution being poured into this Glass of Water, there was a Pearl-coloured turbid Appearance, and in ten Minutes a copious whitish Sediment took Place, which, on standing, changed to a purplish Colour.

Nearly the same Appearances happened with Pump-Water, used in this Experiment, instead of Buxton-Water.

This Mixture, made with distilled Water, was transparent, and without Sediment ; but upon adding *Sea-Salt*, in Quantity a thousandth Part of the distilled Water, a Precipitation like that of the other Mixtures ensued.

As

As the nitrous Acid added in the above Experiment, was sufficient to saturate any Alkali or Earth contained in the *tepid Water* examined, and prevent the Solution of Silver from being decomposed by Dilution with Water, I deduce, that the Pearl-coloured Appearance and Precipitation was occasioned by *muriatic Acid* combining with the Silver dissolved in nitrous Acid; and that the nitrous Acid would at the same Time dissolve the Alkali, Earth, or probably other Substances combined in the Water naturally with the muriatic Acid, provided this Acid be not combined with the mere Water.

As muriatic Acid is so very generally, perhaps, universally, contained in Spring-Water, it is not remarkable that it should be found in the Pump-Water, subjected to the Test of this Experiment.

*E. Calcareous Earth; which is
perhaps Gas combined with the Compound of
Gas and Quicklime.*

In another Part of this Work it will be submitted to the Opinion of the Reader, whether calcareous Earth should not be considered as an earthy Salt composed of an Acid, which is a permanent Vapour; namely, *Gas*, and a Substance which appears to be a Species of Alkali, viz. *Quicklime*. Also, whether I have not discovered, that calcareous Earth is composed of Gas united to a Compound of Gas and Quicklime,

Dr.

Dr. Cullen, I am well-informed, in his chymical Lectures, used to reckon Quicklime an alkaline Substance.

Exper. VIII. To a Pint Jar of *Buxton-Water* was added a Drachm of *saturated Solution of Lead* in nitrous Acid.

This Mixture was at first *slightly muddy*, and, on standing, deposited a *brown or gray Sediment*. After decanting the clear Water, the Sediment was dried, and a Drachm of nitrous Acid was poured upon it: After several Days Exposure in a gentle Heat in a warm Room, *a Part of this Sediment appeared to be dissolved*.

To another Jar, containing a Pint of *Buxton-Water*, was added about one Drachm Measure of nitrous Acid, and the same Quantity of Solution of Lead in nitrous Acid: This Mixture was *less turbid*, and deposited a *smaller Quantity* of Sediment than the former Mixture. After pouring off the clear Fluid, the Sediment was evaporated to Dryness, and mixed with about a Drachm Measure of nitrous Acid: This Mixture was exposed in a warm Room, the same Space of Time as the former Mixture of Sediment and nitrous Acid, when either a much smaller, or no Solution appeared to have taken Place.

A Drachm Measure, or thereabouts, of the *saturated Solution of Lead* in nitrous Acid, was added to a Pint Measure of *distilled Snow-Water*: On standing several Days, exposed to the Atmo-

sphere, the Transparency of this Mixture appeared much disturbed, but no Sediment could be distinctly perceived.

From the *two first of these Mixtures* it may be inferred, that *there is calcareous Earth dissolved in this tepid Water*; for in the first of them, the Solution of Lead is decomposed, by the Quicklime of this Earth combining with some of the Acid in which this Metal is dissolved; and the Gas, the other Element of which calcareous Earth is composed, probably, at the same Time, joins the Calx of Lead rather than the Water: The Compound, thus formed, of nitrous Acid and Quicklime, is dissolved by the Water; but the Compound of Calx of Lead and Gas, is not soluble in Water; therefore, it is deposited in the Form of Sediment. As the Solution of Lead, added in this Experiment, contained more nitrous Acid than is sufficient to saturate the Quicklime in this Quantity of Water, the superabundant Solution of Lead is also decomposed, by vitriolic Acid in the Water combining with the Calx of Lead; thereby forming a metallic Salt, which, being soluble in an exceedingly small Quantity of Water, the greatest Part of it is deposited in the Form of a Sediment; while the nitrous Acid unites with absorbent Earth (if the vitriolic Acid be combined with Quicklime or Magnesia) forming a Salt of ready Solubility in Water: So that the Sediment found in the first of these three Mixtures,

tures, was probably Calx of Lead, combined with Gas, and another Compound, viz. Calx of Lead and vitriolic Acid; therefore, on exposing this Sediment, for several Days, to the Action of nitrous Acid, the Whole or a Part of the Calx of Lead would be liable to be dissolved in this Acid; which accounts for the Diminution in the Quantity of Sediment, after the Mixture of this Sediment with nitrous Acid.

In the *second of these two Mixtures*, the nitrous Acid, added to this tepid Water, would necessarily saturate any absorbent Earth dissolved therein; therefore, the turbid Appearance, and subsequent Formation of Sediment, must be solely ascribed to the Combination of vitriolic Acid and Calx of Lead, in the same Quantity as in the first Mixture; but as the first Mixture, not only contained the Compound of Calx of Lead and vitriolic Acid, in as great a Quantity as the second Mixture, but the Calx of Lead in Conjunction with Gas, the Sediment must be *greater in Quantity*; and no Diminution of the Quantity of the Sediment of the second Mixture happened when digested with nitrous Acid, because the whole of it was a Compound of vitriolic Acid and Calx of Lead.

The Diminution of Transparency, and even the somewhat *turbid Appearance* of the *third Mixture*, on Exposure to the Atmosphere, was occasioned by the *mere Dilution of the Solution of Lead*

Lead in Water. For all dilute Solutions of metallic Salts decompose spontaneously, certainly if exposed to, and perhaps also when excluded from the Atmosphere. This, by the Way, accounts for the Decomposition of chalybeate Waters erroneously referred to the Escape of Gas, of which we shall speak more fully hereafter. There was no Sediment formed, because the Particles of the Calx of Lead were too minute, and suspended in too large a Bulk of Water, to be able to overcome the Cohesion of this Fluid.

Exper. IX. Into a Jar, containing half a Pint of *Buxton tepid Water*, were poured three Teaspoonfuls of saturated and filtered *Solution of corrosive Sublimate* in distilled Water; and to eight Ounces of *distilled Water*, was added about a Drachm Measure of this *Solution of Sublimate* in Water.

For some Hours the above Mixtures remained *transparent*; but after standing a Day or two, the former of them deposited a *close gray Sediment*, and the latter had its *Transparency disturbed*.

As it is shewn by Experiments IV. and V. that this Spring-Water contains no Alkali, the Precipitation in the Jar of Buxton-Water is occasioned, principally, by *calcareous Earth* in the Water; for the Quicklime of this Substance combines upon this Occasion with the muriatic Acid of the corrosive Sublimate, while the Gas of the Earth unites either with the Calx of the Quick-silver,

silver, or the Water; and thus a turbid Appearance and Sediment is produced. In Part, however, the Decomposition arises from the Solution of the metallic Salt here employed being extremely diluted.

The Diminution of Transparency in the second Jar of the Mixture on standing, was occasioned merely by the Decomposition of the metallic Salt with so large a Quantity of Water.

Exper. X. Four Grains of *Saccharum Saturni* were dissolved in a half Pint Glass of *Buxton-Water*, which immediately made a *turbid Appearance*; and, after standing, there was a Deposition of a *copious Sediment*.

A like Mixture with distilled Snow-Water, (which distilled Water was previously found to contain no Gas, either combined with the Water or with Quicklime) was immediately rather milky, but not so turbid as the former Mixture; and after remaining at Rest, let fall a *less copious Sediment* than the other Mixture.

We only know two Things that could, upon this Occasion, produce the turbid Appearance and Sediment in the *Buxton-Water*, viz. *calcareous Earth*, acting upon this metallic Salt in the Manner related in the Observations upon the last Experiment; and *Dilution*.

The Appearances in the *other Mixture*, are occasioned entirely by a *Decomposition* of this metallic Salt in Consequence of *Dilution*. The turbid

bid Appearance and Sediment is remarkably great with this Salt of Lead, and a large Quantity of Water; and the Decomposition being so much more speedy of *Saccharum Saturni* by Water, than of other metallic Salts, or earthy Salts, it may be considered as the most striking Instance of the Property in general of Decomposition of metallic, and earthy, and perhaps neutral Salts, by dilute Solution in Water.

I take this Opportunity of pointing out a Mistake in the generally received Opinion, that Water saturated with Gas decomposes Sugar of Lead in Consequence of the Gas combining, from its stronger Attraction than acetic Acid, with the Calx of Lead. Those who have made this Experiment, and drawn this Conclusion, did not at the same Time perform the Experiment with simple Water, or recollect the Fact, that *metallic Salts are decomposed by Dilution with Water* (r).

F. Sub-

(r) This Opinion is founded entirely on the following Experiment, related in the Appendix, p. 291, of the first Volume of Dr. Priestley's *Experiments and Observations on different Kinds of Air*. "Distilled-Water saturated with fixed Air, formed a white Cloud and Precipitation upon being mixed with a Solution of *Saccharum Saturni*." I remark upon this Part of the Experiment, that the same Appearance takes Place with simple Water. "I found likewise that fixed Air, after passing through the Tube filled with alkaline Salt, upon being let into a Phial containing a Solution of the metallic Salt in distilled Water, caused a perfect Separation of the
Lead

F. *Substances composed of any Earth or any Metal with any Acid, forming neutral Salts with any earthy or metallic Bases, excepting the earthy Salt, calcareous Earth, consisting of Gas and Quicklime, or, perhaps more justly, of Gas and the Compound of Gas and Quicklime.*

Exper. XI. Two Drachms Measure of a perfectly clear Solution of *pure fixed vegetable Alkali*, in a mild State, were added to a Jar containing four Ounces of *Buxton-Water*: This Addition rendered the Water immediately *turbid*, and on standing, there was a *copious Deposition of white Sediment*.

Lead in the Form of a white Powder; for the Water, after this Precipitation, shewed no Cloudiness upon a fresh Mixture of the Substances which had before rendered it opaque." Upon the latter Part of this Experiment I remark, that unless a Phial containing Solution of Sugar of Lead without Gas, had been compared along with the Phial of Solution into which Gas was transferred, it is uncertain whether the Decomposition was occasioned by the Water alone, or by the Gas in the Water; perhaps, however, the Precipitation is rendered more compleat and speedy by the Gas contained in Water.

The Author of a *Treatise on Gases*, says, "This Gas occasions a *Precipitation* in a Solution of *Sugar of Lead*, as Mr. *Hey of Leeds* observes."

Mr. *Cavallo* also, in his late Work on *Air and other permanently elastic Fluids*, 4to, on the Event of the Experiment here related, says, that fixed Air decomposes Lead dissolved in acetous Acid.

The same Appearance occurred on the Addition of the *above Solution* to common *Pump-Water*; but *Solution of mild Alkali* and *distilled Water* formed a *clear Mixture*.

The Matter here deposited, was, in all Probability, a Substance which might have been combined with any Acid, excepting Gas; for I found that mild Alkali did not decompose or precipitate Solution of calcareous Earth in distilled Water. From the Colour of the Sediment, independently of the preceding Facts, it is most probable it was entirely, or principally, *absorbent Earth* deposited in Consequence of the Quicklime before combined with Acid now uniting with the Gas of the Alkali, and Acid combining with the pure or caustic Alkali.

To determine the Kind of Substance or Substances thus precipitated, which might be in too small a Quantity to be observed by the external Senses in the above Quantity of precipitated Matter, the following interesting Experiment was made.

Exper. XII. To 116 Wine Gallons of Buxton-Water, contained in a brewing Tub previously made perfectly clean, immediately after this Water was conveyed in wooden Vessels from the Well, was added one Pound of *Salt of Tartar*, free from extraneous Matters. This Salt occasioned, immediately upon its Solution, a *turbid Appearance throughout the whole Fluid*. This Vessel of Solution Mixture, after standing four Days, during

which Time Care was taken to exclude any Dust, or other foreign Matters from being introduced, was become perfectly *clear*, and a close gray-coloured *Sediment* was formed at the Bottom of the Tub.

Some of this clear Fluid, on the Addition of Syrup of Violets, became Grass green; while fresh Buxton-Water turned blue with the same Parcel of Syrup; and a small Quantity of this transparent Solution, with an additional Solution of Alkali, did not become in the least turbid immediately, or on standing deposit any Sediment. It was therefore rendered certain, that a sufficient Quantity of Alkali had been added to decompose the Substances proposed.

As much clear Fluid as possible was drawn off from this Mixture, by Means of a Spigot and Faucet inserted near the Bottom of the Tub. By allowing the remaining Mixture to stand, and by decanting the clear Fluid from it repeatedly, I obtained the whole of the Sediment deposited in this Experiment, with only a very small Quantity of the Solution mixed with it.

In the Manner just related, Sediment was procured three Times from the above-mentioned Quantity of Buxton-Water, namely, from 348 Gallons of this Water. The whole *Sediment* from the Tub filled three Times, i. e. from 348 Gallons of Buxton-Water, weighed four Ounces and two Drachms and a Half Troy; so that each Gallon afforded about six Grains of Sediment.

Sediment was also procured from 12 Gallons of Buxton-Water in the Manner above-related, which, when evaporated to Dryness, weighed three Pennyweights, twelve Grains; so each Gallon of Water afforded seven Grains of Sediment.

This *Sediment* was an extremely light, smooth, gray Powder, without Taste or Smell; and supposing the Gas combined with this Sediment to be one-third of the Weight of this Sediment, and the Acid with which this Sediment was combined to weigh as much as the Sediment here procured, when free of Gas, or four Grains in each Gallon, then the Quantity of metallic or earthy Salt in the Water will be eight Grains in a Gallon; provided no earthy Matter was formed and deposited, by the dilute Solution of Alkali employed to produce this Precipitation (s).

All that can be determined from the simple Properties of this Sediment is, that it either contains but a small Quantity or no Calx of Metal, because it is grey.

Exper. XIII. To a small Portion, about six Grains, of the above Sediment, was added *mu-*

(s) *Boerhaave*, and other Chymists, speak of the Conversion or the Production of Earth from fixed Alkali by Solution, Dilution, Evaporation, Heat, and Exposure to Air; and relate Processes for this Purpose.

Margraaf fears, that in this Experiment the Properties of the Substances contained in the Water may be changed; but gives no Proof to demonstrate this Change to obtain upon this Occasion.

riatic

riatic Acid gradually, till the Effervescence excited ceased; and it then appeared to be entirely dissolved; and the Solution was a yellowish transparent Fluid, that had a bitter saline Taste, not much unlike muriatic Selenites.

Vitriolic Acid was added, Drop by Drop, upon this Solution; which occasioned a Deposition of a copious white Sediment, exactly with the same Appearances as happened upon pouring vitriolic Acid upon muriatic Selenites.

This Experiment shewed, that the principal Part at least, if not all the Sediment precipitated, by adding mild fixed Alkali to Buxton-Water, was *absorbent Earth*: And, also, that a principal Part, or the whole of this Earth, was calcareous Earth, but did not demonstrate whether there was not a small Quantity of other absorbent Earths, and of Calces of Metals; therefore the following Experiment was made.

Exper. XIV. To one Ounce of the above Sediment, procured from the Buxton-Water in the above Experiment, in a Glass Jar capable of containing two Quarts of Fluid, was added vitriolic Acid, diluted with six Times its Bulk of distilled Rain-Water, until no further Effervescence ensued. When it was supposed a sufficient Quantity of Acid had been added to saturate the whole earthy Sediment, this Mixture was exposed in a Sand Heat twenty-four Hours, and then diluted with six Ounces of distilled Rain-Water boiling hot, and

filtered through Paper. Water was poured a second Time upon the Solution, in Quantity two Pints, and filtered as before. These filtered Fluids were of a light brown Colour, had a bitterish Taste, and were more bitter than a Solution of vitriolic Selenites, made by dissolving vitriolic Selenites, composed of Quicklime which had been combined with Water, and precipitated by combining it with Gas, and uniting this Sediment with vitriolic Acid.

To a small Quantity of the above Mixture, poured off soon after adding the vitriolic Acid, *before it was first filtered*, were added a few Grains of *Galls* powdered in a Marble Mortar; by which it was changed, first of a *yellowish* Colour, then *greenish* and *thick*, afterwards *blackish*. The same Appearances presented themselves, on adding Galls of different Sorts, to some of this decanted Solution.

To small Quantities of the above Solution *after Filtration*, were added powdered Galls of different Parcels; which, on standing, became *brown* coloured, like Infusion of Galls in Water, and *turbid*, but *no purple, blue, blackish*, or other Shades of these Colours were produced.

To some of this filtered Liquor was also added a small Portion of *phlogisticated Alkali*, or Ley of Alkali calcined with Blood (*t*), which instantly produced

(*t*) See *Opuscules Chymiques de M. Margraaf*, Tom. I. p. 81. for the Method of making *phlogisticated Alkali*.—This
most

duced a *blackish Colour*, that immediately disappeared, and left a *white* and muddy fluid. Solution of *mild fixed Alkali*, produced with this filtered

most accurate and laborious Chymist observes, that the Consideration, that *Prussian Blue* owes its Colour to Iron, suggested to him, that alkaline Ley, calcined with dried Blood, would readily detect any Particles of Iron in the Earths; in principally calcareous Earth, procured from Waters by Distillation: But, for this Purpose, such Sediments must be dissolved in Acid of Vitriol, which would form a Compound of sparing Solubility in Water, and combined with Iron, would be readily soluble. Therefore, Mr. *Margraaf* saturated the Sediment, which was principally calcareous Earth, left after the Evaporation of Water, with diluted vitriolic Acid. The Fluid filtered from this Mixture, was a Solution of vitriolic Selenites, and the whole, probably, of any metallic Solution that might be contained therein. If any *Iron* were contained in the Water, it was manifested by the *blackish* or *blue Precipitation*, upon the Addition of this alkaline Lixivium. As this Precipitation of *blackish* or *blue Matter*, was obtained from the calcareous Earth of a Variety of Spring and River-Waters, as well as from the calcareous Earth of a Variety of animal Matters, which had not been suspected to contain Iron, from their Appearance, Taste, the Addition of Galls, &c. he concluded they contained Iron, which Substance was shewn by this more delicate Test than Galls or other Means. Further; this precipitated *blue Matter*, was decisively proved to be Iron, by collecting it in pretty large Quantity. By Calcination, it was first found to be red Saffron of Iron, and then, by combining it with Phlogiston, it was reduced to a metallic Form.

When I was a Student at Edinburgh, Dr. *Black* used to recommend this phlogisticated Alkali, as a more delicate and certain Test of Iron in Water than *Galls*.

Fluid a turbid Appearance; and, afterwards, a Deposition of a *white Sediment*, similar to that upon adding Solution of the same Alkali to the Solution of the above-mentioned artificial Selenites.

The Sediment procured from twelve Gallons of Water, in Quantity 3 dwt. 12 grs. was treated exactly as the Ounce of Sediment just mentioned, but diluted after Solution with twenty-four Ounces of Snow-Water; and all the same Appearances happened, excepting, that the Liquor filtered also produced a *dark blue Colour* with *Galls* on *standing*, as well as *soon after the Solution was made*.

To small Quantities of Solution of the preceding artificial vitriolic Selenites, were added Powder of *Galls* of various Parcels, and also *phlogisticated* and *common Alkali*, without producing *any coloured Fluids*; the Alkalies only occasioning a Precipitation of a gray Sediment.

The preceding Solutions filtered from the *Ounce of dissolved Sediment*, as well as that from the *precipitated Matter of twelve Gallons of Water*, and the filtered *Solution of artificial vitriolic Selenites*, were evaporated slowly in Glass Vessels to Dryness. This last Solution yielded about half a Grain in an Ounce of Fluid; and the two former about three-fourths of a Grain to a Grain, from each Ounce of filtered Fluids. The Sediment of the Fluids thus evaporated was crystallized, and had a bitter Taste. It is remarkable, that
the

the Solution of artificial Selenites evaporated to Dryness afforded Crystals of a bitter Taste; but before Solution, and without being crystallized, it had no Taste.

The Sediment afforded by the whole filtered Fluid from the Ounce of Sediment above dissolved and evaporated to Dryness, as well as that from the twelve Gallons of Water, were re-dissolved in Snow-Water, and perfectly decomposed by pure fixed alkaline Lixivium. They afforded a *white Sediment* without Taste or Smell.

Twenty Grains of the preceding *Compound of Sediment and vitriolic Acid*, afforded by the filtered Fluid from the Solution of the precipitated Matter of twelve Gallons of Water, evaporated to Dryness; and six Grains of *Magnesia-Glauber Salt*, were boiled a short Time in half a Pint of Snow-Water, then strained, and the filtered Liquor evaporated to Dryness; whereby twelve Grains of Crystals of much the same Figure as, but of a much more bitter Taste and more soluble than the former, were produced. The Sediment left upon the Filter was then boiled a little a second Time in eight Ounces of Snow-Water, filtered, and evaporated as before; by which Means, seven Grains of a crystallized, rather bitter, slowly soluble earthy Salt was procured.

The Colour produced by the Addition of *Galls* to recent Solutions of Sediment, indicated the Existence of *Iron*, or other Metal; but the Want
of

of this Colour, upon some Occasions, when the Solution had stood some Time, the transient Colour produced by phlogisticated Alkali, and the light *gray Sediment* precipitated by Alkali (*u*), denoted, that these Metals were either there in accidental Portions of Solutions, or depended upon some Circumstances with which we are not acquainted; or, that Galls are a fallacious Test of Iron (*x*). At any Rate, the very equivocal Signs of even a most minute Portion of Metal,

(*u*) “ Si quelqu’un avoit trop de peine à préparer mes Lèssive Alcaline de ce Sel Alkali fixe avec le Sang calciné, il peut s’en tenir à une Lèssive de cendres gravelées ordinaires pour faire la Precipitation de l’Extrait des Terres Calcaires par le Moyen de l’Esprit de Vitriol; il lui fournira un précipité Martial d’un *jaune d’Ochre* qui s’arrêtera au Fond du Vase; & en continuant à la traiter de la Maniere susdite, il sera Témoin des mêmes Circonstances.”—(Margraaf, Opuscules Chymiques, Tom. II. p. 68).

(*x*) Mr. Boyle says, Galls are neither of that extensive Use, nor Certainty, for the Discovery of Iron, or other Metals, that is imagined; for Arsenic cannot be detected by this Means in Water; and green Vitriol, mixed with a large Quantity of Copper, only turns muddy or opaque, with Galls; and *Saccharum Saturni*, produces no Colour with this Substance. Solutions of Gold in *Aqua Regia*, of Mercury in Aqua Fortis, and Lead in nitrous Acid, produce no Colour with Galls: But volatile sulphureous Acid, alone, or with some of these Metals, produce Colour with Galls. In another Place, he says, *Saccharum Saturni* produces some Colour with Galls, but sulphureous Acid strikes Colour immediately; and other Bodies, supposed to be Iron, turn black or purple with Galls, independent of that Metal,

in

in a Solution that must necessarily contain the metallic Matter of upwards of eighty Gallons of Water, justify the Conclusion, that *this Water either contains no Metal, or an exceedingly minute Quantity indeed*; and that this Portion depends perhaps upon certain Circumstances of the Solution of absorbent Earth with which we are unacquainted.

These Appearances with Galls being inexplicable, I was led to perform a Variety of Experiments, that informed me of many Things altogether new, curious, and, perhaps, important. The principal of these I shall relate, after concluding my Observations on this Experiment (y).

The preceding Experiment, I think, decisively proved, that this Water contains *no Magnesia, or any absorbent Earth*, excepting calcareous Earth, at least that is discoverable in the Sediment formed by decomposing earthy Salts from 70 or 80 Gallons of Water. There was indeed in the Solution of the Sediment from the twelve Gallons, a more than usually bitter Taste than is perceived

(y) I proposed to expose the Matter precipitated by Alkali from the filtered Solution of an Ounce of *Sediment* in the vitriolic Acid, and the like Solution of the other Parcel of Sediment, to the Action of Phlogiston; which would decisively ascertain, whether a visible Quantity of Iron, or other Metal, be contained in more than 80 Gallons of Water; but I am prevented performing this Experiment for the present; and other Appearances, taken together, are sufficiently conclusive, that *Buxton-Water* contains no Iron or other Metals.

from

from calcareous Earth combined with vitriolic Acid, which might indicate a small Portion of Epsom Salt; but, if even a small Portion of this Substance could be demonstrated, upon this Occasion, I should rather suppose it arose from the Decomposition of the Alkali (z) employed to precipitate the Sediment, than from any Magnesia contained in the Water.

Appearances on the Addition of Powder of Galls to Solution of absorbent Earths, and Alkalies in Acids.

Calcareous Earth of any Kind, particularly Chalk, of various Parcels; the *Sediment* procured from Buxton-Water, or common Spring-Water, by adding fixed Alkali, as described in Exper. XII. and various Parcels of *Magnesia alba*, with a Variety of Specimens of very diluted vitriolic and muriatic Acids, added to nearly saturate them, to exactly saturate them, or to rather more than saturate them, when *recently dissolved*, on the Addition of Galls of various Sorts previously powdered in a Marble Mortar, always produced instantly, or in a few Minutes, *Colour*; which was *black*, various Shades of *blue*, *green*, *purple*, and *pink*; but calcareous Earth which had been *long combined* with vitriolic Acid, and then dissolved

(z) Several Chymists, as before observed, notice the Conversion of fixed Alkali, by Dilution, &c. into Magnesia.

in Water, or Solution of native Gypsum, did *not* produce a Colour upon the Addition of powdered Galls, either without, or along with, fixt Alkali:

When a Colour was, by this Means, produced, the *Kind* and *Shade* of it appeared to depend upon the Quantity of Acid, and might be varied accordingly; so when the Colour was *black*, by adding a very small Quantity of Acid more, it might be changed blue; by a little more Acid a light blue or deep purple; by still more, a light purple; and by still more, pink; and so on until the Solution was colourless, or only a transparent Amber Brown, not depending upon any Thing but the Solution of Galls in Water.

If the Solution had, on being first made, beyond a certain Quantity of superabundant Acid, so as to prevent the Appearance of Colour with Galls; or, if the Colour after being produced was destroyed, by adding too much Acid, *Colour* might be made appear, or reproduced, by gradually adding Alkali of any Kind, or absorbent Earth of any Kind, so as to nearly saturate the superabundant Acid: Which *Colour* might be again *destroyed* by adding fresh Portions of Acid, and again produced on adding Alkalies or absorbent Earth; and in this Manner, Colour of any of the above Kinds and Shades might be produced and destroyed at Pleasure.

The Fluid poured off from a Quantity of vitriolic Selenites, after a recent Solution of calca-

aceous Earth in diluted vitriolic Acid, produced Colour upon the Addition of Galls. The same Effect is commonly produced by a small Quantity of boiling Water, poured a second Time to dissolve a Part of this selenitic Mass; and by a third, and sometimes a fourth Solution of it in Water: But after several Solutions have been made by a small Quantity of Water, the Mass of vitriolic Selenites, from which they have been produced, ceases to give Colour when dissolved in Water; although as large a Portion of this Substance be obviously contained in the Solutions that do not, as those which did, produce Colour.

When a Mass of vitriolic Selenites, after repeated Affusions of Water, has ceased to produce Colour, by Galls added to the Solution of it in Water; such a Solution may sometimes be made to yield a Colour, by adding *fixed vegetable Alkali* to this Solution with powdered Galls; which Effect also ceases, after a few further Solutions in Water.

When the Solution of a Mass of vitriolic Selenites has ceased to afford Colour with Galls alone, and also with the Addition of fixed Alkali to this Solution and Galls; if this vitriolic Selenites be decomposed by Alkali, and the precipitated calcareous Earth be re-dissolved in vitriolic Acid, Solutions of this Compound, recently made, in Water, will produce Colour as before,
with

with Galls, either with or without Alkali; and cease to yield it a second Time in the Manner above-mentioned, but may again be produced and destroyed as before, as often as we please, till the whole Mass be dissolved in Water.

The *Sediment* left after Evaporation of the Fluid poured off from the Compound of vitriolic Acid and Quicklime; and from the Compound of the same Acid, and the *Matter precipitated* by Alkali from Buxton-Water, re-dissolved in Water would always, either immediately, or on the Addition of Alkali, produce Colour with Galls; even when before this Evaporation, Solutions of these Substances produced no Colour with Galls alone, Solution of the Sediment of them, left after Evaporation, produced Colour with Galls, upon the Addition of Alkali; provided, however, Colour could be produced before the Evaporation, either without or with Alkali, but not otherwise, which appears to be a curious Fact.

If to *muriatic Selenites*, recently composed, vitriolic Acid be added to decompose this Solution, and form vitriolic Selenites, and the muriatic Acid be washed, or poured off, so as to leave this Substance saturated without any, or with but a small Quantity, of superabundant Acid; upon the Addition of *Galls* to a Solution in Water of this Compound, Colour may be produced, without, or certainly with, the Addition of *Alkali*.

Neither

Neither the Acids diluted with Water, nor absorbent Earths, nor Alkali, nor Compound of Alkali and Acid, would produce Colour with Galls; but when a very small Quantity of Iron was added to Alkali, it produced Colour with Galls, when dissolved in vitriolic Acid and Water.

The Alkali used, was obtained by deflagrating Nitre; also that procured by the chymical Analysis of Vegetables.

Extremely dilute Solutions of Copper, Zinc, and Iron, mixed with saturated Solution of vitriolic Selenites in Water, produced, with Galls, according to the Degree of Dilution, *black, white, purple, blue, and red* Colours; but the Species of Metal could not be distinguished by the Colour struck with Galls, nor when the Galls were added to merely dilute Solution of these Metals in Water.

The learned and ingenious Bishop of Llandaff, (see *Chymical Essays*) found one Grain of green Vitriol dissolved in 15 Gallons of Water, produced Colour with Galls; and supposing half a Grain of Iron to be contained in this Quantity of Vitriol, then half a Grain of this Metal is discoverable in 30 Gallons of Water.

A dilute Solution of *Alum* with Galls, produced immediately a turbid Fluid, that on standing, exhibited white Clouds, suspended in a watery transparent Fluid.

I found

I found a very small Quantity of Calx of Iron, as well as of Copper and Zinc, with a large Quantity of calcareous Earth, might be dissolved by vitriolic Acid, and yet not made appear by Galls added to the filtered Liquor, until fixed Alkali should be added to the Galls; and that then a coloured Precipitate would be made, but the Metals were not distinguishable by any particular Colour of this precipitated Matter.

Neither found animal Mucilage dissolved in vitriolic Acid and diluted with Water; nor putrid animal Mucilage diluted with Water, as putrid Serum of human Blood, produced Colours with Galls, either with or without the Addition of Alkalies.

Sal Ammoniac dissolved in Water, produced no Colour on the Addition of Galls.

It is probable, that the Solution of absorbent Earths in other Acids besides vitriolic and muriatic Acids, have the above-described Property of producing Colour with Powder of Galls.

The *turbid Water*, after standing several Days upon the Sediment of the twelve Gallons of Water (see p. 196) before it was evaporated; in Quantity about a Pint, became fetid. To a little of this turbid and fetid Liquor were added a few Grains of Powder of Galls: At first there was no Alteration, but in an Hour or two the Water became *still more turbid, thicker, and whitish*. In twelve Hours it was *greenish at the Top, and under*

this it was milky, and deposited a whitish Sediment. By standing longer this Fluid became curdy, and of a purplish Hue; the middle Part was milky and thick, and the Top was of a dark blue Colour. Upon adding two Drops of vitriolic Acid to the Water in this State, it was changed to the Colour of red Port, was thinner, and half transparent.

The very same Appearances were exhibited on a Repetition of this Addition of Galls to a fresh Portion of this turbid Liquor; and likewise with Water, added several Times to this Sediment only rendered turbid without being fetid.

I have found, that the above Liquor with powdered Galls, sometimes, for perhaps twelve Hours, had no Effect, but would then turn muddy and of a horny brown Colour; and in a Day or two would have a Ring of a blue or black Colour. This I look upon, from various Observations, to be the smallest Effect of Iron or some other Substance which is precipitated by Galls that is visible.

Calces of Iron, Zinc, and Copper, produced no Colour when they had been infused in Water and filtered; but Water containing a Sediment of Calx of Iron agitated with Powder of Galls, occasioned a black Colour.

Dr. *Fordyce* observed in his chymical Lectures, that fixt Alkalies in a caustic or mild State, exposed with Phlogiston of animal or vegetable Substances, as with Charcoal or Blood, to a red Heat,

Heat, form phlogisticated Alkali; from which Substance a Matter may be precipitated of a *blue Colour*, called *Prussian Blue*;—that as green Vitriol was employed to precipitate this Substance in the Manufactory of Prussian Blue, the blue Colour was supposed to depend upon *Iron*;—that *this blue Matter may be precipitated of a blue Colour by vitriolic Acid without Iron*;—that *the same Matter may be precipitated by other Acids, but then it is not of a blue Colour*; and that this Substance, free of Iron, has not been properly examined.

The Result which I shall relate of a Repetition of these Experiments, was rather different from that of my learned Friend; as muriatic Acid likewise occasioned a blue Precipitate to be thrown down, upon being added to phlogisticated Alkali.

To phlogisticated alkaline Lixivium, was added diluted *vitriolic Acid*, which occasioned an Effervescence *without producing Colour till nearly saturated*; when, as well as when rather more than saturated, there was a *transparent Fluid of a Prussian blue Colour*. Upon adding more of the alkaline Ley it became *colourless*, and had the *Colour again restored* upon adding more Acid. By standing, it deposited a *blue Powder like Prussian Blue*.

The above Appearances continued, during the Addition of much more vitriolic Acid than was sufficient to saturate the alkaline Lixivium; which

super-saturated Alkali, on standing, deposited a Sediment of a *Prussian blue Colour*.

Nitrous Acid poured upon this alkaline Lixivium produced a turbid Fluid, which after standing had a *thick, copious, yellow Sediment*.

Phlogisticated alkaline Lixivium, and also Lixivium after detonating Nitre, with *muratic Acid*, produced the same *blue Colour* and *Precipitate* as above-mentioned.

Nitrous Acid and Lixivium of deflagrated Nitre produced only a *white turbid Fluid*, that on standing deposited a *copious white Sediment*.

Solution of mild fixed Alkali with Powder of Galls, and Spirit of Vitriol to saturate this Alkali, produced no Colour till it had stood an Hour, when a *blue Colour* appeared.

Calcareous Earth with *Spirit of Vitriol* to saturate it, and *Powder of Galls*, produced a *pink Colour of the Chalk while dissolving*; and when the Solution was finished, the *Sediment was, towards the Bottom, tinged of a pinkish Colour*, and the Fluid above was transparent and Amber-coloured. To some of this transparent amber Fluid I added Solution of *common mild Alkali*, which changed it immediately *muddy, thick, and purple-coloured*.

This phlogisticated fixed Alkali here employed had the Odour precisely of volatile Alkali, and was made by calcining common fixed vegetable Alkali with dried Blood.

In various Parcels of Potash, I have seen several Parts of it coloured of a Prussian blue Colour; but it is with me a Question, to what this Colour is owing: It may be a Matter of the same Kind as that precipitated by vitriolic Acid from phlogisticated Alkali.

The general Observations, that may be made upon the preceding Results, are

1. That a coloured Matter, apparently of the same Kind as Prussian Blue, may be precipitated from Compounds of absorbent Earth and any Acid by Galls alone, or by Galls and fixed Alkali; which is not only a new Fact in Science, but may be of immediate Application to the Arts; because it shows various Methods of effecting the same End.

2. That this blue Precipitation cannot be made from Combinations of absorbent Earths and Acids long formed.

3. That as this Precipitation of coloured Matter may be produced from Solutions of vitriolic Selenites in Water repeatedly made till the whole Compound is dissolved in Water; provided after it has ceased to yield a coloured Precipitate, the Compound be decomposed by Alkali and again dissolved in Acid, this Matter is either a Production of the whole Compound by Galls, or it is diffused through every Part of the Compound of which a small Portion only can be precipitated at a Time.

4. That this *coloured Substance* cannot be produced, in general, merely from recently-made Combinations of Acid with Alkali or other Matters in general, but only from Compounds of absorbent Earths and Acids, excepting upon some Occasions.

5. That the Principle upon which this Precipitation is made, is not understood, but considering the Effect of Substances, containing Phlogiston loosely combined, in producing *black Colours* with Galls, as volatile vitriolic Acid, fetid Water containing calcareous Earth, phlogisticated Alkali, or, perhaps, fixed Alkali converted into volatile Alkali by uniting it to Phlogiston, it may perhaps be reasonably conjectured, that *Phlogiston, not Iron, is essentially necessary to the Production of Prussian Blue.*

6. That phlogisticated Alkali, as well as Galls, is a fallacious Test of Iron; for Iron may exist and not be discovered by these Substances, or not till fixed Alkali be added, and the colouring Substance, said to be peculiar to Iron, appears where we have not the most distant Suspicion of the Existence of this Metal; or if this coloured Matter be composed of Iron, then this Metal exists in Substances, and under Circumstances not before pointed out or understood. And this suggests, that *Alkali added to Galls and any fluid Mixture, is a more delicate Test of Iron than Galls alone.*

It is much to be desired, that some Person would collect a sufficient Quantity of this precipitated Matter and investigate its Properties; particularly, whether with Phlogiston it may be converted into Iron, or any other metallic Substance, and with Acid form a metallic Salt.

Exper. XV. Solutions were made of six Sorts of Soap, viz. Spanish, common Ball, Turpentine, Castile, Almond, and sweet Soap, in eight or ten Times their Weight of distilled Water, with which they formed viscid, pearly-coloured, uniform Fluids.

The Almond and Spanish Soap were viscid Mucilages, but the Ball and Turpentine were Jelly-like; and the Castile Soap was a much more stiff Solution than the other Soaps with this Quantity of distilled Water. All these Solutions changed bright Grass-Green, on being mixt with Syrup of Violets; but every Thing which changes Syrup of Violets green is not Alkali, although Alkali always changes blue vegetable Juices green.

A little of each of the above Solutions was agitated with sixty Times its Bulk of *Buxton-Water* fresh from the Well, with the same Bulk of this tepid Water *after boiling*, both hot and cold; and with this Spring-Water, which had *stood in the open Air* till it was cold.

The Solution of Spanish, Almond, and sweet Soap united with Buxton-Water, under the above Circumstances, without the least apparent De-

composition. The Solution of Castile Soap was partially decomposed, and that of Ball and Turpentine Soap were wholly decomposed, by being agitated with Buxton-Water. Sometimes Buxton-Water when cold lathers well with Castile Soap, but decomposes it when hot.

These Solutions of Soap were also agitated with common *Pump-Water*, and with Solution of vitriolic Selenites in *distilled Water*, and the same Effects, or nearly the same, ensued as with *Buxton-Water*.

Any Compound of Acid and Earth, or Acid and Calces of Metals, dissolved in Water, will decompose Soap, excepting calcareous Earth; which last Substance does not prevent Water forming uniform Solutions with Soap, because *Gas is an Acid that has a stronger Attraction for Quicklime, than for the caustic Alkali combined with the Oil forming Soap.*

Any *Acid* combined with Water, as volatile sulphureous Acid, and Gas(a), decomposes Soap: And any *neutral Salt*, although it does not decompose the Compound of Oil and caustic Al-

(a) Mr. *Cavallo*, says Dr. *Priestley*, (Exper. and Observs. Vol. I. p. 31.) also frequently found Water impregnated with Gas, does not dissolve Soap so readily as without it; but that upon repeating the Experiment with Mr. *Fontana*, no Difference was observed, between Water with, and Water without, Gas.

Upon Repetition of this Experiment, I found distilled Water decomposed Soap impregnated with Gas: But there are, frequently, Circumstances accompanying the same Experiment, that occasion a different Result.

kali,

kali, when dissolved in Water prevents Water saturated therewith from uniting with Soap (*b*).

A Spring-Water that decomposes Soap, is called a *hard Water*; and the best known Signs of this Decomposition are the curdling of the Water upon mixing the Soap therewith, its not forming a smooth Mixture with Soap when employed for washing the Skin of the Hands or Face, and its not making an effectual Solution for removing Filth from Linen.

Spring-Waters that are *hard*, from whatever Substance, excepting the Compound of vitriolic Acid and Quicklime, or what is commonly known by the Appellation of gypseous Earth or Plaster-Stone, have so much, or so disagreeable a Taste, and also, frequently, such a Smell, as to prevent their being employed for culinary Purposes: But Springs are sometimes, although but rarely, so highly saturated with gypseous Earth, as to have a slightly nauseous Taste. In general, it is contained in such Proportions, that the greatest Num-

(*b*) Dr. Fordyce, in his Chymical Lectures, asserted, that Solution of Soap in Water, was decomposed by neutral Salts and Alkali; but upon mixing saturated Solution of fixed vegetable Alkali, and also Solution of vitriolated Tartar with the Solution of Soap, they formed uniform Mixtures: However, I probably did not effect the Decomposition, for want of Attention to proper Circumstances; or, probably, the small Quantity of such a neutral Salt, as vitriolated Tartar, dissolved in Water, is not sufficient for this Purpose.

ber of the most pleasant tasted Springs in this Island, are *hard Waters* from this Substance.

As Buxton-Water has neither Taste nor Smell; as it decomposes Soap, too, equally after boiling, as before Exposure to Heat, we conclude, that *its Hardness is occasioned by the general Cause of hard Waters, namely, a Solution of vitriolic Selenites.*

There was no apparent Decomposition with the Solution of Spanish Soap, i. e. Compound of caustic fossil Alkali and certain expressed Oils of Animals; nor with Almond Soap, which, I believe, is expressed Oil of Almonds and caustic fossil Alkali; or with sweet Soap, which is expressed Oil of Fishes and caustic vegetable Alkali; not only because the Union is more close and perfect between the Elements of these Compounds, and therefore such as requires the Aid of particular Circumstances in Order to effect their Decomposition, but on Account of the great Viscidity of the Solution of the Part of these Soaps not decomposed, the Oil of the Part decomposed is diffused throughout the Solution.

The Decomposition was very evident with the Solution of Ball-Soap, the Compound of fixed vegetable caustic Alkali and expressed Oil found in the adipose Membrane of Quadrupeds; and Turpentine Soap, which is, I am informed, this last Compound with a Portion of essential Oil or Resin; and in general, this Decomposition was evident

dent with Castile Soap, or caustic fossil Alkali, saturated with expressed Oil of Quadrupeds.

Sometimes a *hard* Water, with a Portion of Soap used for washing the Hands, is not decomposed, because a Quantity of superfluous Alkali adhering to the Soap decomposes the vitriolic Selenites. The above green Colour of Solution of Soap and Syrup of Violets was, I think, rather occasioned by the Soap than any superfluous Alkali; for a green Colour is but an equivocal Sign of Alkali.

As these three last Soaps are the ordinary Sorts in Use for culinary Purposes, we can understand why Buxton-Water is avoided by Washers of Linen for dissolving Soap; because, before this Water dissolves this Substance, the vitriolic Acid of the Gyps must be saturated with the Alkali of the Soap. This having taken Place, the Water unites with the Soap not decomposed; but, as a Portion of Soap is thus destroyed, and the expressed Oil as well as Earth suspended in the Water in Consequence of the Decomposition, is liable to soil and injure certain Things of a delicate Colour and Texture to be cleansed, it is both improper and too expensive, to use this tepid Water for cleansing Substances from Dirt by Means of dilute Solutions of Soap.

As the finer and specifically heavier Sorts of Soap, as Spanish and Almond Soap, &c. are commonly used for washing the Skin of the Face

and Hands; which, although partially decomposed, form such viscid Solutions, as that this Effect is not perceived, and the Destruction of Part of the Soap is here not an Object of Expence, we can see the Reason why Buxton-Water is in ordinary Use for this Purpose. However, the End is not answered so well, upon this Occasion, as by soft Waters; for, it is observed, that not only Linen is washed of a better Colour, but also that the Hands and Face are rendered whiter by Solutions of Soap in Water that does not occasion any Decomposition at all, as in Snow, Rain, or distilled Water, than in common hard Waters.

The Substance occasioning the *Hardness* of Buxton-Water, is further shewn by *the Means of rendering it soft*. It appeared from various Trials, that with a less Quantity than a Grain of fixed vegetable Alkali to an Ounce or 480 Grains of Buxton-Water, or at least, with less than half a Drachm of this Salt to a Quart of this Water, it was not rendered perfectly *soft*, or capable of forming an uniform Mixture with the Solution of Ball-Soap above-mentioned. The Water was rendered soft by this Substance, because the vitriolic Acid of the Gyps united with the Alkali added, and formed vitriolated Tartar, while the Quicklime of the Gyps combined with the Gas of the mild Alkali, and formed calcareous Earth; but as neither vitriolated Tartar in small Quantity,

tity, nor calcareous Earth, prevents the Union of Soap with Water, this Fluid, after the Addition of a sufficient Quantity of mild Alkali, united with Soap without occasioning the smallest Decomposition.

This is the Principle, upon which may be explained the most frequent Method of rendering Waters *soft*, by the Addition of Ashes of Vegetables or Potash, in Situations that are at a Distance from *soft* Waters afforded by Springs, or Rivers; and where, perhaps, Water is not plentifully precipitated in Rain or Snow; or where the Custom does not prevail of collecting Rain and Snow-Water. The fixed vegetable Alkali is the Substance contained in these Ashes, that renders Water *soft* in the Manner above-related.

Those who are desirous of employing Buxton-Water as a *soft* Water, are furnished, by the above Experiment, with the cheapest Method or smallest Portion of Alkali that will effect this Purpose. After adding the Alkali, the Solution should stand at least 24 Hours, and then be decanted or filtered for Use.

Buxton-Water may, perhaps, also be rendered *soft*, by two other Methods employed by Nature, namely, *Exposure to the Air of the Atmosphere*, and *Evaporation*.

First, It is a known Fact, that all, or the greatest Number of Rivers, are *soft* Water; but, that the Springs by which they are formed are, for

the most Part, of *hard* Water. I have more than once traced pretty large Rivers of soft Water to their Source in *hard* Spring-Waters, and found this Quality to diminish according to the Extent of their Course, and Exposure in broad and shallow, or narrow and deep Channels to the Atmosphere. Accordingly the *Springs* were found *hard*; a *shallow Stream* formed by many of these Springs was *less hard*; a *Rivulet*, from still more of these Springs contained Water which had *this Quality in a less Degree* than the Brook flowing into it; and by the Time a large Body of Water, namely, a *River* was formed, by the Junction of numerous small Streams, *soft Water* was found.

Soon after considerable Falls of Rain, or Snow, in the eminent Lands destined for the Origin of Springs, Rivers and even *hard* Springs are rendered soft by the Mixture of a large Quantity of Rain, or Snow-Water, that has not been impregnated with Selenites and other Substances in the subterraneous Passages of the Earth: But, upon other Occasions, when Rivers or Rivulets of *soft* Water are evidently supplied by Springs of *hard* Water, the Change in the Quality of the Water is occasioned by *Exposure to the Air of the Atmosphere*; the Effect of which is the same as upon dilute Solutions of earthy and metallic Salts; namely, to decompose them, and therefore to render *hard* Water *soft*. This Operation of Nature is imitated, by exposing *hard* Spring-Water

in Vessels to the open Air, by which Means, its Quality of *Hardness* is diminished. And this Change may be accelerated, perhaps, by *Exposure to Heat*; for sometimes by boiling, hard Waters are rendered *soft*; because the Selenites is decomposed by Heat: Sometimes, they are made *harder* by boiling; because, this Salt is not decomposed, and the Solution of it is more concentrated by having evaporated Part of the Water.

Secondly, The *hardest* Waters, after being converted into Vapour by Heat, or dissolved in Air, and again brought into a fluid Form by Condensation, or Precipitation, are perfectly *soft*; because the solid Substances with which they were impregnated, and therefore Gyps, were not raised along with this Vapour. Hence Rain and Snow-Water are always perfectly *soft* Waters; and, excepting on Account of the Substances they meet with in their Passage through the Atmosphere, are as pure, as well as *soft*, as distilled Water. *Distillation* is scarcely in Use for rendering Water *soft*, for culinary Purposes.

The tepid Springs of Buxton never vary in their Quality of Hardness by Rains, Drought, or any other Cause.

Having shown then, that the tepid Springs of Buxton belong to the Class of *hard* Waters, and that the Substance on which this Quality depends is the same as that of *hard* Waters in general; we shall be able to account for some known Effects in domestic,

domestic, or culinary Uses, and to infer other Effects dependent upon this Substance.

1. The tepid Waters of Buxton are in ordinary Use, as well as those of Matlock, for making *Infusions of Teas*. The *Flavour* and *Colour* of the Infusion of these Substances is more agreeable in Buxton-Water than in common Spring or River-Water; which may be accounted for by considering, that the Proportion of vitriolic Selenites is not so great in Buxton-Water, as in many *hard* Springs, therefore either to communicate a Taste; or occasion too sparing a Solution; or, like Water that contains none, or in so small a Quantity as not to impart the agreeable Colour peculiar to Infusions of Vegetables in dilute Solutions of vitriolic Selenites. But, like all other hard Waters, a greater Quantity of Tea is necessary to make an Infusion in this tepid Water of a given Strength, than in *soft* Water; because, it seems, Water containing vitriolic Selenites, does not so readily or so effectually dissolve vegetable Substances as Water without this Impregnation.

On the Power of Solution being different in different Waters, various Effects in the Practice of Arts depend. For *Dying, Bleaching, Tanning, &c.* *soft* Waters are preferred, or are essentially necessary. In *Dying*, the Excellency of the Colour is said, upon some Occasions, to depend upon the Water peculiar to certain Situations. *Boerhaave* says, the Water near *Leyden* is peculiarly proper

proper for Dying, and producing finer Colours than other Places. In general it is observed, that Waters which have stood long, putrefied, and been filtered through Sand, are the best for Dying; because they extract the finest Colour, and to the greatest Advantage; and in short, for Solution in general, the lightest and *softest* Waters are preferable: therefore, Buxton-Water is improper for these Purposes.

In the washing of Deal-Floors, *hard* Water is said to have the Effect of producing a blackish Colour. For *tempering* of Steel *hard* Water is preferred. *Plants* watered with *hard* Water are liable to be injured or killed; therefore, Gardeners expose it to the open Air some Time before using it.

Particular Brooks or Rivulets being adapted particularly to certain Fishes, depends as much upon their Impregnation with calcareous Earth or other earthy Salts, as any other Causes.

2. The Water of these tepid Fountains is rarely employed for *brewing Malt-Liquors*, although, according to Information, it answers well for this Purpose; probably, not because the *Ale* would not be so good in *Quality*, but because it would not dissolve so compleatly the Sugar of Malt, which is to be fermented into that Species of Wine called *Ale*; and consequently, not afford vinous Liquor in so great *Quantity* as Solutions in *soft* Water. It is, I find, a Custom in many

Q

Places,

Places, to employ for brewing, equal Parts of *soft* and *hard* Waters; which seems, as if a dilute Solution of Selenites answered better than Water entirely without this Substance. Also hard Waters are preferred for Wines intended to be long kept. But the peculiar Excellency of the *Thames-Water* for making Porter, probably, does not depend entirely upon its *Softness* as a River-Water, and consequently Want of Selenites, but upon some other Qualities not understood.—Does it depend upon its containing such a Proportion, viz. $\frac{1}{300}$ of its Weight of animal and vegetable Matter as to be fermentable of itself?

The *Spreewater* used for brewing, *Margraaf* found contained in 900 Ounces, or 25 Quarts, four Drachms 15 Grains of calcareous Earth, 30 Grains of common Salt, a small Quantity of alkaline Ley, and a Substance like Nitre.

3. The Buxton-Water is in Use for *coagulating Vegetables* in the boiling Heat of Water, where a *fine green Colour* and *Firmness* is wished for, that certainly depend upon the vitriolic Selenites; and yet, I am told, a very dilute Solution of vegetable Alkali in Water, boils Vegetables of a fine green Colour: But where Colour and Firmness are not required, as I am informed, in boiling certain Roots, as Potatoes, Turnips, &c. *soft* Water is preferred. One of the Signs of Salubrity of Springs is taken from the Effects of them in coagulating Vegetables.—“Ex iis quæ ponderare

dere pares sunt, Eo melior quæque est quo celerius & calefit & frigescit, quoque celerius ex ea Legumina percoquantur.”— *Celsus*.

As *hard* Waters even diluted with *soft* Water, impart a reddish or brown Colour to animal Mucilage boiled therein, instead of a white Colour when coagulated by boiling in *soft* Water; this tepid Water is, probably, not employed upon those Occasions in the Kitchen, where *Colour* is an Object, as of Rabbits, Fowls, Veal, &c. but where *Firmness* merely is required as in the boiling of *Fishes*, then hard Water is preferred. Likewise for Substances to be preserved by Sugar or Acid, which are to be first boiled, *hard* Water is more proper. I believe, that if a Slice of Veal be put into a Cup of *hard* Water, and another Slice into a Cup of *soft* Water, on standing, the Water of the latter will become reddish-coloured, and the Flesh be soft, while the Water in the former is almost *colourless*, and the Flesh *hard*.

5. This tepid Water will frequently not be employed in Summer Time, merely for common Drink, or diluting Wine, because of its Temperature so much exceeding that of other cold Springs of *hard* Water; and, because it cannot, in general, by mere Exposure to the Air, be cooled to the Degree of Springs of cold Water, or about 48° ; but in cold Weather, or in the Winter Season, after cooling it in the Atmo-

sphere, it may be used for common Drink, as well as any ordinary Spring-Water.

A pleasant Spring, much used at *Berlin*, for drinking, according to *Margraaf*, contained in 100 Quarts, each of which held 36 Ounces, 1 Ounce 2 Drachms and 15 Grains of calcareous Earth, 7 Grains of Gypsum, 2 Drachms and a half of common Salt, 8 to 10 Grains of Nitre, and 30 Grains of Mother-Ley of Salt-Petre.

II. A I R.

Exper. XVI. An eight Ounce wide-mouthed Phial, containing about a Drachm Measure of *vitriolic Acid*, was filled with Buxton-Water, by immersing it in the Well; which, being withdrawn the Instant it was filled, was inverted in a Bason of this tepid Water, and placed near a hot Fire. In the Space of a Night, about half a Drachm Measure of permanent Vapour, apparently *Air*, was collected at the Top of the inverted Bottle; and while this Quantity was collecting, the Water *sparkled* much more with *bright Bubbles* than this tepid Water inverted and placed in the same Exposure, without the Addition of any Acid, and which did not separate more than about two-thirds of this Quantity. On the Addition of Spirit of Vitriol to this tepid Fountain-Water of Buxton, the Number of Bubbles, that manifest themselves spontaneously in Vessels filled with it, is increased; and this increased Number
of

of Bubbles, even takes Place on the Mixture of Solution of Metals in nitrous Acid, for other Purposes. It appears, that during the Union of Acid of Vitriol with this Water, *Air*, or some other permanent Vapour, combined with, or diffused throughout, this Fluid, was disunited; as was manifest by its adhering to the Sides of the Vessels, gradually collecting together, and rising to the Top of an inverted Vessel of this Water.

III. PHLOGISTON.

Exper. XVII. A Piece of Writing-Paper, that had been dipped in a Solution of *Saccharum Saturni*, and afterwards dried, was suspended immediately over the Parts of Buxton-Bath where the Bubbles rose spontaneously, and vanished upon its Surface; but no Colour was induced in the Paper by this Exposure.

A Mass of *polished Silver* was immersed some Time in this tepid Spring, but it was not tarnished by this Means.

I have found, that phlogistic Vapours, or Phlogiston, rising from various Substances, as from Animal Matter during the putrid Fermentation, tinge Paper that has been moistened with Solution of Sugar of Lead, suspended over the Surface of them, of an Orange-Colour first, and afterwards of the Colour of Lead; and that a similar Colour is produced on the Surface of Silver, by the same Means.

As no Colours were produced in this Experiment, it is inferred, that no phlogistic Matter is contained in, or separates from, this tepid Water.

*Result of the whole of the preceding Experiments by
Means of MIXTURE.*

The Mixture of Substances with Buxton-Waters, instructs us, that they contain *no Acid*, excepting, perhaps, a small Quantity of Gas, and *no Alkali*;—that they are impregnated with *vitriolic Acid combined with Quicklime*, forming vitriolic Selenites, but whether united with other Substances also, these Experiments do not make appear;—that they contain *muriatic Acid combined with some Substance*, but with what Kind of Matter is not ascertained; and also *calcareous Earth*;—that it is extremely doubtful, whether they have any *metallic Salt*, but that, if they do contain any, it is Iron dissolved, probably, in Acid of Vitriol, certainly not by Gas; and that they are impregnated with a *permanent Vapour*, which is probably Air, but *not with any phlogistic Substance*.

The Proportion of these Substances, dissolved in Buxton-Water, to each other, and to the Water, doth not appear from these Experiments by Mixture; but from the Comparison generally made, of the Appearances on Mixture with common Spring-Waters, it is probable, that they are not only the same Sort of Substances, but in Quantity not exceeding that which is usually contained in ordinary cold Springs.

We

We shall next relate the Properties of this tepid Water of Buxton, that are made appear by Means of Heat.

SECTION III.

Containing Experiments to discover, by Means of
 HEAT, *the Properties of Buxton-Water.*

Exper. XVIII. **I** Propose to ascertain by this Experiment, whether any, and what Quantity of *permanent Vapour* may be separated by Heat.

A Tin-Pan was procured with an inverted Funnel, of the same Kind as that invented, described, and employed by the Hon. Henry Cavendish, for separating Air from Rathbone-Place Waters (c). This Pan held 20 Pints, 16 or 17 of which, were contained under the Funnel.

It was filled at the Spring with the tepid Water of Buxton, and at the same Time a three Ounce wide-mouthed Phial quite full of this Water, was inverted over the Throat of the Funnel. During

(c) See Phil. Transf. Vol. LVII. 1767. Vessels for the Purpose of extracting permanent Vapour from Water, have been also contrived by Boerhaave, (see his Chymistry, translated by Shaw) and by Abbé Fontana.—Phil. Transf. Vol. LXIX.

the Space of five Minutes after this Pan was filled, and previously to its being placed upon the Fire, the inverted Bottle sparkled with Bubbles that adhered to the Sides of it; and, about half a Drachm Measure of apparently permanent Vapour collected at the Top of this inverted Phial. After two Hours Exposure to Heat, not exceeding 160° or 170° , about two Ounces and two Drachms Measure of apparently permanent Vapour were observed within the inverted Phial: And, as the Water ceased to separate this Vapour during the Continuance of the Exposure of it to this Heat, the inverted Phial was removed, and set to stand in a Saucer of cold Buxton-Water; where, in a few Minutes, the Bulk of Vapour diminished to one Ounce and six Drachms Measure. After this Time, I found that a boiling Heat continued for two Hours and a half or three Hours, was required, in order to extricate the Remainder of the apparently permanent Vapour that was capable of being detached from this Bulk of Buxton-Water; and which contracted its Bulk on standing in cold Water, much more than the former inverted Phial of Vapour. This apparently permanent Vapour rose within the inverted Phial visibly, in the Form of small bright Bubbles, rather smaller, but as sparkling as Bubbles of Air in Water.

After the Water ceased to separate these Air-like Bubbles, and a boiling Heat was continued, it exhibited large Bubbles which rose within the
inverted

inverted Bottle, and there vanished, without augmenting the Bulk of Vapour already collected, or remaining in the State of Vapour, excepting during the Ebullition. These Bubbles might be produced till the whole Water was evaporated, and yet no further permanent Vapour be collected.

A Quantity of the above apparently permanent Vapour was procured by Means of this Tin-Pan, filled several Times with Buxton-Water; and, it was found, that each Panful of this tepid Spring afforded from *four Ounces to four Ounces and a half Measure* of this Vapour, when the Temperature of the surrounding Medium was about 54° , and the Atmosphere was of its mean Degree of Weight.

If the inverted Phial of apparently permanent Vapour was only warm, when removed from the Pan into a Vessel of cold Water, the Diminution in the Bulk of it was not considerable, and the utmost Contraction of which it was susceptible, under the above Circumstances, was effected in the Space of a few Minutes. But, when the inverted Bottle was hot at the Time it was carried from the Pan into the Saucer of cold Water, the Contraction in the Dimensions of the apparently permanent Vapour was very considerable, and required several Hours Exposure, under the above related Circumstances, before this Contraction entirely ceased. After this Time, it varied little in Bulk

Bulk while standing in Water for a Day or two, provided the Temperature and Weight of the Atmosphere remained nearly in the same State.

It is worthy of Notice, that however hot the inverted Phial of Vapour was at the Time of removing it from the Pan; and however great the Diminution of its Bulk would have been under the above-related Circumstances, the greatest Degree of Contraction of its Dimensions might be produced in the Space of a few Minutes, by transferring it through a large Bulk of cold Water from one Phial into another.

Buxton-Water, after being deprived of apparently permanent Vapour by Heat, in the Manner above-described, was quite clear, and a white earthy Matter was found adhering to the Sides of the Pan, Funnel, and Outside of the inverted Phials.

The invisible Substance, by the above Means collected, and contained in the inverted Phials, was varied readily and evidently in its Bulk by Pressure; as appeared by merely immersing in a very deep Vessel, as a Tub of Water, a Tube filled with this Vapour to a certain Mark while it stood inverted with the End just below the Surface of Water. In Consequence of this Immersion, the Water was seen to rise within the Tube above the Mark, or the Column of Vapour within the Tube was shortened, and might be reduced to its former Dimensions, when the Water was made to fall within the Tube to the Mark, by elevating it

to its former Position, or so that the open End of it just touched the Surface of the Water. Many other Appearances shewed the Variation of the Dimensions of this Substance, to be according to the Degree of Pressure to which it was exposed; and the Bulk of it was as sensibly altered by different Degrees of Heat.

Deduction. The Substance procured from Buxton-Water by Heat in the above Experiment was a *Vapour*; because it was *elastic*, and readily and considerably varied *in its Bulk*, according to the Temperature and Weight of the surrounding Medium; also because it was *invisible* in a small Quantity viewed together, which is a peculiar but not essential Property of Vapour. From its retaining the State of Vapour in various Temperatures of the Atmosphere, it belongs to the Class of *permanent Vapours*; but concerning the Sort of Vapour we can only infer, that it is not Gas, or any other Vapours which are readily, or at all soluble in Water; nor any of those that have a Smell, as that permanent Vapour called Hepatic Air.

Exper. XIX. I proposed, in the next Place, to determine the *Kind* of permanent Vapour procured by the last Experiment.

To *two* Measures of this permanent Vapour, were added *one* Measure of nitrous Gas; which being agitated in a white Flint Phial, immediately produced a turbid Orange-coloured Appearance,
and

and some Degree of Heat, for a few Seconds; the Mixture then became transparent, and was sensibly diminished in Bulk. After several Mixtures of this Sort, with different Parcels of permanent Vapour, had stood two or three Days, they were transferred into a Tube for measuring the Bulk of permanent Vapours. The three Measures were always found diminished, but in various Degrees; in some Instances measuring two Measures and one-eighteenth, and in other Cases two Measures and four-ninths; and again, in some Instances two Measures and a half.

The greater Differences of Bulk happened with different Parcels of permanent Vapour procured at different Times, and after various Degrees and Times of Exposure to Heat, but smaller Differences appeared in different Trials with the same Parcel.

One Measure of nitrous Gas, was mixed with two Measures of common atmospheric Air; which Mixture immediately, upon Agitation, was attended with a turbid, Orange-coloured Appearance, Heat and Transparency; and a sensible Diminution of Bulk, succeeded in a few Seconds. Several Mixtures of this Kind were made, and after they had stood two or three Days, they measured from one Measure and six-ninths, to one Measure and eight-ninths.

A lighted Wax Taper was several Times introduced within a six Ounce Jar, filled with various
 Parcels

Parcels of this permanent Vapour separated from Buxton-Water by boiling, by sliding Part of the Mouth of this Vessel over the Edge of a Tub quite full of Water, and returning it to its inverted Position over the Water the Moment the Candle was placed within the Bottle; the Flame was, upon the Introduction of the Taper therein, always instantly extinguished.

The same Wax-Light introduced into the Jar just mentioned filled with common Air, and in the Manner above-related, burnt for the Space of several Seconds before it was extinguished.

The same Species of *Quadrupeds* lived different Spaces of Time, and with various Degrees of Uneasiness, in a certain Bulk of this permanent Vapour of Buxton-Water, from the same Parcel. They always lived a *shorter Time* than in an equal Bulk of common Air, and always diminished the Bulk of it by breathing and dying in it. For a middle-sized vigorous Mouse, introduced into a Receiver containing *three and a half Ounces Measure* of this permanent Vapour, standing inverted in Water of 70° of Heat, lived without manifesting Signs of Uneasiness thirty Minutes; it then began to shew Symptoms of Pain, its Eyes began to protrude, and it died in twenty Minutes further convulsed. In this Quantity of common Air, under the above Circumstances, I apprehend this Species of Animal will live without Uneasiness forty Minutes, or upwards,

wards, in general. A Mouse, introduced as above-mentioned, within a Receiver containing *two Ounce Measures* of this permanent Vapour of the tepid Water of Buxton, on its first Introduction appeared to be in Pain, as its Respiration was quick and short, and its Eyes protruded; however, it lived thirteen Minutes, and then expired apparently in a paralytic State. Another Mouse also introduced into two Ounce Measures of this permanent Vapour, as above-mentioned, died, after living only seven Minutes, and during this Time in Pain.

A Mouse will commonly live about twenty Minutes with tolerable Ease, in two Ounces and a half Measure of common Air of a temperate Heat, and thirty or thirty-five Minutes before it dies.

This Experiment furnished a decisive Proof, that a great Part of the permanent Vapour detached by exposing Buxton-Water to Heat was *Air*; for this permanent Vapour only *combines* with nitrous Gas, and produces a considerable Diminution of the joint Bulk of these two Vapours mixt together, accompanied with a turbid Appearance and Heat during the Act of Combination: And in this permanent Vapour only, can Animals *breathe*, and by Respiration diminish its Bulk. But only a Part of the permanent Vapour separated from Buxton-Water by Heat is Air; because the Diminution of Bulk, on Mixture with
nitrous

nitrous Gas was always *much less*, sometimes very considerably less, than with an equal Bulk of common Air, and because it supported animal Life a *shorter Time* than an equal Bulk of common Air. This permanent Vapour of Buxton-Water *extinguished Flame*; and as its Effects upon nitrous Gas and animal Life demonstrate a Part of it to be Air, and as Air mixt with only a small Portion of any other Species of permanent Vapour is unfit for supporting Flame, its Effects upon the lighted Wax Taper prove it to be a *Mixture of Air and some other Vapour*. The Air in which a Candle has burnt out, will support Respiration nearly as long, and will diminish nearly as much with nitrous Gas, as Air of the same Parcel before the Extinction of Flame therein.

The various Degrees of Diminution with different Parcels of this permanent Vapour of Buxton-Water and nitrous Gas shew, that the *Proportion of Air* to the other Vapour or Vapours is *various*; which Variety will be accounted for hereafter.

Exper. XX. In order to judge better concerning the Effects of Buxton-Water, and to investigate further the Properties of the permanent Vapour procured by the two last Experiments, I subjected *Matlock tepid petrifying Water*, and also several *Spring-Waters* near Doncaster (that were hard Waters, and rose out of a Bed of Gravel, and did not fur Vessels considerably on boiling

I

like

like Waters flowing from Lime-Stone Strata), to Heat in the Tin-Pan above-mentioned.

These Spring-Waters, and the Matlock tepid petrifying Water detached *Vapour* with much the same Appearances as Buxton-Water in Experiment XVIII.

The Tin-Panful of Matlock-Water afforded *three Ounces and a half* to *four Ounces* Measure of permanent Vapour, under similar Circumstances of Pressure and Temperature, as those in Experiment XVIII.: And the Water, after being thus deprived of its permanent Vapour, had its Transparency disturbed, and separated a larger Quantity of earthy Matter than Buxton-Water, by boiling, upon this Occasion. Five Panfuls yielded twenty Ounces and two Drachms Measure of this permanent Vapour, in November 1781, at the Spring-Head.

Each Tin-Panful of the Doncaster Spring-Waters separated, in general, not more than *three Ounces and a half Measure* of permanent Vapour, under nearly equal Pressures and Heat of the Atmosphere as those to which Matlock and Buxton-Water were exposed, as above related. The permanent Vapour of these Spring-Waters near Doncaster, was separated at different Times in the Months of November and December, 1781; and less Earth was found adhering to the Vessels after boiling them, than after boiling those of Buxton and Matlock.

The

The above permanent Vapours from Matlock-Water, and the common Springs near Doncaster, had the same general Properties as those related of the permanent Vapour of Buxton-Water, p. 232, 233, 234; to which we add, that these permanent Vapours were not diminished by Exposure to a Quantity of caustic Ley, and therefore we make the same Inference as that in p. 235.

We likewise observe, that the *sparkling* Appearance of the Bubbles, during their Separation from these Spring-Waters by Heat, is very different from the Appearance of the Particles of Gas during its Separation from Water, which are very dull, like Particles of Sand, and exceedingly small, as described p. 166, 167.

Also as the Diminution of Bulk was rather greater by Mixture of these permanent Vapours with nitrous Gas, than by Mixture of common Air with this Substance (*d*); as Animals lived with Ease, and as long, or longer, on repeated Trials of these permanent Vapours, than in common atmospheric Air;

(*d*) The turbid and Orange-coloured Appearance is most distinctly observed, by mixing the nitrous Gas and Air together in greenish Phials. The turbid Appearance was greater, and Orange Colour deeper, and of longer Duration, on mixing nitrous Gas with the permanent Vapour procured from the Doncaster Springs, than I observed with the Mixture of the permanent Vapour from Matlock, or Buxton-Water. Whether this Difference denotes greater Purity, or depends upon some other Circumstances, remains yet to be determined.

R

and

and as a Wax-Light burnt as long or rather longer in Receivers of these permanent Vapours, than in the same Receivers of Air of the Atmosphere, it was inferred, that *Matlock tepid petrifying Springs, and the Springs near Doncaster, examined upon this Occasion, yield, by Exposure to Heat in the Manner related, permanent Vapour, which is Air (e) ra-*

(e) The Bishop of Llandaff observed, that Well-Water, River, and Rain-Water, discharge Air in about 60° of Heat of Fahrenheit's Thermometer; but that Matlock-Water, which is 68° of the same Thermometer, excepting in very hot Weather, does not separate its Air visibly.

Abbé Nollet found, that Water, which had been purged of its Air by boiling, absorbed $\frac{1}{36}$ of its Bulk.

Dr. Hales procured, by Distillation, from 54 cubic Inches of Water, one cubic Inch of Air.

Eller detached Air, which was $\frac{1}{36}$ of the Bulk of the Water from which it was procured.

Dr. Priestley procured $\frac{1}{4}$ Ounce Measure of Air from a Pint of Pump-Water.

Abbé Fontana says, Seine-Water, after being long boiled, in 40 Days absorbed $\frac{1}{28}$ of its Bulk of Air.

The Quantity of Air, that Water can absorb, depends upon the Purity of it and the Air employed, and upon the Weight and Temperature of the Atmosphere.

Mr. De Luc somewhere observes, that Water retains Air not separable by Heat, or by removing the Pressure of the Atmosphere; but by long Agitation *in vacuo*.

The Air of Springs, and of distilled Water, has been found frequently purer than atmospheric Air. In 40 Days, Fontana says, Water absorbs $\frac{1}{28}$ of its Bulk of common Air, and in the same Time $\frac{1}{4}$ of its Bulk of dephlogisticated Air.

ther more pure than the Air of the Atmosphere; and not like Buxton tepid Springs of two or more Species of permanent Vapour, viz. Air, and permanent Vapour not respirable; but which is not Gas, or permanent Vapour that has any Smell, as hepatic Gas: and which is probably that Vapour spoken of p. 152, 153, concerning which we shall make a particular Enquiry hereafter.

Buxton-Water, p. 175, Experiment II. formed with Lime-Water a milky Mixture; and on standing deposited a white Sediment; as did Matlock petrifying tepid Water, and the Springs near Doncaster; from which Waters permanent Vapour, found to be chiefly or entirely Air, was detached by Exposure to Heat, p. 238, 242. The Appearances in Exper. II. being nearly the same that arise on adding Lime-Water to distilled Water impregnated with Gas, are accounted for by supposing these Spring-Waters contain Gas, which combines with the Quicklime dissolved in Water, and forms a compound, calcareous Earth, that is first suspended throughout, and then precipitated in the Form of Sediment from the Water; because Quicklime and Gas have a stronger Attraction for each other, than for Water with which the former makes Lime-Water, and with which the latter forms acidulous Water. But Water naturally or artificially impregnated with Gas, when exposed to even less Degrees of Heat than those employed p. 232, 240,

is generally deprived of this Vapour (*f*). Therefore it is inferred, that the Gas in Buxton, Matlock, and the common Springs examined, is either so combined with the Water (in a Manner different from

(*f*) Dr. *Hales*, by Means of Heat, expelled both Gas and Air from Fountain-Waters; although he does not appear to have understood the Distinctions between these two Vapours. He says, "From two Quarts of Bath-Water Air, the Size of half a Pea only, was separated." The same Event would have happened with Buxton-Water, and the common Spring-Waters I examined; because they do not, by Heat, separate Gas, but Air and permanent Vapour that is unfit for Respiration. "Neither will all the latent Air which is, by Heat, raised out of several Waters be reformed again, or lose its Elasticity till after several Weeks; as was the Case with the Airs from the Ebbham and Acton-Waters. But as to Pyrmont, Spaw, and Tunbridge-Waters, whence greater Plenty of this elastic Matter is raised by Heat, it does not continue so permanently elastic." The elastic Matter spoke of and reformed so readily is Gas, but that which is said to be more permanently elastic was, probably, Air, or phlogisticated Air.

Dr. *Priestley* says, "The Heat of boiling Water will expel all the fixed Air, if a Phial containing the impregnated Water be held in it; but it will often require about half an Hour to do it compleatly." *Exper. and Observ. Vol. I. p. 31, 32.*

Mr. *Cavallo*, see his Treatise on the Nature and Properties of Air and other permanently elastic Fluids, says, "Spring-Water retains fixed Air more obstinately than Water artificially impregnated with it, which is owing to some earthy, or metallic Particles; for Water impregnated with fixed Air will escape in a few Hours, but this is not the Case with common Water naturally impregnated with fixed Air."

that

that in artificial and many natural Combinations) as not to be detached by Heat, or with some Substance contained in the Water, forming there- with a Compound incapable of Decomposition by the Heat of boiling Water.

In prosecuting then the Investigation of the permanent Vapours of Buxton-Water, the next Subjects of Enquiry that occurred were, to find the *Quantity of Gas* that was probably contained therein; and *the Kind of Substance with which it was combined*, together with its Mode of Combination.

Previously to entering upon these Enquiries, I thought it would be more satisfactory to manifest by actual Experiment, that the Sediment of precipitated Matter, formed by adding Lime-Water to the above Spring-Waters, was a Compound of Gas and Quicklime.

Exper. XXI. I took four wide Glass-Vessels, called Sugar-Glasses, into one of which I poured two Quarts of *Buxton-Water*; into another, the same Quantity of *Matlock-Water*; into the third, the like Bulk of *a common Spring-Water*; and into the fourth, two Pints of *distilled Water saturated with Gas*. To each of these Vessels were added three-fourths of a Pint of *Lime-Water*. A *milky Appearance* ensued immediately in the above three Spring-Waters, followed by the Formation of *Clouds* suspended in various Parts, and after standing twenty-four Hours, the Deposition of a *white, loose, and woolly Sediment* took Place in a

clear colourless Fluid, nearly alike in all the three Glasses containing these Fluids. *No curdy Appearance* or *Clouds* happened in the distilled Water impregnated with Gas; but a *Sediment* gradually subsided to the Bottom, which was close, even, and adhered firmly to the Bottom of the Vessel. The Water was decanted from each of these Sediments, so as to leave behind about one Ounce of turbid white Fluid, that had neither Taste nor Smell.

Concentrated *muriatic Acid* was poured Drop by Drop upon this Sediment. It excited an Effervescence, during which a Vapour was detached that was Gas; for it was readily soluble in distilled Water, to which it imparted an acidulous Taste, it precipitated Lime from Lime-Water, and it was speedily united with caustic Alkali. The *muriatic Acid* united with these Sediments formed Compounds of a bitter Taste, like *muriatic Selenites*. *Vitriolic Acid* added to these Compounds of *muriatic Acid* and Sediment, produced a turbid white Mixture, which had the Smell of *muriatic Acid*.

The foregoing Experiment, perhaps, determined, in a sufficiently satisfactory Manner, that the *Sediment*, formed after adding Lime-Water to Buxton, Matlock, and common Spring-Water, is a Compound arising from the Union of the Gas of these Springs with the Quicklime dissolved in Water. The Precipitation formed by adding Lime-Water

ter to Gas and distilled Water was attended with a different Appearance from that which happened with Spring-Waters; which is a Particular worthy of Notice, and may be explained by the subsequent Experiments.

Article of Enquiry. The *Quantity of Gas* in the three above-mentioned Spring-Waters, it was conceived, might be determined by ascertaining the exact Quantity of Lime-Water that saturates the Gas in each of the Springs, provided the Quantity of Gas that will saturate a given Bulk of Lime-Water be known. Or after precisely saturating the Gas in these Waters with Lime-Water, and collecting the Sediment by ascertaining the *Weight* of the Compound of Gas and Quicklime in each Water; and then, by decomposing this Compound, we learn the Quantity of Gas it contains, which is the Quantity contained in a given Portion of Water. And the Quantity of Lime-Water the Gas thus extricated will saturate, we should expect to be equal to that added to saturate the Gas in the Spring-Water.

Exper. XXII. The Result of a great Number of Trials made with Buxton-Water *taken fresh from the Spring* in the Winter and Summer Season of the Year 1782; and with this Water *after remaining in Bottles* some Time; also with this Water *after being exposed to the open Air*; mixed with Lime-Water soon after, and also some Time after making; with different Sorts of Quicklime used

shortly after the calcareous Earth, from which it was produced, was decomposed by Heat, dissolved in hot and cold, hard and soft Spring-Waters, instructed me, 1. That Mixtures composed of *three Measures*, or a smaller Quantity of this Spring-Water, and *one Measure* of Lime-Water, after standing a sufficient Time in close Vessels for the Sediment to subside, and pouring off the Water from the Sediment, had its Transparency disturbed, or became pearly-coloured or milky, on the Addition of Gas. On the further Addition of Lime-Water it remained clear, but a Crust formed on the Surface of this Mixture by standing. *Syrup of Violets*, of various Parcels, changed either a deep Grass-green or yellowish Green, in falling through this Mixture, into which it was poured, or certainly was a deeper Green than before. Upon Agitation, this Mixture was either a deep Grass or Yellow-green. Therefore it was concluded, that *one Measure* of Lime-Water was more than sufficient to saturate the Gas contained in *three Measures* of Buxton-Water.

II. Mixtures composed of *four Measures* of Buxton-Water and *one Measure* of Lime-Water, under the Circumstances above related, very generally, but not always, made a second Precipitation, on the Addition of Lime-Water;—was always perfectly transparent after mixing it with a Portion of Gas;—formed, very generally, a more blue-coloured Mixture with *Syrup of Violets*,
than

than the same Syrup and Buxton-Water, but, sometimes, was greenish like Buxton-Water and this Syrup;—therefore, the general Conclusion made was, that the Gas contained in *four* Measures of Buxton-Water, is not saturated by *one* Measure of Lime-Water.

III. Mixtures composed of *seven* Measures of Buxton-Water and *two* Measures of Lime-Water, after depositing Sediment, in no Instance either formed a turbid Mixture on the Addition of Lime-Water, or of Gas; and the Colour of Syrup of Violets, as it lay at the Bottom of a Glass of this Mixture, was of a yellowish Hue; but when stirred and mixed with it, had rather a deeper cast of Green, than this Syrup mixed with Buxton-Water. This Mixture, after being separated from the Sediment, and standing exposed in open Vessels to the Atmosphere, had either a *Ring of white earthy Matter* formed round the Sides of the Glass in Contact with the Surface of the Fluid, or earthy Particles floated upon its Surface; and the same Appearance was observed with *fifteen* Measures of Buxton-Water and *four* Measures of Lime-Water; but, with a greater Proportion of this Spring-Water, as with *four* Measures of Buxton-Water and *one* Measure of Lime-Water, the Mixture poured off from the Sediment, was rarely even of a greenish Hue with Syrup of Violets, and had no Deposition of earthy Matter upon the Sides of the Vessel containing it,

it, or upon the Surface of the Fluid. And with a smaller Quantity than *seven* Measures of Buxton-Water to *one Measure* of Lime-Water, the Fluid upon the Sediment, formed by this Mixture, uniformly produced a muddy Appearance, on the Addition of Gas; and was of a yellowish green, or green when mixed with Syrup of Violets.

From the Result here related it may be deduced, that *the most exact Proportion of Lime-Water that saturates the Gas in a certain Portion of Buxton-Water, is two Measures or Parts of Lime-Water to seven Measures or Parts of this tepid Spring.*

By the same Means employed to discover the exact Quantity of Lime-Water that would saturate the Gas in a certain Quantity of Buxton-Water, it was found, that *thirteen to fourteen Measures of Matlock-Water contain a Quantity of Gas which is saturated by one Measure of Lime-Water; and that two Measures of a Fountain-Water near Doncaster, contained a Quantity of Gas that was not saturated by less than one Measure, or half of its Bulk of Lime-Water.*

These two last Spring-Waters were examined under the same Circumstances as the Buxton-Water.

Several other *common cold Springs* and *hard Waters* were examined, and found to contain Gas which was saturated by *two Measures of Lime-Water*

Water added to from *five* to *seven* Measures of Spring-Water; and the *Gas* contained in from *three* to *four* Measures of several *cold petrifying Springs*, was saturated by *one* Measure of Lime-Water.

Although the Quantity of Lime-Water that is necessary to saturate the Gas in a certain Quantity of Spring-Water, be not apparently varied by previous Exposure of the Spring-Water to the Air, by keeping in close Vessels, and by the Seasons or Times at which it is collected, excepting, perhaps, cold Springs, which are increased by Rain, and diminished by Drought; yet there sometimes appeared a Difference of about half a Measure in the Quantity of Spring-Waters containing Gas, required to saturate the Quicklime dissolved in one Measure of Lime-Water; which Difference of Quantity, I was inclined to ascribe to the Difference that may naturally be expected in the State of the Solution of Quicklime employed to combine with the Gas of these Springs; because, when I had the Opportunity of examining several or all of the Springs above-mentioned at the same Time, with the same Parcel of Lime-Water, the same Difference of Quantity of Spring-Water extended in Proportion to all of them. Lime-Water may, among other Differences, contain a greater Portion of Lime in a State of Solution in a certain Quantity of Water at one Time than at another, owing to the Difference of the Quick-

Quicklime dissolved, the Water dissolving it, Heat, Agitation, &c. to which the Quicklime was exposed during Solution, accidental Precipitation of Quicklime after Solution by combining with the Gas of the Atmosphere &c.; and, considering the Variety liable to happen in the Condition of the Lime-Water, it would not be surprizing if the Quantity of Solution of Quicklime required to saturate the Gas in a certain Quantity of Spring-Water, should be various; although the Quantities and Qualities of the Gas to be saturated be uniformly the same.

Moreover, it must be remembered, that the Proportion found, which most exactly saturates the Gas in the Spring-Waters investigated, was the Result of the Examinations of Mixtures of Lime-Water and Spring-Waters, that had not been left to stand more than five or six Days; for upon some, if not all Occasions it happens, that a Mixture which a few Days after being made, does not to the Test of Lime-Water manifest any Portion of Gas contained therein, on the contrary, even shews by the Addition of Lime-Water or Syrup of Violets, a superabundant Portion of Lime-Water, after standing two Months or longer, appears to contain Gas not saturated; because it turns milky on the Addition of Lime-Water, and precipitates a fresh Portion of Sediment composed of Gas and Quicklime.

It

It appears upon estimating the Quantity of Gas in Spring-Water, by the Quantity of Lime-Water necessary to saturate it in a determinate Quantity of Water, that Buxton-Water contains nearly half the Quantity only of this permanent Vapour which is contained in ordinary Springs; and that Matlock-Water and petrifying Springs contain rather more Gas than Buxton-Water. How greatly, then, have Physicians erred in ascribing the peculiar Efficacy of Buxton and Matlock-Waters to the Gas they contain! Further; that Principle must be exceedingly erroneous, which explains the petrifying or incrustating Property of Springs to the Solution of calcareous Earth in Water by Gas; in Consequence of the Escape of which, Earth is said to be deposited upon Bodies immersed in such Springs, and the Channels on the Surface of the Earth in which they flow, is incrustated by the Deposition of this Earth.

From the above Result the Question arises, whether the most usual or mean Quantity of Gas in Springs, is not that which is saturated by one-third of its Bulk of Lime-Water?

As the Attempt to estimate the Quantity of Gas in a Spring-Water, by the Quantity of Lime-Water required to saturate this Vapour in a given Portion of Spring-Water, has never yet, as far as I know, been made; and as that Mode of Estimation may furnish an easier Method of ascertaining this Point than the Application of Heat and Instruments,

ments, and may supply us with a Method in those Cases in which Gas cannot be detached by Heat; with the View of assisting those who wish to prosecute this Subject, I shall relate

Some Observations and Remarks on the Tests employed to judge of the Saturation of Gas in Water with Quicklime dissolved in Water.

In order to determine whether the Mixture of Spring-Water and Solutions of Quicklime contained superabundant Lime-Water, a pretty large Quantity of it at a Time, as a Pint Jar full, was subjected to the Test of Gas.

After a great Number of Experiments, made with all the Exactitude that appeared possible, I must confess, that the Tests employed are not sufficiently delicate for shewing, either a small Quantity of superabundant Lime-Water, or a small Portion of Gas which remains unsaturated, in Mixtures of Lime-Water and a Spring-Water containing Gas. Therefore, the Quantity of Lime-Water here stated as the Proportion that just saturates the Gas in the Spring-Waters examined, is only to be understood as the nearest Approximation to the Truth, upon this Occasion, that can at present be obtained. For, I have found, that distilled or Snow-Water, combined with a small Quantity of Gas, (which distilled, or Snow-Water, before Gas was added, was found to make a perfectly transparent Mixture with
Lime-

Lime-Water) will not have its Transparency apparently disturbed on the Addition of Lime-Water, or form any Sediment, or Ring, on standing: And, distilled Water, which forms a blue Mixture with Syrup of Violets, may have a small Portion of Lime-Water added, and after such Addition, will not have its Transparency disturbed by the Addition of Gas or leave a Ring upon standing, nor change Syrup of Violets of a greenish Hue. Also, the clear Fluid, poured off from the Sediment, formed by Mixture of Lime-Water and Gas, although it neither discovers superabundant Lime-Water to the Test of Gas, nor Syrup of Violets, yet, by standing exposed to the Atmosphere, it generally either precipitates earthy Matter upon its Surface, or a Ring of white earthy Matter collects round the Glass, which seems to arise from a Portion of Quicklime not saturated, (which is in too small a Proportion to be detected by Gas, or Syrup of Violets) absorbing Gas from the Atmosphere; and being in too small a Quantity, and divided into too minute Particles, to form Sediment, appears upon the Surface of the Water.

The Syrup of Violets was a more uniform and instructing Test of the Quantity of Lime-Water required to saturate the Gas of a certain Bulk of Water than, considering the delicate Nature of the Colour of the blue Juice of Violet Flowers, and the various Approaches it is liable to make
towards

towards a State of Acidity by keeping, I expected. I observed many Appearances which assisted me much after I understood their Connection with the Gas or Quicklime dissolved in Water, but I shall avoid relating particularly the various Phenomena upon Mixture of Spring-Water and Water containing Gas or Quicklime with this Substance, on Account of their increasing too considerably the Bulk of this Work. I shall, therefore, mention only a few of the Appearances on mixing Syrup of Violets with Spring-Water, or Mixture of Spring-Water and Lime-Water.

I must first observe, that when I employed Syrup of Violets to judge whether the Gas in Spring-Water was saturated by Lime-Water, a Comparison was made at the same Time between this Mixture, the Spring-Water alone or without Lime-Water, and between distilled Water mixed with the same Syrup; and that the Syrup was poured upon four Times its Quantity of Water.

1. If a Mixture, composed of Spring-Water and such a Quantity of Lime-Water as was supposed nearly to saturate the Gas in the former, after depositing Sediment, was *yellowish Green*, the Spring-Water was *blue* or bluish Green, and distilled Water was *blue* when mixt with this Syrup, the Mixture contained more Quicklime than was necessary to saturate the Gas; for it became milky on the Addition of Gas, and even

tasted

tasted of Lime-Water. Such a Mixture also with this Syrup, by standing twenty-four Hours, generally changed to a *brown Colour* or yellowish brown, while the Spring-Water and this Syrup remained *blue*, and the distilled Water and this Syrup was changed to an *almost colourless Fluid*.

2. If the clear Fluid from the Mixture of Lime-Water and Spring-Water imparted a *yellowish Colour* to the Syrup as it passed through the Water, and as it lay at the Bottom of this Fluid where it touched the Water, and on Agitation was *Green* or *Grass-Green*; and the Spring-Water alone formed a *blue Mixture*, or a Mixture of a greenish Blue, and the distilled Water with this Syrup was a *palish Blue*; in this Case, the Spring-Water contained more Lime-Water than was necessary to saturate its Gas, but the Superabundance of Lime-Water was less than in the former Case: For, although it had its Transparency disturbed by the Addition of Gas, and a slight Sediment was thereby formed on standing, yet it scarcely had a Taste of Lime-Water. This Mixture and Syrup generally became brownish or colourless in about twenty-four Hours.

3. If the clear Water poured off from the Sediment after mixing Spring-Water and Lime-Water together was *green* when agitated with Syrup of Violets, the Spring-Water was *bluish green* or *blue*, and the distilled Water was *blue* with the same Syrup; as in this Case, sometimes, there

was a pearly Colour on mixing this decanted Fluid with Gas, after which on standing there was, now and then, a small Quantity of Sediment, at other Times no Sediment, but a white earthy Ring round the Sides of the Glass in Contact with the Surface of Fluid, and again sometimes neither Ring nor Sediment, and never in this Case any Milkiness or Disturbance in Transparency with Lime-Water, I was assured there was a complete Saturation of the Gas in the Water: But, it was uncertain whether there was not more Lime-Water than necessary to saturate the Gas, although certain that the superfluous Lime-Water was in exceedingly small Quantity.

4. After pouring off the clear Fluid from a Mixture with a smaller Proportion of Lime-Water to the Spring-Water, than any of the preceding Mixtures contained, it was found to make a *greenish*, or *bluish green* Colour with Syrup of Violets exactly like, or rather greener than, the Spring-Water and this Syrup; and mixed with Gas, and also with Lime-Water, neither had its Transparency disturbed immediately, or on standing deposited a Sediment. Excepting very rarely, this Mixture which made a pale Blue or bluish Green with this Syrup, never deposited the least Sediment after the Addition of Lime-Water. Therefore this Mixture was considered as the nearest Approach to the exact Point of Saturation that could be discovered.

5. I have sometimes observed, that a Mixture of Spring-Water, and a still smaller Proportion of Lime-Water than in the last Case, poured off clear from the Sediment, with Syrup of Violets, communicated a Tinge of a *greenish Colour* as this Syrup lay at the Bottom of the Mixture; but when agitated, the Colour of the Fluid was a *greenish Blue*, or blue like the Spring-Water alone, and the distilled Water with this Syrup was *pale Blue*. In this Case, there was in general no Disturbance in the Transparency of this Mixture on the Addition of Lime-Water, or Gas, or Sediment after the Mixture of these Substances on standing; but, at other Times, there was a slight Disturbance in the Transparency and a Sediment, after the Addition of Lime-Water. The Colour of the Syrup and this Mixture disappeared sooner than the Colour with the Spring-Water and this Syrup.

This Proportion of Lime-Water, either nearly or compleatly saturated all the Gas in the Spring-Water; it certainly was not more than sufficient to saturate it.

6. The Fluid poured off from a Mixture of Spring-Water and a smaller Proportion of Lime-Water than in the last Case, after depositing Sediment, with Syrup of Violets produced a *pale blue Colour*, nearly as pale as this Syrup with distilled Water; while the same Syrup and the Spring-Water, produced a *greenish* or *greenish blue Colour*: And there was always, or at least, in

general, a second Precipitation and small Quantity of Sediment deposited by the Addition of a fresh Portion of Lime-Water, and no Disturbance in the Clearness after the Mixture of Gas with this decanted Fluid. The Syrup and this Mixture, as well as the Syrup and distilled Water, generally soon became nearly colourless; but this Syrup and this Spring-Water was still a greenish Blue, or Blue after 12 or 24 Hours.

It was estimated that, upon this Occasion, the Water was deprived of perhaps three-fourths of its Quantity of Gas. It appeared, that this Diminution of the Quantity of Gas and total Privation of this Substance, had the above Effect; so that it seems, as if Water partially or wholly deprived of Gas by Lime-Water, had its Power of producing a greenish Colour with Syrup of Violets destroyed, and like distilled Water, produced therewith a pale blue Colour.

7. Spring-Water that produced only a bluish Colour, or greenish Hue, with Syrup of Violets, after boiling, formed a Mixture that was of a green or greenish Colour, as happened with Buxton and Matlock-Waters. This is occasioned, most probably, by the Water after boiling containing a greater Proportion, or being a more concentrated Solution of calcareous Earth, that like all other earthy Salts, changes Violets of a greenish or green Colour; for it did not appear to

to contain a less Quantity of Gas than before boiling.

I am inclined to think, the Syrup of Violets is a more nice Criterion than Gas or Lime-Water, of the exact Point of Saturation of the Gas in Spring-Water by Lime-Water; provided the Mixture be made of this Syrup and the Spring-Water, and also of distilled Water, when the Mixture of Spring-Water and Lime-Water is examined; and not only the Colour be attended to, but also the Appearance or Disappearance, or Changes of it on standing.

Having ascertained the Quantity of Lime-Water that will most exactly saturate the Gas in Buxton, Matlock, and in common Spring-Water, p. 250, *I next endeavoured to learn the Quantity of Gas that will saturate a certain Quantity of Lime-Water.—See Subject of Enquiry, p. 247.*

Exper. XXIII. According to the Inference from the last Experiment, p. 250, the Quantity of Gas required to saturate four Ounce Measures of Lime-Water, is the Quantity of Gas contained in fourteen Measures of Buxton-Water; the Quantity of Gas in thirteen to fourteen Measures of Matlock-Water; and the Quantity of Gas in double this Quantity of Lime-Water, of Spring-Waters near Doncaster; and so on of the other Springs, mentioned p. 250, 251.

The Gas separated from Chalk by vitriolic Acid, after passing through a wide Tube containing fixed vegetable Alkali, was combined in various Proportions, several Times, with the different Sorts of Lime-Water mentioned p. 247, 248; and the Result was, that the clear Fluid decanted, after uniting *four* Measures of this Gas, exposed to the Heat of 58° to 64° , and under the mean Pressure of the Atmosphere, with *nine* Measures of Lime-Water, remained *perfectly transparent* after combining a fresh Portion of this Gas, and neither formed a *white earthy Ring* round the Sides of the Vessel in Contact with the Surface of the Fluid, nor any *Sediment* on standing; consequently, that *four Measures of this Gas, of the Density above-mentioned, completely saturates nine Measures of Lime-Water.*

As the clear Fluid poured off, after combining *one* Measure of this Gas, under the above-mentioned Circumstances of Pressure and Heat, with *two* Measures of Lime-Water, on the Addition of more Lime-Water became somewhat pearly-coloured, and on standing, deposited a very small Quantity of Sediment, or had a Ring of earthy Matter round the Sides of the Glass in Contact with the Surface of the Fluid; it may be inferred, that this Proportion of Lime-Water was supersaturated by *one* Measure of Gas.

Moreover, as the clear Fluid decanted, after uniting *five* Measures of Lime-Water with *two* Measures

Measures of Gas, under the same Pressure and of the Temperature above-mentioned, became less transparent, or rather pearly-coloured, on the Addition of a Portion of Gas, and was clear after adding Lime-Water, it may be concluded, that this Quantity of Lime-Water is not saturated by *two* Measures of Gas.

Hence it was found, that the nearest Approach to the Point of Saturation of a given Bulk of Lime-Water by Gas, was *nine Measures of Lime-Water combined with four Measures of Gas*; heated to from 58° to 64° , and subjected to the mean Pressure of the Atmosphere; and, consequently, as the Gas in *seven* Pints of Buxton-Water is saturated by *two* Pints of Lime-Water, *this Quantity of Buxton-Water contains $\frac{4}{7}$, or about $\frac{2.8}{6.3}$ of a Quart Measure of Gas; or, about one Ounce Measure of Gas is contained in eight Ounce Measures of this tepid Spring.*

On the same Grounds it was concluded, that *Matlock-Water contains the same Quantity, or rather more Gas than Buxton-Water; and, that two Pints of Spring-Water, near Doncaster, contain about seven Ounce Measures of Gas.* These Measures of Gas are supposed ascertained, when subjected to the mean Pressure of the Atmosphere, and exposed to a Temperature of 58° to 64° .

This Conclusion, respecting the Quantity of Gas in these Spring-Waters, is likewise founded on the Supposition, that the Gas is *in the same*

State naturally combined with these Waters, as that which is separated by Art, in the Manner above-mentioned, from calcareous Earth; and, that this Vapour extricated from Chalk, &c. is uniformly in the same State as to Degree of *Concentration or Purity*.

If, upon a Repetition of this Experiment, the Result should be different from that here related, which, from the Tests employed, to judge of the Saturation of Lime-Water with Gas not being sufficiently delicate, from the different Qualities of the Lime-Water, and the probable Difference in the State of the Gas, I apprehend, is very likely to be the Case: still, the relative Quantities of the Gas here stated, in the Waters examined, may be accurate; and unless the Estimate be very erroneous indeed of the Quantity, the practical Conclusion will be the same as that we should draw from this supposed Fact; namely, *that the tepid Waters of Buxton have no peculiar Efficacy dependent upon the Gas they contain, whether the Quantity of it be as above assigned, or twice, or three Times that Quantity.*

I proceeded in the next Place, to enable myself to judge more satisfactorily of the Quantity of the Gas in Buxton, Matlock, and the Spring-Waters near Doncaster, *by combining the Gas contained therein, with Quicklime dissolved in Water, and collecting this Compound agreeable to the Enquiry proposed* p. 247.

Exper.

Exper. XXIV. To the following Kinds and Quantities of fresh drawn Spring-Water, in large and glazed deep earthen Vessels, were added the Quantities of Lime-Water below-mentioned.

Immediately upon pouring the *Lime-Water* upon the *Spring-Water* a *Milkiness* ensued; in 25 or 30 Minutes, the Mixture was like *Masses* of *Curds suspended in Abundance uniformly throughout a watery Fluid*; on standing longer, *larger curdy Masses or Clouds* collected, some of which were seen floating upon the Surface of the Mixture; others were suspended irregularly, in various Parts of a Fluid as transparent as the Spring-Water itself; and some were deposited, in Form of a curdy white Sediment. To the ragged Edges of these curdy Masses, Bubbles of Vapour were seen adhering, by Means of which, they were partly, if not entirely, suspended, and assumed the various Shapes of Clouds; for when, by a warm Exposure, these Bubbles were made to detach themselves from the precipitated curdy Masses, and rise to the Surface of the Mixture, where they formed Clusters or Rings of Beads of Vapour, they were observed to fall towards, or to the Bottom of the Vessel. Sometimes in a warm Situation, the precipitated Matter was suspended in the Form of Ropes hanging from the Surface of the Fluid, where they had these Bubbles adhering to their Terminations; and sometimes, the
Sediment

Sediment rose from the Bottom of the Vessel, in Strings or ropy Masses, to some Height in the Fluid, with Bubbles adhering to their Sides and Tops.

After standing four, five, or six Days, the Whole of the *precipitated Matter* was *deposited* at the Bottom of the Vessel, forming a *light woolly Sediment*. The clear Fluid was then poured off, so as to leave behind a Pint or a Quart of Milk-like Fluid, that was put into small Jars; and after it had stood some Days in covered Vessels effectually excluded from the Atmosphere, that the Sediment might be deposited, the clear watery Fluid was decanted, and left a few Ounces of white, thick, and Cream-like Fluid, which was evaporated slowly to Dryness. This dried Sediment was *white, friable, light, perfectly smooth, and insipid*; it weighed as follows.

The dried Sediment, procured by		}	Dwt.	Gr.
adding six Wine-Pints of Lime-Wa-				
ter to 21 Wine Pints of Buxton-Wa-				
ter, weighed — —				
————— from seven		}	4	3½
Pints of Lime-Water and 24 $\frac{1}{2}$ Wine-				
Pints of Buxton-Water —				

The Gas was *exactly saturated* in these two last Mixtures, there being three and a half Measures of the tepid Water of Buxton to one Measure of Lime-Water.

from

_____ from seven		} Dwt. Gr.	
Pints of Lime-Water and 21 Wine-	}		4 3;
Pints of Buxton-Water, weighed			

_____ Ditto	—	4 2.
-------------	---	------

In the two foregoing Instances, the Gas of the Buxton-Water was *not sufficient to saturate* the Lime-Water added; but in the following ones, the Gas of this Water was *more than sufficient* to saturate the Lime-Water added.

Twenty-eight Pints of Buxton-	}	4 14.
Water and seven Wine-Pints of Lime-		
Water yielded — —		

Twenty-four Wine-Pints of this	}	4 0;
Spring-Water and six Wine Pints of		
Lime-Water afforded —		

And 27 $\frac{1}{2}$ Pints of this tepid Spring	}	5 8.
and five and a half Pints of Lime-		
Water, gave of Sediment —		

Ditto second Trial afforded of Se-	}	4 10.
diment — —		

Twenty - four Wine - Pints of a	}	6 10.
Pump-Water, that required 12 Wine-		
Pints of Lime-Water to saturate its		
Gas, deposited of Sediment		

Ditto second Trial	—	6 5.
--------------------	---	------

Ditto third Trial	—	6 10.
-------------------	---	-------

The same Quantity of this Pump-	}	5 4.
Water and six Wine-Pints of Lime-		
Water, yielded of Sediment		

Ditto second Trial	— —	5 12.
--------------------	-----	-------

Twenty - eight Wine - Pints of } Dwt. Gr.
 Pump - Water and eight Pints of } 8 6.
 Lime - Water, rendered of Sediment }

Observations. 1. As the Precipitation made by Mixture of Spring - Water with Lime - Water, is the Gas of the Spring - Water combined with the Quicklime dissolved in Water; when Lime - Water is added to any Fountain - Water *exactly to saturate this Gas* contained therein; the Sediment collected we consider to be the Whole of this Gas in the Water combined with the Whole of the Quicklime; and which, for aught we know, should always *be the same in Quantity in the same Water*; provided the Water, from which it is precipitated, require the same Quantity of Lime - Water to saturate the Gas: And in this Respect, the Result of the preceding Experiment does not appear to differ considerably, in general, from what might be expected from this Theory.

Moreover, the Quantity of Sediment should be the same in *different Spring - Waters*, where the same Quantity of Lime - Water is saturated with Gas contained in them; which, upon Trial, is not the Fact; for the Sediment procured from the Gas of 21 Pints of Buxton - Water exactly saturated by six Pints of Lime - Water, was 4 Dwt. 3 Grs. and the Gas exactly saturated by 12 Pints of Lime - Water added to 24 Pints of Pump - Water, was 6 Dwt. 10 Grs. or by 6 Pints of Lime - Water added to 12 Pints of Pump - Water, was 3 Dwt. 5. Grs.

2. After

2. After ascertaining the Weight of Sediment, procured by exactly saturating the Gas in a certain Quantity of Water, we should expect, that the Weight of Sediment might readily be inferred, when a *smaller Quantity of Lime-Water is added to the Spring-Water than is sufficient to saturate the Gas it contains*. For Instance, if only half the Quantity of Lime-Water be added, that is requisite to saturate the Gas of a certain Quantity of Water, the Weight of Sediment should be half of that Sediment produced by completely saturating the Gas, in this Quantity of Fountain-Water. But this does not appear to have been the Event of the Experiment, for the Sediment afforded by 24 Pints of Pump-Water, and 12 Pints of Lime-Water weighed 6 Dwt. 10 Grains; and that afforded by 24 Pints of the same Pump-Water and 6 Pints of Lime-Water weighed 5 Dwt. 4 Grains, instead of 3 Dwt. 5 Grains only, as might have been expected from this Theory. And,

3. If to a certain Quantity of Spring-Water, a *greater Quantity of Lime-Water be added, than is necessary to saturate the Gas dissolved therein*, the Weight of Sediment should be the same, according to the Principle of Reasoning employed upon this Occasion, as that when the Gas of the Water is precisely saturated by Lime-Water; and the Event of two Trials demonstrated this to be the Fact: For this Gas in 21 Pints of Buxton-Water,

was

was exactly saturated by six Pints of Lime-Water, and afforded the same, or nearly the same Weight of Sediment, as this Quantity of Buxton-Water, and seven Pints of Lime-Water; or, as with one Pint more Lime-Water than was necessary to combine with the whole of this permanent Vapour of this Quantity of Buxton-Water.

Therefore it does not appear, that we can estimate the Quantity of Gas in a certain Quantity of Water, by the Weight of the Sediment produced by the Combination of this Gas with Quicklime, or merely by the Quantity of Lime-Water required to saturate this Substance.

This Experiment, however, affords another Proof of the Error in the Opinion of Physicians in general, that Buxton-Water contains a greater Quantity of Gas than is usually found in Spring-Waters.

We are unable to account for the Difference between the Fact upon Trial in this Experiment, and the Result to be expected according to Principle, by any Properties of Substances yet known. We may conjecture, that Gas combines with Quicklime and forms different Substances therewith; each of which are deposited in Sediment from Mixtures of Lime-Water and Spring-Water. A certain Quantity of Gas may combine with Lime-Water added in Quantity sufficient to saturate the whole of this Vapour in the Water to which it is added, and form a Substance different from that produced

produced when added in Quantity not sufficient for this Purpose; and therefore, in the latter Case, the Weight of the Sediment is greater than might be expected from the Weight of the Sediment when the Gas in the same Spring-Water is saturated. Perhaps, also the Compound of Gas and Quicklime forming the Sediment when this permanent Vapour of the Spring-Water is fully saturated by Lime-Water, is more soluble in Water, than the Sediment formed by adding Lime-Water in Quantity not sufficient to combine with the whole of the Gas in Spring-Water; by which Means, the Weight of the Matter deposited is greater in the latter Case than might be expected, from the Weight of the Sediment in the former.

A Decomposition of these Sediments, and Measurement of the Gas separated from them, might throw further Light on this Subject, and either verify, or shew the Falseness of the above Conjectures. We should expect the Gas detached from these Compounds, would saturate as much Lime-Water as that added to saturate the Gas in the Spring-Water and the Bulk of it to be four-ninths of a Pint Measure, see Page 263, for every Pint of Lime-Water saturated by the Gas of the Spring-Waters.

Supposing the Gas in the above Sediments to be in the same Quantity in all, and that Quantity to be three-eighths of their Weight, then the Weight of this Substance in the Sediments formed

ed

ed by precisely saturating the Gas in 21 Pints of Buxton-Water will be about 36 Grains, p. 266. the Bulk of which, under a mean Pressure, and subject to a temperate Heat, will be, perhaps, about one-third less than the Bulk of an equal Weight of Air, under the same Pressure and of the same Heat, or about 24 Ounce Measures instead of 42 Ounce Measures, according to a former Calculation, see p. 263; and the Quantity of Quicklime in six Pints of Lime-Water thus saturated, is 60 Grains, or 10 Grains of Quicklime in a Pint of Lime-Water is saturated by about six Grains, or about four Ounce Measures of Gas. And by the same Method of Deduction, 24 Wine Pints of Pump-Water, p. 263, contain about 72 Grains of Gas, or three Pints Measure of this Vapour, instead of 84 Ounce Measures, according to the Calculation, p. 263.

The following Experiment was made before that last related, but not being performed with the same Exactitude, the Inferences to be drawn from it are not to be considered as so well founded.

Exper. XXV. The Gas of the three following Spring-Waters, was combined with the Quicklime dissolved in Lime-Water; and this Compound collected in Form of Sediment, with such a Quantity of Water as to make it of the Consistence of Cream.

This Sediment was put into a Retort that held about 12 Ounce Measures, and through a small Hole

Hole in the Shoulder of this Vessel was poured gradually vitriolic Acid, till the Effervescence excited by this Acid entirely ceased; immediately after pouring in the Acid, the Hole in the Shoulder of the Retort was stopped with the Finger, and the permanent Vapour separated was received in a Jar filled with Water saturated with Gas, held inverted over the Mouth of the Retort in a large Bason of Water saturated also with Gas; in which Jar the permanent Vapour was measured, after Exposure to the mean Heat and Pressure of the Atmosphere.

1. The Sediment deposited, after adding five Pints of Lime-Water to 20 Pints of Buxton-Water, afforded, on two Trials, about 28 Ounce Measures of permanent Vapour, which combined wholly (excepting a few Drachms of Air,) with Water, and formed acidulous Water; which Vapour formed calcareous Earth when joined with Quicklime, and mild Alkali when united with caustic Alkali, and which therefore was Gas.

2. The Sediment deposited, after adding six Pints of Lime-Water to 20 Pints of Buxton-Water, separated 28 Ounce Measures of Gas upon one Occasion; and on two Repetitions, 26 Ounce Measures of this permanent Vapour each Time.

3. The Matter precipitated by mixing 12 Pints of Pump-Water with six Pints of Lime-Water, which precisely saturated the Gas of this Water,

T

detached

detached 19 Ounce Measures of Gas. The Sediment from 20 Pints of this Pump-Water and 10 Pints of Lime-Water, detached 28 Ounce Measures of Gas. And the Sediment from 72 Ounce Measures of this Pump-Water and 14 Ounces of Lime-Water, rendered six Ounce Measures of this permanent Vapour.

4. The Compound of Gas and Quicklime, formed by mixing 15 Pints of Matlock-Water with four Pints of Lime-Water, detached, by Computation, 12 Ounce Measures of Gas.

Gas from each of the above Sediments, was combined with the Quicklime in Lime-Water of the same Parcel as that employed to precipitate this permanent Vapour from the Spring-Waters; and it appeared, that it required nine to ten Measures of this Lime-Water to exactly saturate four Measures of this permanent Vapour, or about a Pint of Lime-Water was nearly saturated by six and a half to seven Ounce Measures of this Substance under the mean Pressure, and exposed to a temperate Heat of the Atmosphere.

Observations. It was inferred, Page 263, that the Quicklime of a Pint of Lime-Water was saturated by seven Ounce Measures of Gas contained in Spring-Water, because this Quantity of this Vapour, of a temperate Heat, saturated the Quicklime dissolved in a Pint of Lime-Water.

It was estimated, Page 272, that 21 Pints of Buxton-Water contained 24 Ounce Measures of Gas,

Gas, when saturated by six Pints of Lime-Water; and that a Pint of Lime-Water, thus saturated with the Gas of Buxton-Water, yielded, according to this Method of Estimation, four Ounce Measures of this Vapour;—that 24 Pints of Pump-Water, which had its Gas saturated by 12 Pints of Lime-Water, rendered 48 Ounce Measures of this permanent Vapour, or each Pint of Lime-Water so saturated, contained, upon this Ground of Reasoning, four Ounces Measure of this permanent Vapour; because, 21 Pints of Buxton-Water contained about 36 Grains Weight of Gas; and 24 Pints of Pump-Water afforded 72 Grains Weight of this Substance; and it appeared, that no Estimate can be made from the *Weight* of the Sediment, when the Gas of the Spring-Water to which Lime-Water is added, is only *partially saturated* (p. 268—273).

The *Quality* of the Gas precipitated from the above Sediment was not different, in Degree of Concentration, or in Purity, from that employed to saturate the Quicklime in Lime-Water; because it required the same, or nearly the same Quantity of the Gas of this Sediment, as of Gas of Chalk, to saturate a certain Quantity of Lime-Water.

As the Gas precipitated from the Spring-Waters, and the Lime separated from the Lime-Water, which are contained in the Sediment, is the *Whole* of the Lime dissolved in Lime-Water

added, combined with the Gas of the Water, we should expect that this Gas, when precipitated from the Sediment, would saturate the same Quantity of Lime-Water as that added to saturate the Gas in the Water; but as it was not in sufficient Quantity for this Purpose when the Gas was completely saturated in the Spring-Water, a Part of the Compound of Quicklime and this permanent Vapour was wanting in the Sediment, and probably was dissolved in the Water, as conjectured p. 271.

In the foregoing Experiment, the Quicklime dissolved in each Pint of Lime-Water, saturated with the Gas contained in Buxton-Water, afforded, by Admeasurement, from four Ounces and three Quarters to five Ounces and three Quarters Measure of this permanent Vapour; and the Quicklime dissolved in each Pint of Lime-Water, saturated with the Gas of Pump-Water, yielded about three Ounce Measures of Gas, when this Substance in this Water was entirely or nearly saturated: but the Sediment formed by adding Lime-Water to combine with a Part of the Gas only of this Water, afforded after the Rate of seven Ounce Measures of Gas from each Pint of Lime-Water saturated. This Result renders the Conjecture (p. 270, 271) more probable.

The Sediment procured by combining Quicklime with *the Gas of Matlock-Water*, when this Water was nearly saturated, yielded about three

Ounce:

Ounce Measures of this permanent Vapour from the Quicklime dissolved in each Pint of Lime-Water, and then saturated by the Gas of this Water.

It appears then, that the only Method by which we can ascertain with any tolerable Exactitude, the Quantity of Gas in Spring-Water is, *to learn the Quantity of Lime-Water that will precisely saturate this permanent Vapour in a certain Quantity of Water; and as the Gas in the Water is of the same Kind as that separated by Art from calcareous Earths, see p. 274, 275, the Quantity of Gas required to saturate a Quantity of Lime-Water equal to that saturated by Gas in a certain Quantity of Spring-Water, is the Quantity of this permanent Vapour contained in that Quantity of Spring-Water.*

In this Way we ascertained the Quantity of Gas in *Buxton, Matlock, and several common Spring-Waters*, p. 250, 251. 263, whence many practical Inferences in Physick, and the Principles upon which are explained some Phenomena in natural History, will be found erroneous.

Having completed the Investigation of the *Quantity of Gas in Spring-Waters*, proposed p. 245, I proceeded to inform myself, *in what Manner, and with what Substance, the Gas shewn to be contained in them*, p. 246, *is combined*; and which apparently could not be separated by the boiling Heat of Water, applied for several Hours, p. 231. 239. 242.

I made the three following Experiments, to determine decisively, whether any Gas was separated from Buxton-Water by the Heat of boiling Water.

Exper. XXVI. Various Quantities of *Lime-Water* were added to a certain Quantity of the *Buxton-Water* that had been subjected to a considerable Degree of Heat and had separated permanent Vapour (see *Exper. XVIII.* p. 231); and to *Matlock tepid Water*, and *common Spring-Water*, which had been exposed to Heat, and detached Air; (see *Exper. XX.* p. 239); with which they formed turbid Mixtures, with nearly the same Appearances as before being heated, excepting, that no sparkling and apparently aerial Bubbles were seen, when in a warm Exposure, as happened with Spring-Waters that had not been exposed to Heat, as related *Exper. XXIV.* p. 265. These turbid Appearances arose from the same Cause, viz. the Gas contained in these Waters; which permanent Vapour, required the same Quantity of Lime-Water to saturate it that it required to saturate this Vapour in unboiled Water.

As the Waters here examined, required as great a Quantity of Lime-Water to saturate the Gas contained in them after boiling as before Exposure to Heat; and as it has been shewn, Exper. XVIII, XIX, and XX. that the permanent Vapour separated did not contain any Gas, this Experiment may be considered to be decisive, that these Waters
do

do not part with their permanent Vapour by a boiling Heat.

Exper. XXVII. A large Quantity of *Lime-Water* was made of *Buxton-Water*, of *Matlock-Water*, and of the *cold Springs near Doncaster*, immediately after taking them from the Spring, and preserved in a cool Situation, in Vessels closed from the Air till employed.

Several Tin-Pans full of Solutions of Quicklime in these Spring-Waters, were exposed to Heat, in order to separate *Air*, or any other permanent Vapour, in the Manner described p. 231, 232; by which Means, permanent Vapour was separated with precisely the same Appearances, as related during its Separation from *Buxton-Water* and other Springs, p. 232 to 235 and 240, and in the same Quantity, and of the same Quality, see p. 232 to 235, and 241.

The Gas in the three above-mentioned Spring-Waters, was in one Parcel of each, *precisely saturated* with Lime-Water (p. 249, 250) made with the same Spring-Water to which it was added; in a second Parcel, it was *more than saturated*; and in a third Parcel, it was *not saturated* by this Solution of Quicklime.

The clear Fluids were decanted from the Sediment deposited in these Mixtures, and exposed to Heat in the Tin-Pan just mentioned, used for collecting permanent Vapour: they all detached *the same Kind and Quantity* of permanent Vapours,

and with *the same Appearances*, as the Lime-Waters above-mentioned, made of these Waters.

This Experiment affords another Proof, that *Buxton, Matlock, and common Spring-Waters, by Means of a boiling Heat, in Exper. XVIII. and XX. did not separate Gas; for in this Experiment, these Waters detached permanent Vapour, of the same Kind, and as copiously without as with their natural Portion of Gas.*

Moreover, the *sparkling Appearance* taking Place upon heating Water deprived of Gas, as well as in Water in its natural State, is a convincing Argument, that this Phenomenon does not depend upon Gas. This Appearance of Air-Bubbles, has been frequently falsely ascribed to Gas; but the Particles of this Vapour do not sparkle, or are not so brilliant as Air, but dull, small, and sandy-like, as before observed, p. 241.

Exper. XXVIII. Two Quarts of *Buxton-Water* in a Retort, that was capable of holding three Quarts, were distilled with a gentle Heat into a Receiver containing one Quart of Lime-Water. The Receiver was luted *closely* to the Retort. As the Water evaporated, the Sides of the Retort appeared covered with a seemingly *earthy Matter*, in small Quantity. The Lime-Water in the Receiver had a *thin Crust* formed upon its Surface, before any evaporated Water was condensed, or any *Bubbles* had burst upon the Surface of the Water in the Retort; and it was very little or not

at all increased in Thickness, after the Condensation began. In the Course of the Distillation, which was continued till about eight Ounces only remained in the Retort, the Water in the Receiver became rather *turbid*; which appeared to be occasioned by the Crust formed upon the Surface of the Lime-Water, before, and in the Beginning of the Distillation, mixing with the Lime-Water and condensed Water. By standing, a small Quantity of *white Sediment* was deposited in the Receiver.

Rain-Water, that only contained an exceedingly small Quantity of Gas, in the same Quantity, and in the same Manner as above-described, was distilled. *Exactly the same Appearances in the Receiver containing the Lime-Water took Place, but a smaller Quantity of earthy Matter was deposited upon the Sides of the Retort.*

The eight Ounces of *Buxton-Water* remaining in the Retort was tolerably *clear*; and required *as much, or rather more Lime-Water* to saturate its Gas, than before a Quart of it was diminished to this Quantity by Distillation. The *Rain-Water* remaining after the above Quantity was distilled after Mixture with Lime-Water, deposited in the same Manner as before Exposure to Heat, a very small Quantity of *white Sediment*.

I have several Times distilled *Buxton, Matlock*, and the *Spring-Waters* near Doncaster, but never found that these Waters distilled formed turbid Mixtures

Mixtures with Lime-Water, or that they deposited Sediment on standing, as before Evaporation, after the Addition of Lime-Water; but they *sparkled* on being heated, and appeared to be saturated with Air. They all incruited the Retort with earthy Matter as the Water evaporated.

Observation. In this Experiment we should expect to see the Lime-Water in the Retort become *milky* soon after the Evaporation, if the Waters separated Gas by Heat; but it does not appear, that the Crust and subsequent turbid Appearance in this Experiment, were occasioned by this Substance extricated from the Water in the Retort, but merely from Gas contained in the Air within the Vessels in which the Experiment was performed; for the same Appearance occurred during the Distillation of Rain-Water, that was previously found to contain an exceedingly small Portion of Gas, and which remained in the Water not evaporated in the same Quantity as before Exposure to Heat.

Farther, considering the ready and copious Absorption of Gas by Water, we should naturally expect to find distilled Spring-Waters that contain it, such as those examined in this Experiment, to be impregnated with this permanent Vapour; but, I have never yet found distilled Water of the above Springs, or any other common Springs, to become turbid by adding Lime-Water, or to form a Sediment on standing. Most probably,

probably, however, those Fountain-Waters which separate Gas by Heat as the *Acidulae*, of which Number are *Pymont, Spaw, Driburg, Seltzer-Waters*, &c. when distilled, contain this permanent Vapour.

Rain-Water and *Lime-Water*, after being mixed together, either remain quite clear and do not deposit any Sediment, or there is a very slight Disturbance in the Transparency of this Mixture, and a very small Quantity of Sediment on standing. But, *Rain-Water* is the Water of *Springs, Rivers, Lakes, and Seas*, (almost all of which contain Gas to the Test of *Lime-Water*) evaporated by the Heat of the Surface of the Earth and the Atmosphere, and, probably, contains neither Gas, nor any other extraneous Matter, any more than distilled Water; but, as it passes through a pretty large Tract of the Atmosphere, in its Way to the Surface of the Earth, it is liable to combine or mix with various fossil, animal, and vegetable Matters; among these, with Gas; and also to become saturated with Air.

This Experiment will serve to rectify the Error of a very prevailing Opinion, namely, that a *Spring-Water, which to the Test of Lime-Water appears to contain Gas, and which on boiling deposits calcareous Earth, contains this Earth dissolved by Means of Gas*; for this earthy Substance, I have shewn, is deposited, during Evaporation; and at the same Time I have decisively proved, that no

Gas

Gas is extricated. Hereafter will be stated the Arguments to render it probable, that Substances are never or rarely *suspended* in Springs by Means of Gas, and never *dissolved* therein by Means of this permanent Vapour.

This Experiment furnishes *a third decisive Proof, that Buxton-Water does not separate Gas by Heat and Evaporation.*

As it is proved, that Buxton and other Spring-Waters contain Gas; that they do not separate any Part of this Substance by Heat; and that, when reduced to one-fourth of their Bulk by Evaporation, they do not contain decisively a larger Quantity of it than before Exposure to Heat, and therefore a Portion of this permanent Vapour is wanting in Proportion to the Quantity of Water evaporated; the Question occurred, in what Manner is this Gas disposed of during Evaporation? I satisfied myself further of the Reality of this Fact, by evaporating several Times the above Spring-Waters to one-eighth, or even a less Quantity, and always found the remaining Waters to require the same, or nearly the same Quantity of Lime-Water to saturate their Gas, as before Evaporation. This Fact, at first, appeared to me inexplicable, and a Matter of Importance to be understood.

I had conjectured also, that the Gas in these Waters was combined with the simple Water so intimately by Nature, as not to be disunited by

the Heat of boiling Water ; for the longer a Solution of Gas in distilled Water is *kept*, the more intimate the Union between these two Substances is ; but, the Event of this Experiment, which shewed that Gas was contained in the same, or nearly in the same Quantity, in these Waters after evaporating any Portion of them, proved this Conjecture to be false.

After reflecting some Time on the above Phenomenon, an hypothetical Explanation of it occurred.

An Hypothesis.

The Gas, of which these Spring-Waters were deprived in Proportion to the Evaporation, was neither contained in the Water evaporated, nor in the Water left unevaporated ; but I observed, *calcareous Earth* to be deposited as the Evaporation proceeded ; so that the Water to be evaporated contained the same, or nearly the same Quantity of this earthy Salt, in a State of Solution. After contemplating the Properties of this Substance I conceived, that the Gas in these Waters was combined with Quicklime forming calcareous Earth, and not with simple Water, as happens when this Gas is dissolved in distilled or elementary Water. I considered, that calcareous Earth was a Substance composed of Quicklime and Gas, or perhaps, more properly, of Gas and the Compound of Quicklime and Gas. If Quicklime

lime be either a Species of caustic fixed Alkali (g), or has many Properties of that Substance, and Gas be an Acid, the Compound of these two Substances form a *neutral*, or more properly, an *earthy Salt*, called *calcareous Earth*; a Substance soluble in small Proportion in Water, like another neutral Salt with Quicklime for its Basis, vitriolic Selenites. Caustic fixed vegetable Alkali, caustic fixed fossil Alkali, and volatile Alkali in a caustic State combine with Gas, and this Compound, mild Alkali, unites with Gas, and forms a different Substance, namely, *the Compound of mild Alkali and Gas*, which is seemingly a neutral Salt (b). Mild Alkali, or Alkali in the State usually produced by Art is caustic Alkali combined with a Proportion of Gas not sufficient to neutralize it, or destroy any of its Properties, excepting its Causticity.

Quicklime, like other caustic Alkalies, unites with Gas and forms therewith a Compound; which Compound, it was conceived, combines with fresh Gas, and forms a different Substance, perhaps, calcareous Earth in the State in which it is found

(g) Dr. Cullen, as I before observed, formerly considered Quicklime as an alkaline Salt. See *Notes written by several Pupils at his chymical Lectures*.

(b) Vide the Appendix to Dr. Priestley's second Vol. of Experiments and Observations on Air, in which are related Mr. Bewley's Experiments.

Mr. Bergman has also shewn Gas to be an Acid. Vide Mr. Cavallo's Work on Air, 4to.

naturally

naturally in the Bowels of the Earth, in Springs, and elsewhere.

If two Substances, one a Compound of the Compound of caustic Alkali and Gas united with Gas, the other caustic Alkali, be dissolved in Water, and mixed together; the Gas combined with *the Compound of Gas and caustic Alkali* will be attracted by the caustic Alkali, and only one Kind of Substance, viz. the Compound of Gas and caustic Alkali will be found in the Water; excepting, perhaps, a Portion of superabundant Compound of Gas and mild Alkali, or of caustic Alkali. In like manner, if to a Solution in Water, of Gas and the Compound of Gas and Quicklime, i. e. calcareous Earth, be added a Solution of Lime, this last Substance will decompose the other Compound by uniting with the Gas combined with the Compound of Quicklime and Gas; and thus there will be only one Kind of Substance in the Water, viz. Quicklime combined with Gas; excepting, perhaps, a small Quantity of superfluous Quicklime, or redundant Compound of Quicklime and Gas united with Gas.

This Hypothesis is founded on a Fact in Chymistry, that different Substances may be formed of the same Elements, according to the Proportion of these Elements to each other. For Instance, Phlogiston and vitriolic Acid form volatile vitriolic Acid; and volatile vitriolic Acid and Phlogiston, compose Sulphur; Calx of
Quicksilver

Quicksilver and muriatic Acid form corrosive Sublimate; and this Substance and muriatic Acid form Muria Mercurii; and corrosive Sublimate and Calx of Quicksilver make Calomel.

On this Hypothesis we can explain, why Gas cannot be separated by Heat equal to that of boiling Water, because it is combined with Quicklime, or with *the Compound of Quicklime and Gas*, which cannot be decomposed by this Heat. And it is not found in greater Quantity in the Water remaining after evaporating a large Quantity of any given Portion from it, because the calcareous Earth is precipitated as the Evaporation proceeds. Moreover, this Hypothesis explains why the Quantity of Gas, procured by decomposing the Sediment formed by uniting the Quicklime of Lime-Water with the Gas of Spring-Water, (p. 270, 271) is less when the Gas of a given Quantity of Water is saturated by Lime-Water, than when the Gas of the same Quantity of Spring-Water is only partially saturated by Lime-Water; by supposing, that *the Compound of Gas and Quicklime* is attracted stronger than calcareous Earth, *the Compound of Gas and Quicklime and Gas* by Water; and that upon the Addition of Lime to Solution of calcareous Earth in Water, *the Compound of Gas and Quicklime* thus formed is sufficient to saturate the Water; therefore it precipitates calcareous Earth, which contains more Gas in a given Weight, than Sediment

ment formed after adding Lime-Water to saturate the Gas, because it is only *Quicklime combined with Gas*; whereas, calcareous Earth is *the Compound of Gas and Quicklime united with Gas*.

To verify, or prove the Falseness of every Part of this Supposition, would require many Experiments. The following Experiment was made with the View of proving, whether this Conjecture be wholly, or in Part, true.

Exper. XXIX. I took a Florence Flask, that held about three Pints, and poured into it two Pints of distilled Snow-Water; a small Quantity of which, was previously found to remain perfectly transparent, and without depositing Sediment on standing, after Mixture with Lime-Water. Two Drachms of Chalk, finely powdered, were added to this Quantity of distilled Water. The Neck of the Flask was stopped with a soft Cork. This Mixture was kept in a gentle Sand-Heat for a Fortnight, during which Time it was frequently agitated, and when shook formed a Mixture like Milk. After this Time, it was decanted and filtered through Paper; by which Means a Fluid was obtained as clear as the distilled Water before Mixture with Chalk, but which had an *earthy Taste*.

To about eight Ounces of this *filtered Water* were added four Ounces of *Lime-Water*, which immediately occasioned a *pearly-coloured turbid Appearance*, and which on standing produced a

U

white

white woolly Sediment. From this woolly Sediment as much Water was poured off as possible, and to one Portion of it was added a small Quantity of *vitriolic Acid*, with which it *effervesced* and formed *vitriolic Selenites*; and, on the other Part was poured *muriatic Acid*, whereby *muriatic Selenites* was produced.

To small Quantities of this filtered Fluid were added *saturated Solution of Lead in nitrous Acid*, *saturated Solution of Silver in nitrous Acid*, and *Saccharum Saturni*; with all of which either immediately, or on standing, the filtered Water became *less transparent* or *muddy*, and after standing *deposited Sediment*, while the same Substances with *distilled Water* produced either merely a very slight Disturbance in the Transparency of the distilled Water by standing, or much less Sediment than with this filtered Solution.

A Pint of this filtered Fluid was *boiled* in a Pint and a half Florence Flask. It separated Bubbles, apparently of *Air*, during the first ten Minutes of boiling; but afterwards only discharged those large *non-permanent* Bubbles of Vapour peculiar to boiling Water, which no one accustomed to attend to the Phenomenon of the Ebullition of Water can mistake for aerial Bubbles. After about two Ounces of this Fluid were evaporated, a *Ring* of *white*, and *apparently earthy Matter* was formed round the Inside of the Flask in Contact with the Surface of the Water before Evaporation.

ration. The Evaporation was continued till about one-fourth of this Fluid was only left, and the Inside of the Flask was now *covered with, seemingly, earthy matter*, and the remaining Fluid was poured out and found not perfectly transparent.

A little *muriatic Acid* was poured into the Flask from which the Fluid was just poured out; it excited a gentle *Efferescence*, and entirely *dissolved* the Matter deposited upon the Inside of the Flask. A little of this Acid being added to a Tea-spoonful of the remaining Fluid made it quite transparent.

To two Ounces of this Fluid left unevaporated were added about an Ounce of *Lime-Water*, which instantly occasioned a *pearly coloured Mixture*, that on standing deposited a *white Sediment*. To an Ounce of this Fluid also, was added some transparent Solution of fixed vegetable Alkali, which Mixture was *clear and without Sediment* after standing.

This filtered Solution both before Evaporation, and after three-fourths of it were exhaled, formed an *uniform Mixture with Soap*.

Observations. This Experiment afforded me great Pleasure;—to my Apprehension it shewed that the Conjecture made, p. 270, and 285 to 289, was in general true;—for the calcareous Earth was dissolved in simple Water (*i*);—this Solution

ON

(*i*) If I am not mistaken, Dr. Black used to relate in his chymical Lectures some Years ago, that he suspended a Piece

on the Addition of Lime-Water was first *muddy*, and then deposited a *white Sediment*, which was a Compound formed by the Union of the Quicklime in the Lime-Water and the Gas united with the Compound of Gas and Quicklime in the Solution;—after evaporating this Solution to one-fourth of its Bulk it turned rather muddy, and deposited a *Sediment*, as before Evaporation, on Mixture with Lime-Water;—during boiling, for a short Time only, it extricated Bubbles of Vapour, and as the Evaporation proceeded *calcareous Earth* was *precipitated* from the Water.

Therefore, the present Opinion that a Spring-Water is combined with Gas, although it form a *milky Mixture* with *Lime Water* and *deposit Sediment* on standing, is not always true; because Lime-Water added to Fountain-Water containing *calcareous Earth* in Solution attracts Gas from this Substance, which occasions first *Muddiness*, and, on standing, a *Deposition of Matter composed of Gas and Quicklime*. This Appearance, together with others arising from this Cause, which will now be readily comprehended, were observed Exper. II. p. 175, also p. 245 to 251, 265 and 280.

Having attempted to discover the Quantity of Gas contained in a given Quantity of Buxton

of Chalk in Water, and after some Time found it diminished; from which he inferred, that Water dissolves *calcareous Earth*.

and

and some other Waters, and its Mode of Combination, as proposed p. 245; to which I was led, after shewing the permanent Vapours separable by Heat from Buxton and other Spring-Waters; I remark, in Consequence of the Instruction received by Experiments XVIII. to XXIX.

1. That the present generally prevailing Principle, the Solution of calcareous Earth in Water by Means of Gas, employed to explain the Deposition of calcareous Earth from Fountain-Water on exposing them to Heat, does not obtain with *Buxton*, *Matlock*, and the *common cold Springs* examined; nor does it explain justly the petrifying Quality of many cold Springs. For these Spring-Waters do not contain any Gas, excepting as one of the simple Substances necessary to the Constitution of the calcareous Earth dissolved in these Waters; nor separate any of this permanent Vapour during Evaporation, see Exper. XXVIII. p. 280; nor, supposing the Gas demonstrated to be separated from these Waters, see Exper. XXI. p. 245. to be combined with the simple Water and not with any Substance with which it is impregnated, is the Quantity such as can be thought to be the efficient Cause of the Effects above-mentioned.

The obvious Occasion of the Deposition of Earth during Evaporation is the Loss by Exhalation of Part of the simple Water, in Consequence of which the remaining Water contains

more Earth than it can dissolve. See Exper. XXVIII. p. 280.

The efficient Cause of the petrifying Quality, or spontaneous Deposition of calcareous Earth from the Springs here examined, has not been discovered by any Observations or Experiments. This Quality of certain Springs has been noticed by natural Historians and Poets (*k*) in ancient Times, and always regarded as a wonderful Phenomenon of Nature. After it was discovered, that a saturated Solution of Gas in Water contained a pretty large Proportion of calcareous Earth, and deposited it upon Exposure to the Atmosphere, an adequate Cause was supposed to be found of this spontaneous Deposition of calcareous Earth. Dr. Priestley, however, relates (Exp. and Obs. Vol. V.), that he could not separate Gas from a petrifying Spring, as he previously expected.

I have conceived the petrifying Quality of Springs to depend merely upon the Attraction between the minute Particles of calcareous Earth suspended in the Water and the Surface of the Ground, or Substances immersed therein, either because the Menstruum was more than saturated with this and other Substances, or because the Time necessary for the Combination between

(*k*) "Flumen habent Cicones, quod potum saxea reddit

"Viscera, quod tactis inducit marmora rebus.

OVID, Lib. xv. Fab. 5.

Water

Water and this Substance to take Place was not allowed, from the Circumstances of the Exposure of calcareous Earth to the Action of Water before the Spring burst through the Surface of the Earth. For although these petrifying Waters be as clear as any other Spring-Waters, and Transparency be one of the usual Signs of Solution, yet it seems not improbable, that a Solid may be divided into Parts so minute as very little to disturb the Transparency of the Water, when suspended in no great Abundance therein.

It has been observed by Dr. Fordyce, in his Lectures, that all the Fluids of living Animals are petrifying Waters; and although they do not deposit Earth upon *living* Vessels, yet, whenever any extraneous or *dead* Matter is introduced or produced, this Earth is deposited, and forms stony Concretions. Unless I am much mistaken, petrifying Springs only deposit calcareous Earth upon *dead* Matter; for I have observed, that various Species of Plants, as the Water-Parship, &c. grow in the petrifying Springs of Matlock, in the Channel that conveys them, exposed to the Air, some Distance from their Source, without the smallest Incrustation being formed upon them: whereas, *dead* animal and vegetable Matter, and fossil Substances, become covered with calcareous Earth in the Space of a few Weeks, in the very Parts of the Springs where Plants live and thrive as in common Springs that do not possess the

Properties of petrifying. Some Species of Plants, however, as well as certain Parts of living Animals, as the Teeth, become incrustated; for Moss petrifies, although slowly, while growing in these Springs.

2. That it is extremely improbable, that calcareous Earth is dissolved in Springs in general by Means of Gas; because, before Water can perform the Solution spoken of, it must contain a large Quantity, or even be fully saturated with this Vapour; and, consequently, every Spring that contains calcareous Earth dissolved by Means of Gas should be acidulous; deposit this Earth, and lose its acidulous Taste, by mere Exposure to the open Air; for, under this Circumstance, a great Part of the Menstruum escapes; and such a Spring, should precipitate this Earth more abundantly and speedily by Exposure to Heat, than happens from mere Evaporation of Water. But, Springs possessing these Properties are exceedingly rare; yet there are few Fountain-Waters that do not precipitate calcareous Earth during boiling; especially those flowing from Lime-Stone Beds, which are well known to have the Quality of incrustating Vessels in which they are boiled. Moreover, Brooks or Rivulets formed by many Springs containing Lime-Stone deposit copiously calcareous Earth during boiling, and in which Fishes live in Health, and breed abundantly; but these Animals soon die
when

when put into Water impregnated with Gas, as Dr. Priestley has found.—See Exper. and Observ. Vol. II. p. 231.

3. That when calcareous Earth is contained in Water by Means of Gas, it is not *dissolved* by this Substance; because, as Dr. Fordyce has shewn, in his Chymical Lectures, the Gas is not altered by the calcareous Earth; it tastes as acid with this Earth as without it, and the Water remains as perfectly saturated as before the Addition of calcareous Earth. Moreover, upon mere Exposure to the Air of the Atmosphere, of a temperate Heat, this Earth is deposited; so that although a very small Quantity of it may form a transparent Mixture with this Water saturated with Gas, it is rather *suspended* in the *viscid Fluid* produced by Gas dissolved in Water, than by a *Solution* of Earth in this permanent Vapour.

Further, it is now generally believed, that the Iron in chalybeate Springs is *dissolved* by Means of Gas; because, when they are exposed to the Atmosphere, the Iron is deposited in a calciform State; by Evaporation, a mere Calx of Iron is generally procured; and by mixing Iron Filings with a copious Solution of Gas in Water a Part of this Metal is dissolved. But upon Examination of several chalybeate Springs that have the Property of decomposing spontaneously, I have not met with one, which contained Gas sensible to the Taste, or to the Test of Lime-Water in
greater

greater Quantity than in common Spring-Water. See p. 253.

Exper. XXX. A Wine Glass-full of a *chalybeate Spring* that decomposed spontaneously, tasted very strongly of Iron, had no acidulous Taste, and contained no more Gas than common Spring-Water, was placed near the *Fire* of a common sitting Room. Another similar Glass-full of this Spring-Water was placed in a *cool* Part of the same Room.

As soon as the first of these Glasses became rather warm, it *sparkled* with many Bubbles adhering to the Sides of it, was *turbid*, and of a *brown Colour*; but no Particles like Gas were seen to escape. The second Glass was pretty *clear* for half an Hour; but after this Time was of a *brownish* Colour, and pretty *transparent*.

Had the sudden and abundant Deposition in the first Glass depended upon the Escape of Gas, I apprehend, the Flight of this Substance must have been there *visible*, if not during the slow and much less copious Deposition in the other Glass.

Exper. XXXI. A Pint Florence Flask of this chalybeate Water was boiled a short Time, and then set aside for the decomposed Matter to be deposited; this being effected, the clear Water was poured off and filtered. Upon a Mixture of this filtered Liquor with Lime-Water, it appeared to contain *the same Quantity of Gas, although it was deprived of its metallic Impregnation, as a*

Parcel of this Spring-Water taken just before from its Source,

An eight Ounce Phial was perfectly filled with this chalybeate Water at the Spring-Head, and there closely corked, and afterwards kept inverted. Another Phial of the same Size was filled three-fourths full of this Water, then corked, and preserved in an inverted Position. A third eight Ounce Phial was filled with this mineral Water, and set to stand in this Phial open to the Atmosphere.

By standing, all these three Phials of colourless Fluid became *ochry brown*, but remained clear; and they had all a small Quantity of Sediment of the same Colour, but in greater Quantity in the Phial open to the Atmosphere than in the other Bottles.

Hence it appears, that the Decomposition of this mineral Spring was effected under Circumstances that would prevent as well as suffer the Escape of Gas.

Thus then it is shown, that Iron is not dissolved by Means of Gas; and that the spontaneous Decomposition or Precipitation of mineral Waters containing Metals is not occasioned by the Escape of this permanent Vapour. But if the Arguments we have produced in support of these Positions shall be thought insufficient, they will be placed beyond all Controversy by the following Experiment, which may be considered as an *Instantia Crucis*.

Exper.

Exper. XXXII. To a Jar containing a Pint of the above *mineral Spring* just taken from its Source was added such a Quantity of transparent Solution of *fixed vegetable Alkali*, in a mild State, as was supposed sufficient to decompose a Salt composed of Iron and vitriolic or other Acids. Upon adding this Alkali, the Water turned *greenish* and *turbid*; and on standing deposited a *copious brown Sediment* from a *colourless Fluid*. The clear Fluid was poured off and filtered.

To some of this *filtered Mixture* was added powdered Galls, which did not produce any *Colour* immediately or on standing, excepting that of Infusion of Galls in pure Water. But Galls of the same Parcel added to Water *fresh from the Spring* produced immediately a dark *purple Colour*.

Some of this *filtered Fluid* turned instantly *white* as Milk with Lime-Water, and on standing deposited a *large Quantity of white Sediment*; but the *fresh Water* and *Lime-Water* only turned pearly-coloured, and deposited a *small Quantity of Sediment*. With *Syrup of Violets* this *filtered Liquor* changed instantly to a deep *Grass-green Colour*, but the *fresh Water* with this Syrup was only a very *pale Green*, or had a *greenish Hue* on standing.

The *brown Sediment* left after pouring off the above Fluid that was filtered was saturated precisely with *muriatic Acid*, and a Part of this Compound was dissolved in Water. This Solution changed of a *purple Colour* on the Addition of powdered Galls.

The

The *chalybeate Spring* near the Bridge at Buxton was also subjected to the Experiment here related, and with the same Result; therefore, the same Inference is to be drawn from it as from this Experiment on the former mineral Spring.

Inference. As the metallic Matter was precipitated by Means of mild Alkali, although at the same Time a considerable additional Quantity of Gas was contained in the Water, to the Test of Lime-Water, it follows, that the Iron naturally contained in these Springs is not dissolved therein by Means of Gas.

We therefore refer the spontaneous Decomposition of chalybeate Waters, not to the Escape of Gas, as its Menstruum, but to another efficient Cause demonstrable by Experiment, *the Mixture of metallic Salts with considerable Quantities of Water* (1); provided there be no superabundant Acid

(1) “ I never examined any mineral Water in which I
 “ found the Metals combined with any other Substance but
 “ vitriolic Acid; and I am certain many Authors have been
 “ misled by not knowing this Property of metallic Salts, viz.
 “ that if we dissolve them in a small Proportion of Water,
 “ or if there be superfluous Acid, the Solution will remain
 “ perfect when exposed to the Air; but if the Acid be perfectly saturated with the Metal, and the Proportion of
 “ Water to the metallic Salt be very great, on Exposure to
 “ the Air it is decomposed, the Metal being precipitated
 “ in the Form of Calx, and the Acid being lost. This may
 “ easily be tried, by taking common green or blue Vitriol,
 “ dissolving

Acid mixed with these Salts. This Decomposition is accelerated, and made more complete by Exposure of the Water containing Iron to Heat, and the Atmosphere.

In the above Experiment it is not improbable, that a small Portion of the Calx of Iron precipitated by the Alkali added was suspended in the Mixture; but yet this Calx, so suspended, or not dissolved, hath not perhaps the Power of coagulating Galls; and Mr. Lane, who discovered the Property of Water impregnated with Gas to strike Colours with Galls after agitating it with Iron-Filings, did not find this Effect produced by Iron in a calciform State.

Moreover,

“ dissolving an Ounce in three Ounces of Water by boiling,
 “ letting them stand to cool, and filtering the Solution. If
 “ this Solution be exposed to the Air, it will remain perfect;
 “ but if we drop a Drop or two of it into a Wine
 “ Glass-full of Water, in a few Minutes the Transparency
 “ of the Water will begin to be disturbed, and the Metal in
 “ a short Time will fall down in a red Powder, if it be Iron;
 “ in a blue Powder, if it be Copper.”—See *A new Method of assaying Copper-Ores*, by G. Fordyce, M. D. F. R. S. Phil. Transf. Vol. LXX.

Mr. Boyle long ago noticed the spontaneous Decomposition of Mixture of metallic Salts in a large Quantity of Water, especially when exposed to the Atmosphere; but did not understand the Occasion of this Effect. He says, “ The Precipitation was surprising from chalybeate Waters exposed to the Air, but not so considerable in close Vessels, as if the Air contained precipitating Salts.”

Mr.

Moreover, if a small Quantity of Acid of Vitriol be added to a chalybeate Spring that decomposes on standing, no Decomposition ensues, and the Water, by this Means, preserves its mineral Quality. This would scarcely happen, but for the same Reason that dilute metallic Solutions do not decompose with a small Quantity of superabundant Acid.

I next enquired what was *the Kind, and Quantity of solid Substances contained in Buxton-Water.*

By Means of Mixture, p. 173—231, we have discovered many of the *Kinds and Quantities* of some of the Substances contained in a certain Quantity of Water; but the *Kinds and Proportions* of some Things cannot be determined by

Mr. Rouelle observes, that Solutions of Mercury in nitrous Acid should contain superabundant Acid; because when perfectly saturated, they form a Precipitate with any Kind of Water. Also, metallic Salts of all Kinds are, strictly speaking, capable of Decomposition by Water alone. See *A Dictionary of Chymistry*, 8vo. Vol. III. 1777.

Bismuth, a semi-metal, dissolved in nitrous Acid without any superabundant Acid, may be precipitated by Solution in a large Quantity of Water. The Substance thus precipitated by Water is *Magistery of Bismuth*.—*Dictionary of Chymistry*, Vol. I. 1777.

Although several Chymists may have known the Property, that metallic Salts are capable of Decomposition by Mixture with a sufficient Quantity of pure Water, yet, I believe, Dr. Fordyce is the only Philosopher who has made Use of this Fact to explain the spontaneous Decomposition of chalybeate Springs.

Mixture;

Mixture; therefore we have recourse to the Means of *Heat*.

Exper. XXXIII. I cut off the Necks with Part of the Shoulders of two large Florentine Flasks, and ascertained the Weight of each by Means of a fine Balance that had its Equilibrium destroyed by one-sixteenth of a Grain.

These Flasks were filled rather more than three-fourths full of *Buxton tepid Water*: One was found to contain one Pound twelve Ounces and a half, Avoirdupois; and the other two Pounds one Ounce and a half.

This done, the Flasks were placed in a Sand-heat of 150° to 180° ; by which Means, in the Space of five Days, the whole of the Water was evaporated. In order to prevent the Introduction of any extraneous Matter during the Evaporation, the Mouths of the Flasks were covered with Pieces of open Gauze.

After the Evaporation of the Water the Flasks had a Sediment adhering to the Infides and Bottom of them in every Part where the Water had been in Contact with the Flasks; and the larger Flask had *increased in Weight four Grains*, and the smaller one *three Grains and a half*.

About the *Middle* of the Inside of the Flasks, Sediment adhered more copiously than in the other Parts. Upon examining this Part of the Sediment with the naked Eye it appeared to consist of *exceedingly small Needle-like Crystals* of a blue Colour;

Colour; which, viewed through a magnifying Glass, appeared *transparent* and *colourless*, and of the *Figure of Crystals of Nitre and Glauber's Salt*.

As much of the Sediments in the Flasks were washed off as possible, with a small Quantity of boiling hot distilled Snow-Water. These were mixed together, and filtered through Paper previously washed by distilled Water filtered through it.

This *filtered Liquor* was colourless, and a small Portion of it did not alter the blue Colour of Violets; it tasted like Solution of Sea Salt, and a Part of it with Solution of Silver turned immediately pearly-coloured.

A small Quantity of this boiling distilled Water was poured upon the Filter, and this *second filtered Fluid* had an extremely slight Taste of Sea Salt; and Solution of Lead with superabundant Acid, as well as transparent Solution of Alkali were rendered turbid by it.

A small Quantity of boiling hot distilled Water was poured a third Time upon the Filter. This *third filtered Water* was without Taste, but was turbid like the last filtered Fluid with Solution of Lead, and with Alkali.

None of these filtered Fluids produced Colour with Galls, or phlogisticated Alkali.

The *Matter left upon the Filter* effervesced and was dissolved by muriatic and vitriolic Acids, with which it formed muriatic and vitriolic Sele-

nites. The Solution of vitriolic Selenites with powdered Galls did not strike any Colour, but upon adding Solution of Alkali to this Solution and Galls, a blackish and purple Colour ensued.

A Matter adhered so obstinately to the Sides of the Flasks that it could not be washed off by boiling Water repeatedly applied, nor by muriatic Acid to which it was exposed for several Days; but it was removed by Solution of Alkali pretty readily.

Deduction. By thus evaporating Buxton-Water we learn that there is *no Acid or Alkali* contained in Buxton-Water;—that of the *neutral Salts* it contains only one, namely, *Sea-Salt*;—that of the *earthy Salts* there is only *vitriolic Selenites* and *calcareous Earth*;—and that it is not impregnated with any metallic Salt or Earth.

We find that the Proportion of *solid Matter* procured by Evaporation is about sixteen Grains to a Gallon of Water, or one Grain to eight Ounces of Water, or $\frac{1}{3840}$ of the Weight of the Water; and that this consists of three Things, *Sea-Salt*, *vitriolic Selenites*, and *calcareous Earth*.

This Experiment manifests, as exactly as can be contrived, the Proportion of solid Matters to the Water; it also shows that the Substances of which they are composed are the same as I have usually found in common *hard* Waters. From the Smallness of the Quantity of these Substances Buxton-Water is entitled to be ranked *among the*

purest, if it be not the purest of hard Waters, and, perhaps, among those next in Purity to Snow and Rain-Water; for it contains about six Times as much Sediment and of the same Kinds of solid Substances as Rain-Water, and nine Times as much solid Matters and of the same Kinds as Snow-Water (m).

Buxton-

(m) The learned Dr. *Heberden* evaporated many *Pump-Waters* to Dryness, and they all incrustated the Vessels, and left at least ten Grains of Sediment, after each Quart was exhaled away.

Margraaf found all the Wells in and about Berlin impregnated with *calcareous Earth*; in 3600 Ounces, or 100 Quarts of 36 Ounces each, they contained one Ounce two Drachms to four Drachms and 27 Grains of this Substance. In this Quantity of Water, most of them held of *vitriolic Gypsum*, from three Drachms and a half to four Grains: Also, most of them contained *Sea-Salt*, from three Drachms to 30 Grains: And several contained *Nitre*, from one Ounce and one Drachm, to eight or ten Grains. In other Waters, in the above Quantity of them, the following Substances were found: two Springs were impregnated with *Magnesia Glauber-Salts*, in Quantity from 30 Grains, to a few Grains only. Three Wells held in Solution four Drachms to 30 Grains of *nitrous and muriatic Selenites*. Two Springs contained 30 Grains of *alkaline Lixivium*; and in another, a small Quantity of this Substance. Moreover, 100 Quarts of *Snow-Water* afforded one Drachm of *calcareous Earth*, a few Grains of *muriatic Acid*, and a *nitrous Substance*, And this Quantity of *Rain-Water* left a Drachm of *calcareous Earth*, and a few Grains of *nitrous Acid* and *common Salt*. 100 gr

Dr. *Hales* and Dr. *Rutty* found Sediment in rather greater Quantity from Rain and Snow-Water than the ingenious and accurate Chymist of Berlin.

Buxton-Water has been repeatedly evaporated to Dryness by several Persons; from which Experiment we can only conclude, that the *Quantity* of solid Matter impregnating it is less than that of Springs in general: but nothing can be satisfactorily deduced from it with Regard to the *Qualities* of this Sediment. We must except from this Stricture this Experiment made by the following Gentlemen.

Dr.

River-Water contains nearly as great a Weight of Sea-Salt, namely, $\frac{1}{4000}$ Part of its Bulk, as Buxton-Water does of the whole of its solid Substances.

Excepting Buxton-Water, the purest Spring-Water, that has been hitherto examined, is Bristol-Water; which, according to Dr. *Hales*, contains in 34 cubic Inches, four Grains of Sediment, or as 1 to 2222; and according to Dr. *Higgins's* Analysis, this Water contains one Dwt. nine Grains in a Winchester Gallon.

Matlock-Water has been reported to contain 40 Grains of Sediment in a Gallon of Water, which is called *Nitre, alkaline Earth*, and Sea-Salt.

Hippocrates entertained very erroneous Notions of the Nature of Snow-Water, and Water that had been frozen, although he understood well the Properties of Rain-Water. He says, Rain-Water is the lightest, sweetest or most insipid, thinnest, and most limpid of all Waters; for the Sun only takes up what is the thinnest and lightest, as in the Case of Water evaporated from the Sea; but all Snow and Ice-Water is pernicious, for Water after being concreted never returns to its former State, being thereby deprived of its more volatile Parts, as may be proved in the following Manner: If you take a Vessel of Water, and expose it to the Air

to

Dr. A. Hunter says, “ I ordered four Gallons of Buxton-Water to be carefully evaporated over a gentle Fire, and obtained five Scruples of a mixt Composition, whereof one Drachm was a light blue-coloured Earth, and the remaining two Scruples, by all the Trials I could make upon them, appeared to consist of a native alkaline nitrous Salt, with about an equal Portion of marine Salt.” See this Author’s useful *Treatise on Buxton-Waters*.

to congeal, and afterwards bring it into a warm Place to thaw, you will find the Water less in Bulk ; hence we know, that what is thin and light has escaped, not what is thick and heavy. On this and other Accounts, Snow and Ice-Water are the worst Kinds of Water.—See *Hippocrates de Aëre, Aquis & Locis*.

Pliny, perhaps upon the Authority of Hippocrates, also alledges, that Snow and Ice-Water are insalubrious, because the lightest Part is evaporated ; and yet he recommends, upon the same Authority, boiling, Filtration, and extinguishing red hot Iron in Water, in order to make it less unwholesome. *Pliny* also proposes, that the Mischief of Snow-Water may be avoided, and the agreeable Quality, its Coldness, preserved, by putting a Vessel of Water into a Bag of Snow ; this, he says, was the Invention of Nero,—“ Ita Voluptas Frigoris sine Vitiis Nivis.”

The Opinion that Snow contains a considerable Quantity of Nitre, on which its Property of fertilizing the Earth depends ; and that it is an impure and unwholesome Water, prevails even at this Day, although the clearest Proofs have been given by Dr. *Rutty* and Mr. *Margraaf*, that it is nearly as pure as distilled water.

Dr. *Percival*, Phil. Transf. Vol. LXII. p. 455, says, " the Water of St. Anne's Well was found by Analysis, to contain calcareous Earth, fossil Alkali, and Sea-Salt :—That a Gallon of the Water, when evaporated, yields only twenty-three or twenty-four Grains of Sediment." This Account was communicated to this Author by the worthy Physician who at present attends at Buxton.

Dr. *Higgins* reported, in a Hand-Bill, dated June 9, 1782, and also in the News-Papers, that *Buxton-Water* afforded " in a Winchester Gallon $17 \frac{1}{2}$ Grains of Sediment; of which $11 \frac{1}{2}$ Grains were calcareous Earth combined with acidulous Gas, $1 \frac{1}{2}$ Grain Selenite, $3 \frac{1}{2}$ Grains Sea-Salt, $1 \frac{1}{4}$ Grain marine Salt of Magnesia, and $\frac{1}{20}$ Grain was Iron combined with acidulous Gas, exclusive of the Quantity contained in calcareous Earth, in the Heat of boiling Water."

It was necessary to procure a larger Quantity of the above Sediment, *in order to determine more certainly the Kind, and Quantity of each of the Substances of which it was composed*, on which Account I made the following Experiment.

Exper. XXXIV. Three Gallons of Buxton-Water were evaporated to Dryness in a gentle Heat, by exhaling three Quarts of it at a Time in a Glass Retort, that had its Neck and Shoulder broke off, to about *four Ounces*; and then evaporating these small Quantities, to which the three Quarts were reduced, in one of the Flasks employed

employed in the last Experiment, to about *one Ounce*; when there appeared to be, upon cooling, *a few small Crystals*, but not sufficiently large or distinct to denote any particular Salt; and this remaining Fluid *tasted strongly of Sea-Salt*. The Evaporation was then continued to Dryness, and the *Sediment*, collected from the Retort and from the Flask, *was found to weigh forty-five Grains*. The Sediment in the Retort had very little or no Taste, but that in the Flask was saline.

The whole Sediment was mixt with half an Ounce of distilled Water boiling hot, and then filtered. This filtered Fluid tasted Salt. Another half Ounce of this Water, boiling hot, was poured upon the Filter, but this second filtered Fluid had only a very slight saline Taste. A little of the *first* half Ounce Measure of filtered Fluid had not its Transparency disturbed on the Addition of Solution of *Alkali*; and had no Colour produced on the Addition of *Galls* or *phlogisticated Alkali*. These two half Ounce Measures of filtered Fluid evaporated slowly to Dryness together afforded *five and a half Grains of Crystals*, approaching to a cubical Form, when viewed with a Magnifier; which, from their Figure, Taste, forming when dissolved in Water a pearly Fluid on adding *Solution of Silver* with superabundant nitrous Acid, and scarcely a Disturbance of Transparency with Solution of *Alkali* were judged to be principally *Sea-Salt*.

Three Ounces of boiling hot distilled Water were successively poured on the Sediment upon the Filter, and formed Solutions of a somewhat saline disagreeable Taste; but the *fourth* and *fifth* Ounce of distilled Water successively poured upon Sediment of this filtered Water had no particular Taste, excepting that it was rather earthy. A little transparent Solution of *fixed Alkali* being poured upon a small Portion of the last Ounce of filtered Fluid, after it had stood some Time, occasioned a very slight Disturbance in its Transparency, but with the four other Ounces a very evident Decomposition immediately.

These five Ounces of filtered Solution afforded upon Evaporation about *seven Grains and a half* of a somewhat Needle-like Group of Crystals, that had little Solubility in the Mouth, had a bitter nauseous Taste, and hence were pronounced to be *vitriolic Selenites*.

The Matter upon the Filter was dried and weighed *thirty-one and a half Grains*: It was white, light, very smooth upon the Tongue, and without Taste. A small Quantity of this Substance formed vitriolic Selenites with vitriolic Acid, and muriatic Selenites with marine Acid.

Three-fourths of this Matter left upon the Filter was combined with vitriolic Acid, and after Dilution with Water was filtered and afforded a slightly saline, rather nauseous Fluid, that with *Galls* and *phlogisticated Alkali* did not strike a Colour;

lour; and being evaporated to Dryness left a very small Quantity, two or three Grains, of Sediment that had only a somewhat bitter Taste, and required a large Quantity of Water to dissolve it,

Therefore, this Matter left upon the Filter was concluded to be thirty-one Grains and a half of calcareous Earth.

Remarks. The above are the Kinds and Quantities of Substances contained in the Quantity of Buxton-Water used in the above Experiment, that are manifested by Evaporation, Solution, Decomposition, &c. Our Conclusion, however, should be made always with this Condition, that the Substances shewn by this Experiment are in such Quantity and of such a Kind in the Waters as those solid Matters that exist in the Waters, provided they be not altered in their Quality, in Consequence of the Operations in this Experiment; by which it is possible to decompose earthy Salts, alter Substances so as to produce Magnesia from calcareous Earth, Earth from Alkali, &c.

Margraaf observes that the Quantity of Earth or Sediment is various according to the *Heat* employed; for when the Water is evaporated by boiling briskly, there is more Earth than when it is boiled slowly; hence the Quantity may be different on different Trials. Moreover that we only procure by *one Evaporation* of Water to Dryness *Part* of its solid Matters; for Water after being distilled 40 Times still left Sediment upon further Distillation.

It

It is therefore not a Matter of Wonder that the same or different Persons who have assayed Buxton and other Springs, should have found *different Quantities*, and sometimes *different Kinds* of Matter left after Evaporation, although the Experiments were performed with equal Accuracy, and, perhaps, in the same Manner; and although the Water does not vary at different Times either in the Quantity or Quality of its Impregnations. Supposing, however, the Substances shewn by *any* of the above cited Experiments to be the *Sort* and *Quantity* of solid Substances contained in Buxton-Water, we may justly infer, *that this Spring has no peculiar Power of removing or preventing Diseases of which the solid Matter it contains are the Occasion, according to any known Properties of them in the Quantity necessarily exhibited when this Water is applied.*

It has been well known that Buxton and Matlock-Waters, like Springs flowing from Lime-Stone Beds in general, incrustate the Kitchen Utensils in which they are boiled. I accordingly availed myself of the Opportunity of procuring a large Quantity of Sediment deposited during boiling from these Waters by beating off the stony Crust formed on the Inside of Tea Kettles employed at Buxton and Matlock, for the Purpose of satisfying myself further concerning the Properties of the solid Matters contained in these Waters that are procured by Evaporation, or precipitated by a boiling Heat.

Exper,

Exper. XXXV. The earthy Matter deposited by boiling *Buxton-Water*, and found incrustating the Tea-Kettles, examined in this Experiment, was of a *gray* or *light brown Colour*, in *hard Cakes*, *gritty* to the Palate, *insipid*, and of a *close Texture*.

The Matter found adhering to the Sides of Tea-Kettles after boiling *Matlock-Water*, and used in this Experiment, was of a *Snow-white Colour*, *soft*, and *smooth*, *had no Taste*, was much *lighter* than the former, and *readily crumbled to Powder* under the Fingers. There is, I am told, this Difference of Colour and Texture uniformly between *Buxton* and *Matlock-Water*, with Respect to the Sediment deposited by boiling. And I am also informed, that the calcareous Matter incrustating Vessels in which Water in general is boiled, is never like that from *Matlock-Water* in Colour and Texture.

Two Ounces of each of the above Sediments reduced to Powder were separately exposed in a Sand-heat for several Days, with four Ounces of *distilled Water*, and then filtered.

This filtered Fluid had only an earthy Taste. Galls, and phlogisticated Alkali added to a small Portion of it, did not strike any purple or black Colour, or produce any coloured Precipitation. With Solution of Lead in nitrous Acid with redundant Acid, and with fixed Alkali, it was rendered turbid, and on standing, deposited a Sediment; being evaporated to Dryness, it afforded a Grain and a half of Sediment from each Ounce
of

of evaporated Fluid. This Sediment had a bitter Taste: a Part of it only dissolved in mineral Acids.

A Part of this Matter incrustating Vessels is soluble in muriatic Acid, with which it forms muriatic Selenites; and the Part not dissoluble by this Acid appears to be vitriolic Selenites.

Powder of Galls added to recent Solution of this Sediment in vitriolic Acid diluted with Water, either produced a purple, black, or blue Colour, alone, or on the Addition of fixed Alkali to the Galls and Solution.

Therefore, the *Matter deposited by boiling Buxton and Matlock-Water for Infusions of Tea does not contain any neutral or metallic Salts, but only calcareous Earth and vitriolic Selenites.*

It has been shewn, p. 282, that this Deposition does not arise from Gas extricated, which was the Menstruum of calcareous Earth in the Water, but from the Evaporation of the Water, by which Part of the Solvent of this Earth is carried off, and the remaining Fluid having more Substances than it can retain in Solution, calcareous Earth is precipitated, and also vitriolic Selenites; both of which Substances are soluble only in a very small Quantity in Water: But the other Matters, being more soluble in Water, and contained therein in smaller Quantity, by the mere Evaporation from Water boiled for Kitchen Uses, are rarely or never precipitated, and consequently not found making a Part of the earthy Coat

Coat of the Inside of Vessels used to boil Water (*n*).

The three last Experiments were as decisive as any I could employ to discover the Substances left by Evaporation, and the Quantity of each of these Substances; but because diluted Solutions of neutral, earthy, and metallic Salts are apt to decompose, and thereby lose their Acid by Evaporation, it was next enquired, *whether any Acid was carried off by exhaling Water to Dryness.*

Exper.

(*n*) It has been mentioned, p. 310, that *Dr. Higgins* found the Substances here related, in a different Proportion from that found in our Experiments, but yet not such a Difference as is at all to be wondered at, for Reasons before given; and, for the same Reasons, it is very possible there may be some Difference in the *Kind*, as well as *Quantity*, of Substances discovered on Evaporation; accordingly, this professed and celebrated Chymist says, A Gallon of Buxton-Water left upon Evaporation *a Grain and a half of marine Salt of Magnesia*, which might be occasioned by the Conversion of Part of the Alkali of the Sea-Salt into Magnesia during the Experiment, as happens upon other Occasions; and that a Gallon of this Water contains $\frac{1}{20}$ of a Grain of *Iron combined with acidulous Gas*. I can account in no other Way for this last Substance than by supposing that the Specimen examined by this Gentleman, contained a minute Portion of this Metal *accidentally* suspended in the Water, which, if taken from the Bath, might readily happen, because of the Iron Rails within the Water of the Bath. As to its being combined with Gas, the probable Mistake in this Respect, has been fully shewn in various Parts of this Work. It would be extraordinary indeed, that in many decisive Experiments

Exper. XXXVI. I added such a Quantity of *pure fixed Alkali* to *four Quarts of Buxton-Water* as was more than sufficient to decompose any earthy or metallic Salts dissolved therein. After allowing this Mixture to stand a sufficient Time, the clear Water was decanted and filtered; this filtered Fluid was distilled in a Glass Retort in a *gentle Heat*, and a Piece of Paper stained with *Archill* was fixed to the Mouth of the Retort so as to be exposed to the Vapour passing into the Receiver. During the Evaporation in this Manner to Dryness the Paper only became of a *deeper purple Colour* than before, and the Matter left after Evaporation, consisted of three Things, *Sed-Salt, vitriolated Tartar, and fixed Alkali.*

As nitrous Acid combined with Alkali or Earth has been said to be contained in these Waters, I shall relate, in particular, that Paper dipped into a Solution of this Sediment, and after drying ex-

periments which I have related, these two Substances should not have been met with, had they existed naturally in the Water; in particular, see *Exper. XI, XII, XIII, XIV, XXXIII, XXXIV, and XXXV.*; and because we should expect the Heat of boiling Water to decompose muriatic Salt of Magnesia, thus deposit its Earth, and detach its Acid, in *Exper. XXXV.* Whether these Substances do, or do not exist in Buxton-Water, is of no Consequence in the Quantity mentioned, with Respect to the Practice of Physick: I recommend, however, the Reader to consider and determine for himself whether the Experiments here made were adequate to the Detection of these Substances, had they there existed.

posed

posed to the Flame of a Candle, did not burn like a Match made by immersing Paper into a Solution of Salts with nitrous Acid existing as an Element in their Composition.

I was not able to determine, with any Precision, the Quantity of each of these Substances, on Account of the Mixture of Alkali with them, which could not readily be separated from the neutral Salts; but by Estimation it could not much, if at all, exceed the Quantity of neutral and earthy Salt, to wit, *Sea-Salt* and *vitriolic Selenites* formed upon Evaporation in Exper. XXXIV. p. 310.

In this Experiment we should expect to find, upon Evaporation, any Acid combined naturally with Earth or Metal in the Water united to the Alkali added to the Water, forming therewith a neutral Salt according to the Nature of the Acid, as well as the neutral Salts of this Spring. The vitriolated Tartar was formed by the vitriolic Acid of the Selenites decomposed by the Alkali added to the Water, and the Sea-Salt might be this neutral Salt impregnating naturally these Waters, according to Exper. XXXIV: but considering the *Quantity of the neutral Salts* here left upon Evaporation, it is not probable that any earthy or metallic Salt was decomposed by the Alkali, and thereby formed neutral Salts, excepting the vitriolic Selenites; and as no *Redness* of Colour was produced of the Paper exposed to the Vapour arising from this Mixture, it seems to be proved

proved by this Experiment, that *Buxton-Water* does not contain any earthy or metallic Salts, excepting vitriolic Gypsum.

Exper. XXXVII. It did not appear probable, that these tepid Waters contained any *phlogistic Matter* because they had *no Smell*, p. 154, and *did not tarnish Silver*, p. 229. But to satisfy myself concerning this Fact, I fixed a Shred of writing Paper that had been dipped in a Solution of *Sugar of Lead* in Water and afterwards dried, in the preceding Experiment so as to be exposed to the Vapour of the Water during Distillation, as well as the Piece of Paper dyed with *Archill*.

This Paper, which had been immersed in Solution of *Saccharum Saturni*, neither before nor during the Evaporation was at all coloured until the Luting, composed of vegetable and animal Mucilage, was sensibly burnt by the Degree of Heat to which it was exposed in this Experiment, at which Time this Paper was of an *Orange-brown*, and afterwards of a *blackish or Lead-Colour*.

Phlogiston arising from any Substance is frequently announced by the brown or blackish Colour produced of Paper that has been dipped in Solution of the Sugar of Lead, as above-mentioned; by which Means, as I have already observed, I have discovered the Escape of *phlogistic Matter* both before and during the Putrefaction of animal Matter, as well as by immersing polished Silver in the Mass to be putrefied.

In

In the above Experiment, the Colour was not apparently produced by the Separation of Phlogiston from Water, but from the luting during its Destruction by Heat.

Conclusion of PART II.

I shall now close the *Second Part* of this Work, in which, among other Things, we are instructed :

I. *By the immediate Application of Buxton-Water to the external Senses and by Instruments*, p. 150 to 173, that it does not contain any Impregnation evident to the external Senses, excepting, in a very unusual Form and Quantity, permanent Vapour, which is not Gas, any Vapour that has a Smell, or Air; or only a Part of it is this last Vapour;—that if it be impregnated with other Matters it contains a smaller Quantity of them than common Spring-Waters;—that its Heat exceeds that of the interior Part of the Earth and of ordinary Springs, which are of the Temperature of about 48 or 50°, inasmuch as this Water is about 81°; and common Springs excite the Sensation of Cold, but Buxton-Water feels rather tepid.

II. *By Means of MIXTURE*, p. 173 to 231, that the tepid Water of Buxton does not contain any Acid, excepting Gas, (and that only according to a Test afterwards shewn to be perhaps erroneous) or any Alkali;—that it contains Acid of Vitriol and marine Acid combined probably either with Alkali or Quicklime, and Gas combined with Quicklime, or with

the Compound of Gas and Quicklime; also Quicklime united with another Acid besides Gas;—that it does not contain Magnesia or metallic Salt;—it is impregnated with permanent Vapour, a Part of which may probably be Air: and it contains no phlogistic Substance.

III. By Means of HEAT it appears, p. 231 to 321, that this *TEPID WATER* contains about $\frac{1}{64}$ of its Bulk of permanent Vapour, or four Ounce Measures to four Ounce Measures and a half of permanent Vapour (measured when of the mean Heat, and under a moderate Pressure of the Atmosphere) in 16 Pints of Water, a Part of which Substance is Air: But the Kind of Vapour with which this AIR is mixt was not evident, excepting that it was not Gas, or any phlogistic Vapour.

—That *MATLOCK-WATER* contained, in the Quantity of sixteen Pints, three Ounces and a half to four Ounce Measures of Vapour which was found to be AIR.

—And that this Quantity of a *COMMON SPRING-WATER* was impregnated with three Ounces and a half Measure of permanent Vapour that appeared to be Air.—That the Air in these two last Springs rather exceeded Air of the Atmosphere in Purity.

That the Substance which combined with Quicklime on the Addition of Lime-Water to Buxton, Matlock, and common Spring-Waters, and formed therewith a white Precipitation, was Gas; and, estimating the Quantity of this permanent Vapour by the
Quantity

Quantity of Lime-Water that is saturated by a given Portion of this Substance in Spring-Water, Buxton-Water contains about half the Quantity of Gas that is found in common Springs, and rather less than Matlock-Water and other petrifying Springs here examined; that judging of the Quantity of Gas in Springs by the Quantity of Gas that will saturate the Quicklime in a certain Bulk of Lime-Water, as it requires the Gas of fourteen Pints of Buxton-Water, and of about thirteen Pints of Matlock-Water to unite with the Quicklime of four Pints of Lime-Water, and eight Pints of the common Springs examined to unite with the whole of the Quicklime in four Pints of Lime-Water; and as four Measures of Gas are required to saturate the Quicklime in nine Measures of Lime-Water, it appeared that the above Quantities of these Springs contained four-ninths of four Pints, or about twenty-eight Ounce Measures of Gas: That it does not appear we can estimate the Quantity of Gas in Spring-Water by the Weight of the Sediment formed by the Union of the Quicklime of Lime-Water and the Gas of Spring-Water, when this permanent Vapour is only partially saturated, but that when the Gas is precisely saturated it is estimated from the Weight of the Sediment, that seven Pints of Buxton-Water and four Pints of common Spring-Water contain each about four Ounce Measures or six Grains Weight of Gas; that the Quantity of this Gas obtained by decomposing this Compound of Gas and Quicklime is four Ounces and three Quar-

ters to five Ounces and three-fourths Measure of Gas from three Pints and a half of Buxton-Water, three Ounce Measures of this permanent Vapour from two Pints of Spring-Water, and three Ounce Measures of Gas from three Pints and a half of Matlock-Water, and one Pint of Lime-Water, when the Gas in these three Spring-Waters is precisely saturated by Lime-Water; but when this permanent Vapour is not saturated, these Waters afforded seven Ounce Measures of Gas from each Pint of Lime-Water saturated. That the QUALITY of the Gas in these Spring-Waters is the same, with Regard to Degree of Concentration considered as a Species of Acid, as this permanent Vapour extricated from calcareous Earth;—and that the Quantity of Gas may be known in a certain Quantity of Spring-Water by ascertaining the Quantity of Lime-Water that will saturate this permanent Vapour in a determined Bulk of Water; for the Quality of Gas in Springs being the same as that obtained by Art, the Quantity required to saturate a Quantity of Lime-Water equal to that saturated by this permanent Vapour in a certain Quantity of Spring-Water is the Quantity of this Substance in that Quantity of Water.—That the Gas in these Spring-Waters cannot be separated by the Heat of Boiling Water;—that the Conclusion is false, because a Spring-Water contains Gas to the Test of Lime-Water, and deposits calcareous Earth during Exposure to Heat, this Earth is there dissolved by Gas;—that the Water remaining after evaporating

porating any Part of a given Bulk of Spring-Water contains the same Quantity and not more Gas than an equal Bulk of Water before Evaporation;—that the Gas in Buxton, Matlock, and the common Springs subjected to Examination contain Gas combined with Quicklime, or with the Compound of Gas and Quicklime, and not with simple or elementary Water, as hitherto supposed;—and that a Solution of calcareous Earth produced the same Appearances on the Addition of Lime-Water as the above Springs. —That IRON and other Metals were not in general dissolved by Gas in mineral Waters, but by an Acid; and that the spontaneous Decomposition of chalybeate Waters might not, and actually does not, depend upon the Escape of Gas, but upon a different efficient Cause, namely, DILUTION of the metallic Salt with which these Springs are impregnated.—That the tepid Springs of Buxton afforded upon Evaporation $\frac{1}{3840}$ of their Weight, or sixteen Grains of solid Matter in a Gallon of Water, which was Sea-Salt, vitriolic Selenites, and calcareous Earth; that the Quantity of each of these was about one Grain and three-fourths of Sea-Salt, two and an half Grains of vitriolic Selenites, and ten Grains and a half of calcareous Earth;—that the Crust formed on the Inside of Tea-Kettles and other Vessels, after boiling Buxton and Matlock-Water, is calcareous Earth and vitriolic Selenites;—that during boiling or Evaporation by a less than boiling Heat no Acid can be detected to be separated, consequently,

ently, there is no Decomposition by the Heat of boiling Water of any Kind of neutral, earthy, or metallic Salt;—and it was further proved, that this Water contains no Acid excepting Acid of Vitriol, muriatic Acid, and Gas combined with fixed fossil Alkali and Quicklime;—and lastly, that Buxton-Water does not contain any phlogistic Substance separable by Heat and Evaporation.

As common Springs contain the same solid Substances discovered in Buxton-Water, and in much greater Quantity; and as, from the known Properties of these Substances, we have no Reason to expect any beneficial Effects from them in diseased States in the Proportion in which they are contained in these Springs, the Consideration of them may be neglected in Practice, and the peculiar medicinal Qualities of Buxton-Water must be sought for on other Principles.

A Review of the preceding History pointed out, that *this tepid Water* might be particularly powerful in curing Diseases on three Grounds,

I. *On Account of its Purity (o), or small Quantity of Impregnation;*

II. *From its Temperature;*

(o) Concerning the Effects of pure or elementary Water in the Cure of Diseases, perhaps some Facts may be collected from Writings *on the Use of Snow-Water*, which is nearly as pure as distilled Water, and is not a hard Water, or has any Effects dependent upon Nitre, as has been supposed.

III. *In*

III. *In Consequence of the permanent Vapour^{obs.} observed to escape spontaneously from Buxton-Water, p. 152, 153, and which is mixed with Air when separated by Heat, p. 238, 239.*

The History of the Properties of this permanent Vapour that arises spontaneously has been investigated in order to discover whether it had any Effects, or what might be its Powers in diseased States; and as the Experiments and Observations made with this View are numerous, and the Subject is new, copious, and interesting, I have treated it distinctly in the *third Part* of this Work.

END OF VOL. I.

