EXPERIMENTAL

ESSAYS.

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ESSAYS

ON THE FOLLOWING

SUBJECTS:

I. On the Fermentation of Alimentary Mixtures.
II. On the Nature and Properties of Fixed Air.
III. On the respective Powers, and Manner of Acting, of the different Kinds of Antiseptics.
IV. On the Scurvy; with a Proposal for trying new Methods to prevent or cure the same, at Sea.
V. On the Dissolvent Power of Quick-Lime.

Illustrated with Copper-Plates.

By DAVID MACBRIDE, Surgeon.

LONDON:
Printed for A. Millar, in the Strand.
MDCCLXIV.

The wonderful and ſecret Operations of Nature are ſo involved and intricate, ſo far out of the Reach of our Senſes, as they preſent themſelves to us in their natural Order, that it is impoſſible for the moſt ſagacious and penetrating Genius to pry into them, unleſs he will be at the Pains of analyſing Nature by a numerous and regular Series of Experiments, which are the only ſolid Foundation whence we may reaſonably expect to make any Advance in the real Knowledge of the Nature of Things. *Hales.*

THE

PREFACE.

THE general purpoſe of the following eſſays is to ſhew, that there is another principle in matter beſide thoſe which are commonly received; and that it is upon this principle, forming the cement, or bond of union, that the firmneſs, ſoundneſs, and perfect coheſion of bodies, chiefly depend.

It

It being the author's intention to apply this doctrine particularly to medicine, he begins his investigation by tracing the progress of digestion, and shewing that the principle above hinted at is received into animal bodies by the way of the chyliferous canals; and this makes up the subject of the first essay, and of some part of the second.

This point being proved by a number of experiments, and illustrated by some practical observations, he goes on to shew, from experiment also, that animal substances become putrid from the loss of the above-mentioned principle; seeing, that putrefaction is found to arise from the resolution and disunion of the ſeveral conſtituent particles; and offers a new theory for explaining the immediate cauſe of that degree of putrefaction, which often takes place in the living body. Here an opportunity is taken of introducing ſome experiments, in order to determine whether or not putrid animal ſubſtances are to be regarded as alcaline: and it appearing from theſe that ſuch ſubſtances are in reality of an alcaline nature, and that ſome writers of very great note have been mis-led into a contrary opinion, probably from obſerving that alcalies reſiſt putrefaction; he then proceeds, in the third eſſay, to examine, experimentally, the power of antiſeptics in general; and finds that this depends, for the moſt part, on re-

ſtraining

ſtraining the flight of the cementing principle.

An enquiry then commenceth concerning the power of different things to reſtore ſoundneſs and ſweetneſs to ſubſtances already putrid; and it is ſhewn, likewiſe from experiment, that this may be accompliſhed by reſtoring the cementing principle.

This naturally leads to a conſideration of the moſt effectual methods of curing putrid diſeaſes, which is alleged to depend greatly on the application of ſuch things as are known to be capable of furniſhing a large proportion of the principle ſo often mentioned; and this is particularly

cularly exemplied in the cure of the ſea-ſcurvy; a diſeaſe wherein the maſs of fluids is evidently in a ſtate of putrefaction.

In conſequence of this hypotheſis, a propoſal enſues for trying new methods to prevent or cure the ſcurvy, at ſea; and this affords matter for a fourth eſſay, to which is annexed a very accurate account of that moſt deſtructive diſeaſe, extracted from the writings of John Woodall, an old Engliſh ſurgeon, whoſe works ſeem to be but very little known.

The fifth eſſay contains a number of miſcellaneous experiments and obſervations, all tending to a further proof

proof of what had been advanced in the four preceding ones; and concludes with laying down easy and expeditious methods of dissolving in water camphor, and all kinds of resinous substances.

The foundation of the foregoing doctrine having been laid near forty years ago, by the celebrated Doctor Hales, and, of late, much improved by Doctor Black, Professor of Medicine of Glasgow, it will be proper that the reader be thoroughly acquainted with the Analysis of Air, in the first volume of Hales's Staticks; and with the experiments on Magnesia, in the second volume of the Edinburgh Physical and Literary Essays; as also with the experiments

ments made by Doctor PRINGLE, and which are to be found in the Philoſophical Tranſactions, or in the Appendix to that learned phyſician's Obſervations on the Diſeaſes of the Army; the following papers being deſigned as a ſequel to all the three writers juſt now mentioned.

ESSAY

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ESSAY

ESSAY I.

ON THE

FERMENTATION

OF

ALIMENTARY MIXTURES.

The main business of natural philosophy is to argue from phænomena, without feigning hypotheses. NEWTON.

ESSAY I.

ON THE

FERMENTATION of ALIMENTARY MIXTURES.

THE old chemiſts believed, that all the true ſpontaneous changes, or tranſmutations of bodies, were the effects of fermentation; but *Boerhaave*, diſliking ſo enormous an extenſion of terms, reſtrained it within very narrow limits, and would ſuffer nothing to be called Fermentation which did not produce either an ardent ſpirit, or an acid; thus entirely confining it to what are uſually called the *vinous* and *acetous* ſtages, and altogether rejecting the *putrefactive*, as looking on putrefaction to be a quite different proceſs, and no way allied to fermentation.

But this reſtriction, which was meant for the ſake of clearneſs and preciſion, has rather introduced confuſion, with regard to the term putrefaction. This word, in its common acceptation, is always underſtood to imply a plain tendency to deſtruction in bodies, accompanied with every ſign of rottenneſs and offenſiveneſs: and, accordingly, we often meet with it in writers, in this ſenſe, when perhaps, in the very ſame page, we ſhall be told, that the aliment is prepared for nouriſhing the human body by putrefaction; that motion, life, and heat are communicated to the fluids by putrefaction; and that nature throws off morbific matter from the conſtitution by the means of putrefaction.

THE later chemiſts, therefore, who have reduced this branch of natural philoſophy to a more intelligible and methodical ſyſtem, than that of the great man juſt now mentioned, approach nearer to the ancient opinion, and define fermentation to be an "*inteſtine motion, which ariſing ſpontaneouſly among the inſenſible parts of a body, produceth a new diſpoſition, and a different combination of thoſe parts.*" (*Macquer.*)

FROM this definition it is plain, that a great number of the natural changes which daily take place in the animal and vegetable kingdoms, ſhould be looked on as ſo

many

many modes of fermentation; and that, in particular, the digeſtion of our food ought to be regarded as a fermentatory proceſs.

THE experiments already made by the very learned and ingenious Dr. *Pringle* ſeem ſufficient to convince every unbiaſſed reader of the truth of this theory; which, if we conſider the matter with any degree of attention, we ſhall find to be abſolutely neceſſary, in order to bring about that new diſpoſition, and that different combination, of the inſenſible parts of the alimentary ſubſtances which enable the immenſe variety of diſcordant mixtures, that enter the compoſition of our food, to depart ſo far from their original natures as to become one mild, ſweet, and nutritious fluid; for this demands a great deal more than mere mechanical mixture and diſſolution, which is the moſt that the common theories * of digeſtion extend

* Here we muſt except *Hoffman*'s theory; for he inſiſts much on the compleat change that the aliment undergoes in the firſt paſſages; and makes digeſtion a mere fermentatory proceſs; as may be ſeen at large in his

extend to; ſince they do not ſeem expreſſly to require, nor indeed ſuppoſe, ſuch an abſolute change to be wrought, in the firſt paſſages, on the nature of the different kinds of food as would render them ſuſceptible of that firm union, and that ſtrong attraction, by the means of which they become, ſo ſoon, one and the ſame ſubſtance with the body into which they are received.

IT alſo appears pretty plain, from Dr. *Pringle*'s experiments, that there is ſomewhat generated, or ſet free, during the *firſt ſtage* of the fermentation of animal and vegetable mixtures, which hath a power of correcting putrefaction. But, in order to obtain ſtill further proofs concerning this particular point, as well as to gain a more thorough knowledge of fermentation in general, I determined to repeat ſome of the doctor's experiments, and to try ſuch others as I thought had the greateſt tendency towards an illuſtration of both.

his chapter *de Alimentorum Solutione & Salivæ Uſu*, and the three ſucceeding ones.

To

Table I. Of ALIMENTARY MIXTURES.

Mixtures of	At the end of 6 hours.	At the end of 22 hours.	At the end of 30 hours.	At the end of 46 hours	After 54 hours.	At the end of 4 days.
(1) Bread and water.	Shews no figns of inteftine motion.	Still remains perfectly quiet.	Still at reft.	Still at reft.	Still at reft.	A fournefs now perceivable.
(2) Bread, mutton, and water.	Fermentation fairly begun; fmell of the mixture perfectly fweet.	Fermenting now very brifkly.	Brifk; the fmell of the mixture perfectly fweet and a little pungent.	Brifk and fweet; much froth at top.	Brifk and fweet.	Fermentation appeared to be now very near over; liquor fweet, both to the fmell and tafte.
(3) The fame, with frefh juice of lemons.	In brifk fermentation; perfectly fweet; fmell of the lemon juft perceivable.	Very brifk; immerfed a fmall bit of putrid mutton in this mixture.	Brifk; no fmell now perceivable in the bit of putrid mutton, but that of the mixture.	Still fermenting; the liquor clear and fweet; removed the bit of mutton and hung it up to dry, it being perfectly fweet.	Motion ftopt; the bit of mutton dried and fweet.	Diftilled this mixture; an almoft infipid phlegm, with rather a vinous, than an acid tafte, was the produce.
(4) The fame, with fpinnage.	In brifk fermentation; a heavy kind of fweetifh fmell, not unlike that of the fenugreek feed.	Very brifk; fufpended a little bit of putrid mutton in the phial, fo as not to touch the mixture.	Brifk; no fmell in the bit of mutton, but that of the mixture.	Fermentation appeared to be almoft over; liquor clear and fweet; removed this, and the phial with lemon-juice, to a cool place, and corked them clofe; hung up the mutton.	Motion ftopt; the bit of mutton dried and fweet.	The fmell of this mixture, before diftillation, was a little inclinable to the cheefey, and the phlegm obtained by diftillation had a fmall degree of pungency, with the fame rancid flavour.
(5) The fame, with water-creffes.	Motion not fo brifk as in the two laft, but confiderably more fo than in the fimple mixture; fmell of the herb but barely perceivable.	Very brifk; poured half an ounce of frefh ox-gall into the phial.	Not fo brifk as in the morning; perfectly fweet.	Liquor clear and fweet; ftopt the phial well, and removed it to a cool place; the mixture tafted a little of the gall.	Motion ftopt.	This mixture was fweet, with the fenugreek flavour.
(6) The fame, with fome *putrid* animal liquor.	Motion greater in this phial than in any of the others, with a thick fcum and froth on the furface; not the leaft ill fmell to be perceived, tho' the putrid liquor was exceedingly offenfive when firft added.	Very brifk; tho' in the coldeft place of all the phials. (Every one of the mixtures were now perfectly fweet, and had loft the peculiar fmell of the herbs, &c.)	Brifk and fweet.	Still in brifk fermentation, and fweet.	Removed the phial, and ftopt it clofe; fermentation now almoft over.	The mixture was now upon the turn; a little fournefs juft perceivable.

To face page 5.

To fulfil thefe Intentions, I made up the fix following mixtures:

1. Bread and water.

2. Bread and boiled mutton, beat up with the requifite quantity of water.---- This was called the fimple fermentative mixture.

3. Four ounces of the fimple fermentative mixture, with two drachms of frefh lemon-juice.

4. Four ounces of the fimple mixture, beat up with an ounce of fpinnage.

5. Four ounces of the fimple mixture, with an ounce of green water-creffes.

6. Four ounces of the fimple mixture, with two drachms of a very fetid liquor that lay about putrid mutton.

THESE mixtures, being put into phials not clofely ftopped, were all placed in a moderate degree of heat, on the top of a fand furnace, wherein a retort was at work, on a procefs which required a continual fire for three or four days.

IN order to have a fynoptical view of the progrefs from time to time, I formed the annexed table, No. I. wherein I minuted down the feveral appearances, exactly as they fhewed at each examination; but the general progreſs of the five mixtures that fermented was as follows:

IN three or four hours the inteſtine motion was evident; and ſoon after all the ſolid part of the mixtures roſe to the top; bubles of air, and a thick ſcum, formed on the ſurface; a vapour, with ſome degree of pungency, and which extinguiſhed fire, now began to diſcharge itſelf, and the peculiar ſmell of the ſeveral ingredients having gradually gone off, a ſweetiſh kind of flavour, in ſome of the mixtures not unlike that of fenugreek ſeed, ſucceeded to it; while the motion becoming very briſk, little pieces of the ſolid matter every moment fell to the bottom of the phials.

THIS inteſtine motion continued for the periods expreſſed in the table; and by the time that it had ceaſed, the mixtures were clear, great ſhare of what formerly floated having now fallen down; they were alſo perfectly ſweet, and ſuch of them as were committed to diſtillation, ſent over a water, or phlegm, with a ſlight degree of pungency, and of the ſame ſweetiſh ſmell of the mixtures, excepting one, that had a little of the rancid, or cheeſy flavour.

THUS

THUS we ſee that the appearances, during the time that theſe mixtures were fermenting, are exactly like thoſe which attend the working of the ſweet vegetable liquors; and the difference ſeems only to lie in the product of the *firſt ſtage*---which we find does not, like theſe liquors, yield an ardent ſpirit by diſtillation; altho' there are ſome reaſons for believing that mixtures of animal and vegetable ſubſtances, if fermented together in large quantities, would produce a liquor of an intoxicating quality.

TRAVELLERS of good credit aſſure us, that there are among the great variety of *Tartar* tribes inhabiting the wilds of *Siberia*, ſome who have methods of obtaining an intoxicating liquor from milk, which, in all probability, is brought to ferment by the admixture of ſome putrid animal ſubſtance, which Dr. *Pringle* finds (and the ſame thing may be ſeen in the foregoing table, at No. 6) to encreaſe very powerfully the tendency to fermentation, either in milk, or in the common fermentative mixtures. And others of theſe northern nations make themſelves drunk with a moſt nauſeous liquor, made by allowing fiſh and water to ferment in holes dug in the earth, and lined with the bark of the birch-tree.

HOWEVER, until this matter be more fully proved, and that it can be plainly ſhewn that theſe mixtures do produce an intoxicating liquor, or an ardent ſpirit, it will be proper, as well as more clear and comprehenſive, to denominate the *three* ſtages of fermentation, either ſimply, *firſt*, *ſecond*, and *third*; or, if it be more agreeable, *ſweet*, *ſour*, and *putrid*; and characteriſe them by their ſeveral products: The *firſt*, or *ſweet* ſtage, being two fold, as yielding, 1ſt. a ſweet, agreeably pungent, *inebriating* liquor; or, 2dly, a ſweet (*i.e.* ſweet, as oppoſed to ſour, and putrid) liquor, which is *not inebriating*. The *ſecond*, or *ſour* ſtage, as turning the ſubject manifeſtly ſour, and yielding an acid phlegm upon diſtillation. And the *third*, or *putrid*, when the texture of the ſubſtance fermented is fairly deſtroyed, and having loſt its original characters of taſte, colour, and ſmell, it becomes fetid, rotten, and offenſive; and if committed to diſtillation, yields neither an inflammable ſpirit, nor a ſweet phlegm, nor an acid; but a ſharp pungent

liquor,

liquor, being a ſolution of a volatile alcaline ſalt, nearly ſimilar to that ſalt which may be obtained, by the force of violent heat, from animal ſubſtances, without ſuffering them firſt to become putrid *.

THIS diviſion, and manner of denomination, will be found to correſpond with appearances, and will perhaps comprehend all fermentable ſubſtances whatſoever; whereas the terms *vinous*, *ſpirituous*, and *acetous*, can, with ſtrict propriety, be applied to the fermentation of the ſweet vegetable liquors only, which yield, in their

* When it is ſaid, that a volatile alcali may be obtained from putrid ſubſtances by diſtillation, it is to be remarked, that whoever makes the experiment, muſt not ſuffer ſuch ſubſtances to remain too long before they are diſtilled, unleſs kept in cloſe veſſels; becauſe the volatile alcali, which is the offspring of putrefaction, is diſſipated as faſt as it is generated, inſomuch that, at length, nothing is left behind but an inſipid water, or a ſolid matter, being an earth ſimilar to common mould.

And it is in this way, that ſtinking water, after ſome time, becomes ſweet; the volatile alcali, generated by the putrefaction of the animal and vegetable ſubſtances at firſt contained in the water, being, after a while, entirely diſſipated, leaves the remainder without any diſagreeable ſmell.

firſt

firſt and ſecond ſtages, an inebriating, inflammable ſpirit, and vinegar.

THE reader, upon looking into the table, will find, that there were two little bits of putrid mutton put into two of the phials, while the mixtures were fermenting; and that theſe bits of fleſh were rendered ſweet. This was owing to the action of the vapour, ſet free during the fermentation; and, as will be ſhewn at large in another place, the vapour from the ſweet vegetable liquors produceth the very ſame effect.

IT was found, that the vapour from the mixtures agreed likewiſe in another circumſtance with the *Subtile Gas*, as it was termed by the old chemiſts, namely, that of extinguiſhing fire; and, I dare ſay, it would alſo ſuffocate animals. But notwithſtanding that this vapour, if applied in large quantity to the lungs, might prove ſo very pernicious, yet it does not by any means follow, that it muſt neceſſarily produce the ſame deadly effect, if pent up in the bowels: We may be very certain that it does not; for if that were to be the caſe, people would be in very great dan-

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ger after almoſt every meal they eat, ſince it is evident, that the vegetables moſt commonly uſed as a part of our food, when mixed, either with fleſh, or with the native animal juices, actually do raiſe a fermentation in the firſt paſſages, which muſt of courſe produce a great deal of this active vapour.

THERE is not ſufficient ground, therefore, for acquieſcing in a theory which hath ſometimes been taught, attributing the ſudden death of people who had eaten largely of fruit, or the like, to the action of this ſubtile ſpirit, as ſuppoſing it to benumb and deprive the nerves of all power and influence.

IF this hypotheſis were not ill founded, perſons in theſe circumſtances, who have been reſcued from death by the timely exhibition of an emetic, would not recover themſelves ſo immediately as they are known to do; which ſhews that the diſtreſs muſt have been occaſioned merely by the over diſtenſion of the ſtomach; for had the pernicious vapour once fairly made its deadly impreſſion, emptying the ſtomach would avail but little; and, if the party recovered at all, it would be but ſlowly,

and

and not without much consequent relaxation, and weakness of the paralytick kind *.

THEREFORE, instead of imagining this active and subtile vapour to be productive of any harm in the body, it will appear hereafter, that there are very strong reasons for believing, that it is the *grand preserver* of animal fluids from *putrefaction*; that it attempers acrimony; is a *principal agent* in *nutrition*; and, perhaps, contributes somewhat to animal heat †.

SINCE things of such different natures as bread, lemon-juice, spinnage, and water-cresses, all run with equal facility into fermentation, we might almost venture to conclude that any vegetable, when mixed with an animal substance, and furnished with the requisite quantity of water, will likewise ferment. But to try this matter still farther, in a few days after going thro' the foregoing experiment, I mixed up no less than twenty-one of this kind of mixtures,

* Vide *Boerhaavii Elementa Chemiæ*, tom. ii. p. 180 & 181.

† Dr. *Pringle* found the thermometer raised three degrees by a fermenting mixture of bread, beef, and saliva; so that there appears to be some ground for this conjecture.

tures, moſt of them being in quantity about four ounces; *viz.*

1. Bread and water.
2. The ſame, with two drachms of ſaliva.
3. Bread and water, with green herbs.
4. The ſame, with two drachms of ſaliva.
5. Flour and water.
6. The ſame, with two drachms of ſaliva.
7. Green herbs and water.
8. The ſame, with two drachms of ſaliva.
9. Flour and water, with green herbs. (The green herbs were ſpinnage, water-creſſes, and onions, equal parts, beat up together.
10. The ſimple fermentative mixture. (*i. e.* Fleſh meat, bread, and water.)
11. Flour and fleſh meat, with water.
12. The ſimple mixture, with about an ounce of green water-creſſes.
13. The ſimple mixture, with an ounce of ſpinnage.
14. The ſimple mixture, with an ounce of green onions.
15. The ſimple mixture, ſix ounces; lemon-juice, one ounce.
16. The ſimple mixture, ſix ounces; freſh wort, one ounce.

17. The

17. The ſimple mixture, ſix ounces; ſtrong ſolution of ſugar, one ounce.

18. The ſimple mixture, ſix ounces; ſtrong ſolution of honey, one ounce.

19. The ſimple mixture, ſix ounces; vinegar, one ounce.

20. The ſimple mixture, ſix ounces; brandy, one ounce.

21. A ſimple fermentative mixture, made with ſalt beef.

THESE mixtures were all made up at night, and lay fourteen hours before they were placed in a ſand bath, where it was intended to have kept up a moderate degree of heat.

THEY were all placed in the ſand at ten o'clock in the morning, being then, every one of them, perfectly ſweet.----The fire was now ordered to be kindled: In ſix hours I went to ſee how things were going on, and was greatly vexed and diſappointed to find that the fire, through inattention of the ſervant entruſted with the care of it, had been made ſo ſtrong that the mixtures were all in a much fairer way to boil than to ferment. I therefore removed the phials from the ſand, and reckoned all this as ſo much loſt labour, not expecting, after having

Table II. Of ALIMENTARY MIXTURES.

MIXTURES of	1.	2.
(1) Bread and water.	No figns of inteftine motion.	Appears not to have ftirred at all; four.
(2) The fame, with about ℥ij of faliva.	No figns of motion.	Appears to have fermented, there being froth at top; now at reft, and quite fweet.
(3) Bread and water, with fome green herbs.	No figns of motion.	Had *not* ftirred; fmell of the herbs ftrong.
(4) The fame, with ℥ij of faliva.	Motion fairly begun.	Had fermented; now at reft; fweet, of the fenugreek fmell.
(5) Flour and water.	No figns of motion.	Had *not* ftirred; not four.
(6) The fame, with ℥ij of faliva.	No figns of motion.	Had fermented; now at reft; fmell fweet, like the fenugreek.
(7) Green herbs and water.	No figns of motion.	Had *not* ftirred; fmell of the herbs ftrong.
(8) The fame, with ℥ij of faliva.	Motion beginning.	Had fermented; fcum on the furface; fmell fweet, like the fenugreek.
(9) Boiled mutton, with fome green herbs.	No figns of motion.	Had undergone the fermenting motion, tho' now at reft, the mutton and herbs having all rifen to the furface.
(10) Bread and boiled mutton, with water.	Motion juft perceivable.	Still in motion; great fcum at top; fmell fweet, like the fenugreek.
(11) Flour and boiled mutton, with water.	Motion fairly begun.	Still at work; the fmell perfectly fweet.
(12) Bread and mutton, with water-creffes.	Motion begun; fmell of the herb not perceivable.	Had wrought brifkly; now on the decline; fmell of the fenugreek ftrong.
(13) The fame, with fpinnage.	Motion begun; fmell of the herb not perceivable.	Still at work; fmell fweet, exactly like the preceding.
(14) The fame, with green onions.	Motion fairly begun; fmell of the onion yet ftrong.	Did not appear to have wrought much; fmell of the onion ftill ftrong.
(15) The fame, with juice of lemons.	No motion begun.	Had fermented; fmell of the lemon entirely gone; mixture fweet.
(16) The fame, with frefh wort.	Motion fairly begun.	Not yet quite at reft; fweet; peculiar fmell of the wort now loft.
(17) The fame, with fugar and water.	Motion begun; not fo brifk as the preceding.	At reft; fourifh, with a little of the cheefey fmell.
(18) The fame, with honey and water.	Motion begun, and as ftrong as in the mixture with the wort.	Mixture fweet, and at reft; appears to have wrought pretty brifkly.
(19) The fame, with vinegar.	No motion.	Does not appear to have ftirred.
(20) The fame, with brandy.	No motion.	Does not appear to have ftirred.
(21) Salt beef and bread, with water.	No motion.	Appears to have wrought, the lighter parts, and much fcum, being on the furface; fweet, like the mixture with the frefh meat.

To face page 15,

ing been ſo much over-heated, that they would ferment at all. However, in ſix hours more, I again viſited them, and finding ſome of the mixtures in motion, I marked down the ſeveral appearances, exactly oppoſite to each, as may be ſeen by looking into the ſecond table, and firſt column.

BUT as I imagined that the natural courſe of the fermentation muſt have been diſturbed from the firſt ſetting out, on account of the extraordinary heat, I was not very ſolicitous about a minute and accurate obſervation of the progreſs; more eſpecially as I intended to take the trouble of mixing up an entirely new ſet. I therefore did not go near the place where the phials ſtood for two days, leaving them all this while in the cold; but going then to examine them, was ſurprized to find that notwithſtanding their being unaſſiſted by heat, yet moſt of them had fermented, and ſome of them were ſtill in motion. I therefore minuted down, in the table, the appearances particularly belonging to each, as they ſtand in the ſecond column.

SOON after this time, I engaged in a courſe of experiments, with a view of diſcovering the relative quantity of air, ſet ſree from different compounds, and therefore found it unneceſſary to repeat all the experiments of the ſecond table, as I had once intended; but at the end of a fortnight I went to the Elaboratory, where the phials had been left, and found ſome of them ſour, ſome putrid, others muſty, and ſome of the mixtures ſtill ſweet; but as I had not the table with me, did not minute them down particularly.

Now ſince it appears, that theſe mixtures ferment ſo very readily, even when unaſſiſted by heat, how can there be any doubt but they muſt run through the ſame proceſs when they are received into the warm ſtomach, and are put in motion by the fermentative power of the ſaliva? which not only the authorities of *Hoffman* and *Boerhaave*, but likewiſe the experiments juſt now recited, ſhew to be poſſeſſed of this power in a very eminent degree; as may be plainly ſeen by comparing the numbers 1, 3, 5, and 7, of the ſecond table, with the mixtures numbered 2, 4, 6, and 8, in the ſame table.

THE progreſs of digeſtion in the human body may be traced in the following manner.

THE food, divided by *maſtication*, and mixed with the *ſaliva*, is fitted for beginning the *inteſtine motion* very ſoon after the alimentary ſubſtances are received into the ſtomach; this motion being raiſed by the temperate warmth of the place, by the remains of the former meal, and by the fermentative power of the *ſaliva* and *gaſtric juice*. The firſt effect of this motion, is, to throw up to the ſurface the ſolid part * of the alimentary mixture; which ſoon again ſubſiding, the air which buoyed up the ſolid particles having eſcaped, the union of theſe is preſently deſtroyed, and the whole mixed with the digeſtive fluids; this intimate mixture being much aſſiſted and completed by the agitation cauſed by the periſtaltic motion, by the alternate preſſure of the diaphragm and muſcles of the abdomen, and by the continual pul-

* Every perſon muſt have perceived, at one time or other, that after a hearty meal, if an eructation ſhould by any means be excited, ſome of the ſolid part of what had been taken into the ſtomach comes back towards the mouth. If the meal conſiſted of a mixture of animal and vegetable food, it is part of the vegetable that always riſes; which correſponds exactly with the appearances in the phials, where I conſtantly obſerved the vegetable part of the mixture to riſe firſt.

ſation of the neighbouring large blood veſſels.

THUS the aliment paſſeth on from the *ſtomach* into the *duodenum*, and through the long tract of the *ſmaller inteſtines*; where having its original nature entirely changed, by the admixture of the *bile* and *pancreatic* juice, but *chiefly* by the fermenting motion, which ſtill continues going on, the ſeveral kinds of food are all blended and mixed together into one mild, ſweet, and nutritious liquor, now in briſk fermentation, called *chyle*. This *chyle* *,

* That the chyle is a liquor in a ſtate of actual fermentation may be proved from obſerving the changes that happen in milk, which is nothing but chyle, a very little animalized. "The acidity which milk naturally contracts in a few days, muſt be conſidered as the effect of a fermenting motion, which diſcovers in that liquor an acid that was not perceptible before; this, properly ſpeaking, being an acetous fermentation, which the milk paſſeth through in its way to putrefaction, which ſoon follows if it be expoſed to a hot air." *Macquer*.

Hence the reaſon why a diet conſiſting entirely of milk is ſo apt to create a ſourneſs in the firſt paſſages; for being in actual fermentation when taken into the body, if it be not very ſoon carried through the ſmaller inteſtines, the ſecond ſtage will come on. And here we may perceive the neceſſity that there is for the agitation and exerciſe of infants at the breaſt.

ſo

ſo compounded, is taken up by millions of little abſorbent veſſels, fully charged with the ſubtile, active, antiſeptic ſpirit, and conveyed to the *receptacle*; where, and in the *thoracic duct*, it is further mixed with great quantities of *lymph*, and, after no very long courſe, is poured into one of the large veins, in order to communicate its inteſtine motion to the blood, to prevent the natural tendency of the fluids to putrefaction, and to repair the waſte which our bodies, every moment of our lives, muſt neceſſarily ſuſtain.

THE groſs, inſoluble, and fecal parts of the aliment being thrown off from ſuch as were finer and more nutritious, paſs on to the larger inteſtines; where, at their very firſt entrance, they meet with a ſtore of ſour and putrid ferments, lodged in the *cæcum* and *appendicula vermiformis*, which, in a very ſhort time, convert the alimentary remains into their own nature; and thus communicate a degree of ſharpneſs which muſt ſoon ſtimulate the inteſtines to a contraction, that ends in expelling theſe uſeleſs and offenſive matters out of the body.

ALL this is to be underſtod of the digeſtive proceſs, as carried on in perſons who have the happineſs to enjoy a perfectly ſound ſtate of health; but in valetudinary people, of weak and relaxed habits; in pregnant women, whoſe ſtomachs, and a great ſhare of the ſmaller inteſtines, are thruſt out of their natural ſituations; and in people whoſe inclinations or profeſſions oblige them to lead ſedentary lives; the food is often detained ſo long in the firſt paſſages, as to paſs on to the *ſecond* ſtage of alimentary fermentation; and then it produceth a moſt auſtere acid, which however is exactly in the ſame ſtate with a foreign acid, for the lacteals will admit none of it: It is therefore of neceſſity accumulated, and proves the cauſe of ſour eructations, heartburning, vomiting, griping, or looſeneſs, according to its quantity, degree of ſtrength, and place where lodged.

THIS ſour acrimony, when once eſtabliſhed, is not to be removed without ſome difficulty; for ſome of it always lying in the firſt paſſages, ſerves as a leaven to act on every thing taken into the ſtomach; and thus, hurrying the alimentary mixture through the firſt ſtage, and immediately bringing on the ſecond, renders the food incapable of furniſhing a nutritious chyle,

chyle, as not being thoroughly fermented, and alſo wanting a ſufficiency of the true invigorating ſpirit; all which plainly appears from the paleneſs and languid diſpoſition of thoſe people who are much afflicted with a ſourneſs in the ſtomach. And hence the reaſon why exerciſe, eſpecially riding, (which agitates the viſcera, and prevents the too long ſtay of the aliment in the firſt paſſages) and the aromatic gums and bitters, together with chalybeates, (which produce the ſame effect, by their ſtimulating and ſtrengthening qualities) prove ſo very ſerviceable in all theſe caſes.

BUT if the aliment, either from its own very putreſcent nature, or from its too long ſtay within the confines of the ſmaller inteſtines, ſhould ever proceed on to the *third* ſtage of fermentation, it will then become ſo offenſive as to occaſion immediate efforts to throw it off, if the quantity of putrid matter be in any degree conſiderable; but if that ſhould not be the caſe, it may then remain in the body, and gradually inſinuate itſelf into the maſs of fluids, until it accumulates to ſuch a height as to throw the whole ſyſtem into a confusion, which must terminate either in the concoction and expulsion of the offending matter, or in the destruction of the machine itself: For any thing putrid is totally incompatible with the perfect well-being of an animal body; and therefore *Putrefaction* cannot by any means be admitted to a share in the process which is to furnish this body with nourishment and support.

AND here we may remark the admirable œconomy of nature, in guarding so effectually against this hostile putrefactive principle, by so ordering the process of alimentary fermentation, that, of the two first stages, the one should have the property of producing a spirit of such amazing activity that it must pervade the most intimate recesses of the vascular system; and that the other stage should yield an acid, which, if it hath not in itself all the penetrating power of the antiseptic spirit, shall yet be enabled to correct the putrefactive tendency of whatsoever it comes into contact with, and thereby render it mild and inoffensive.

THIS spirit, or vapour, which is set free from the mixtures during their fermentation

mentation in the firſt paſſages, which enters the compoſition of the *chyle*, and with that fluid is tranſmitted to the *blood*, there to prevent or correct the putrefactive *diatheſis*, appears to be chiefly the *Fixed Air* of the alimentary ſubſtances; but as this matter cannot be fully explained, nor thoroughly underſtood, without a knowlege of the properties of *air*, when conſidered as a conſtituent principle of bodies, I muſt reſerve the further illuſtration until it be ſhewn what thoſe properties are.

mentation in the first passages, which converts the composition of the Chyle, as when that fluid is transmitted to the blood. There to prevent or correct the putrefactive tendency, appears to be chiefly the province of the alimentary substances; but as this matter cannot be fully explained, nor thoroughly understood, without a knowledge of the properties of air, when considered as a constituent principle of bodies, I must refer the further illustration until it be shewn what those properties are.

ESSAY II.

ON THE

NATURE and PROPERTIES

OF

FIXED AIR.

May we not, with good reaſon, adopt this now fixed, now volatile Proteus, among the chymical principles, and that a very active one? HALES.

ESSAY II.

ON THE

NATURE and PROPERTIES of FIXED AIR.

THAT great improver of natural knowlege, the honourable Mr. *Boyle*, knew from a variety of experiments, " that " air might be produced from the fer- " mentation, corroſion, and diſſolution of " bodies; by the boiling of water, and " other liquors; by the mutual actions of " bodies upon one another, eſpecially the " ſaline ones; and, laſtly, by the analyſing " and reſolving certain ſubſtances*;" but this noble philoſopher ſeems not to have known the principal uſe of this air, which is ſo intimately mixed with, and wrought into the compoſition of animal, vegetable, and mineral bodies.

* Boyle's Works, abridged by Shaw, vol. iii. p. 21.

IT is therefore to the indefatigable induſtry of the excellent Dr. *Hales*, that the world is indebted for the diſcovery that this elaſtic matter, ſo nearly reſembling common air, is the *principle* which *forms* the *cement*, or *bond of union*, between the ſeveral conſtituent particles.

BUT although it is now near forty years ſince this truly uſeful philoſopher publiſhed the account of his curious experiments, and thereby opened a new field in natural philoſophy, yet the enquiry hath been but little proſecuted; and, excepting *Haller*, there is no ſyſtematic writer that I know of, either in chemiſtry or phyſiology, who has given that attention to Dr. *Hales*'s diſcoveries which they certainly merit.

THIS celebrated phyſiologiſt indeed hath fully adopted the ſyſtem of *Hales*, and holds *air* to be the *vinculum elementorum primarium*, the *true cement* which binds together the earthy particles of bodies *.

ALL

* Videtur aer vinculum elementorum primarium conſtituere, cum non prius ea elementa a ſe invicem diſcedant quam aer expulſus fuerit. *Halleri Elem. Phyſiologiæ*, tom. i. in capite primo.

Gluten

ALL the other writers, and *Gaubius*, one of the lateſt, ſeem either not to know, or not to believe any thing of this theory; ſince they make coheſion to depend, altogether, on the attraction ſubſiſting between the particles of elementary earth, excluſive of any other principle. And this very celebrated profeſſor does not ſo much as mention air, when he is laying down the chemical analyſis of the human body *.

BUT it did not occur to theſe gentlemen, that if *earth* were the *only* cauſe of *coheſion* in bodies, there *never* could be any

Gluten præſtat verum moleculis terreis adunandis, ut conſtat exemplo calculum, lapidum, aliorum corporum durorum. In iis omnibus ſolvitur tunc demum partium vinculum quando aer educitur. *Ejuſdem Primæ Lineæ*, ſect. 244.

* In ſicca materie terreum præ aliis cohærentiſſimum eſt, atomorum ſuarum in proximos contactus compactione duritiem daturum vix edomandam niſi aliorum interventu molliretur. Hoc principium cohæſionis, quietis inertiæ. Et ipſa glutina, terræ quam continent ſuam cohærentiam debent. *Gaubii Inſtit. Patholog. Med.* ſect. 142 & 143.

But iſinglaſs, and other ſubſtances of the like nature, are deprived of the glutinous quality by quicklime; the reaſon of which will be laid before the reader in the courſe of theſe Eſſays, particularly the Fifth.

change

change in their *combination*: For " if all
" the parts of matter were only endued
" with a ſtrongly attracting power, whole
" nature would then immediately become
" one unactive, cohering lump; where-
" fore it was abſolutely neceſſary, in or-
" der to the actuating and enlivening this
" vaſt maſs of attracting matter, that there
" ſhould be every where intermixed with
" it a due proportion of ſtrongly repelling
" elaſtic particles, which might enliven
" the whole maſs by the inceſſant action
" between them and the attracting parti-
" cles *."

IT is plain, therefore, that the principle upon which coheſion *immediately* depends muſt be of a *volatile* or *fugitive* nature, not *fixed* and *indeſtructible*, like earth; otherwiſe, the face of this globe would be covered with dead bodies; for when once a ſtop is put to the life of either animal or vegetable, they become no longer uſeful in the general ſyſtem, as organized bodies; and it is then abſolutely neceſſary that their frame ſhould be diſſolved, and their elementary particles diſperſed, in order to

* Hales's Staticks, vol. i. p. 314.

form

form nouriſhment for thoſe beings that yet continue to live.

IT will appear hereafter, that the opinions of *Hales* and *Haller* are well grounded; and that the *principle* which is generally known by the name of *Fixed Air*, is the *immediate* cauſe of coheſion, ſince the preſervation of firmneſs and ſoundneſs in bodies depends on reſtraining the eſcape of this *air*; for the moment it *flies off*, and *reſumes its elaſticity*, we ſhall ſee that the other conſtituent particles, the *earthy*, the *ſaline*, the *oily* or *inflammable*, and the *aqueous*, being thereby put in motion, immediately begin to exert their ſeveral peculiar attractive and repulſive powers, and run into *new combinations*, which firſt change, and at length altogether deſtroy, the texture of the ſubſtance they formerly compoſed, provided that this ſubſtance contained in itſelf a ſufficient quantity of water to allow of the inteſtine motion, by giving the proper degree of fluidity *; for without fluidity there can be no inteſtine motion,

* Here we are not to underſtand abſolute fluidity, but only ſuch a degree of moiſture and ſoftneſs as will allow the ſeveral conſtituent particles to ſhift and change their places.

motion, and without inteſtine motion there can be no change of combination; ſince we ſee that ſuch animal and vegetable bodies as are ſuddenly deprived of their water, or naturally contain very little, are almoſt as durable and unchangeable in their textures as minerals.

THAT this *air*, which is alleged to be the *cementing principle*, ſhould have the property of paſſing from a *repellent*, *elaſtic* ſtate to the oppoſite of *nonelaſtic*, and *ſtrongly attracting*, and *vice verſa*, is not eaſily comprehended; nor indeed could it be believed, if the number of experiments, which prove it, had not put the matter beyond all manner of doubt: So that the fact is as certain as that we breathe air *.

THIS, as well as the property of *elective attraction* in the minute particles of matter, was not unknown to that amazingly comprehenſive genius, Sir *Iſaac Newton* †; and it was by purſuing the hint of that great man, that Dr. *Hales* engaged in an enquiry which enabled him to eſtabliſh the theory aforementionəd, and which

* See Hales's Staticks, vol. i. p. 293, and vol. ii. p. 279 & 281.

† See Newton's Optics, queſt. 30 & 31.

hath

hath been illuftrated and confirmed, with regard to a particular clafs of bodies, by the experiments of Dr. *Black* *.

BUT there is ftill a great deal wanting to complete the illuftration, which demands a number of accurate experiments; more, perhaps, than will fuit the leifure or inclinations of any one perfon, and therefore muft be brought to perfection by the united labours of many.

WITH this view, I began a fet of experiments, and refolved to obferve carefully the appearances attending the fermentation of fuch mixtures as ufually make up part of our food, and alfo the appearances which attend the putrefaction of animal fubftances; hoping from this branch of enquiry to obtain further light concerning fome points of very great importance in the animal œconomy.

EXPERIMENT I.

To try the relative quantity of air, fet free from different mixtures by fermentation, I put into three phials, marked 1, 2, and 3, firft, the fimple fermentative mix-

* In his Experiments on *Magnefia*.

ture, about three ounces; fecondly, a like quantity of bread and water; and the third phial had nothing but three ounces of common water; thefe two laft being defigned as ftandards.

THE phials, as reprefented at B, (fig. 1) were placed in a tin pan (A), half full of water, on little pedeftals, and covered over with cylindrical glaffes (C) of feven inches in height, and three in diameter.

THE air was then drawn out of the cylindrical glaffes, by fuction through a fyphon, fo as to raife up the water about half way, and then little bits of paper were pafted on the fides, to mark the rife of the water.

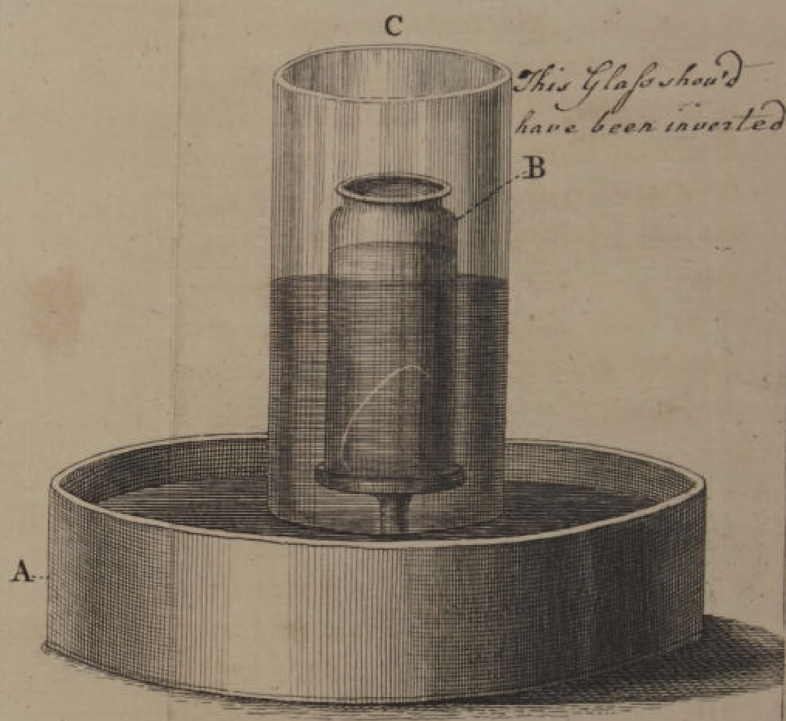
EVERY thing being thus ordered, the whole apparatus was placed before a fire, at fuch a diftance as was fufficient to keep up a moderate degree of heat.

As the heat began to operate, the vapour in each of the glaffes expanded itfelf, and forced down the water to a certain depth, nearly about half an inch; but at the end of eight hours, when the mixture of bread and flefh-meat (No. 1) was in brifk fermentation, the water in its cover was funk one third more than in the other two, and

in

facing p. 34.

Fig. 1.



in twelve hours it was double, being then a complete inch from the mark.

DURING the night, the whole became cool; the confequence of which was, that the expanded vapour in the glaffes 2 and 3 was found in the morning perfectly condenfed, the water having returned to its original height; while the air that had been fet free from the fermenting mixture (No. 1) ftill maintained its elafticity, keeping down the water in the cylindrical glafs an inch and two tenths.

THE pan was again placed before the fire; and, at fix in the evening, the water in the glafs belonging to No. 1 was forced down two inches, that in the other two half an inch.

NEXT morning, the vapour being again condenfed by the cold during the night, the water ftood at an inch and a half from the mark in the fermenting phial, but in the phials No. 2 and 3, it rofe to the marks as before.

I placed the whole again near the fire, and the vapour operated as before. On the third morning, the water belonging to the phial No. 2 had returned as ufual to the original heighth; while in the other, No. 1, it was ſtill kept down a full inch and half, by the force of the extricated air.

I now threw out the bread and water, (from No. 2) and put into the ſame phial half an ounce of boiled beef cut ſmall, and two ounces of water; and having placed it under the cover, and raiſed the water by ſuction, as before, I ſet it in the pan along with the fermented mixture, which by this time had entirely ceaſed from working. After ſtanding ſix hours in the warmth, no elaſtic air appeared to have been ſet free from the beef, the water being ſunk only half an inch. The other phial (No. 1) now ſtood exactly at an inch and a half, which, allowing half an inch for the expanſion of the vapour, ſhewed that the mixture had now been for ſome time in a condition to abſorb air, as Dr. *Hales* termed it, for at the ſame hour the day before the water was down two inches.

ON the 4th morning, when all was cool, the fermented mixture was found ſtill to keep down the water near an inch, but in the glaſs with the beef only the water was up to the mark.

FROM

FROM hence, and from other experiments *, it ſhould ſeem, that animal ſubſtances when alone, and the ſubſtance of vegetables when alone, do not part with their air without ſome reluctance; but that when the two are mixed together, under certain conditions, that then an attraction begins, which preſently throws off the air that ſo cloſely adhered to each of them in a ſeparate ſtate; and this air, in the moment of its extrication, reſuming its elaſticity, deſtroys the union of the minute particles, and, producing an inteſtine motion, totally changes the nature of the body in which it was fixed, by allowing a new diſpoſition and a different combination, to take place.

AND in this manner is brought about the perpetual tranſmutation of animal and vegetable bodies, whereby they mutually afford nouriſhmeut to each other.

IT has appeared that the alimentary mixtures, though at firſt they throw off a conſiderable quantity of elaſtic air, yet,

* See No. 1 of the firſt table; and No. 1, 3, 5, and 7, of the ſecond table; and compare them with thoſe mixtures that had either fleſh or ſaliva.

after ſome time, they *abſorb* this air, and again reduce it to a *non-elaſtic* ſtate.

As the fermentation in the ſtomach muſt begin very ſoon after the aliment is received into it, we may reaſonably conclude, that the alimentary mixture will alſo begin to *abſorb* much ſooner in the bowels than it appeared to do in the phial; and thus the elaſtic air, which is ſet free from the food, will, in great meaſure, return to a fixt, or non-elaſtic ſtate, before the chyle enters the lacteals *.

* "Since we find ſuch great quantities of elaſtic air "generated in the ſolution of animal and vegetable "ſubſtances, it muſt needs be, that a good deal does "conſtantly ariſe from the diſſolving of the aliments "in the ſtomach and bowels, which diſſolution it "greatly promotes; ſome of which may, very proba- "bly, be reſorbed again by the fumes which ariſe "with them.——Thus we ſee, that the variety of "mixtures in the ſtomach appear ſometimes to gene- "rate, and ſometimes to abſorb air. In a true kindly "digeſtion, the generating power exceeds the abſorb- "ing power but a little; but whenever the digeſtion "deviates in ſome degree from this natural ſtate, to "generate a greater proportion of elaſtic air, then are "we troubled more or leſs with diſtending flatuſes." *Hales's Stat.* vol. i. p. 309.

IT

IT has been imagined by a very ingenious gentleman †, that the alimentary ſubſtances carry their fixed air into the blood, without its ever having been extricated, or thrown off into an elaſtic ſtate, during digeſtion; but this is to ſuppoſe, that theſe ſubſtances are never thoroughly broken, nor ſuffer any change of combination, from the action of the digeſtive organs; a ſuppoſition which cannot by any means be allowed; it being *demonſtrable* (as I humbly apprehend) that the food is intirely broken, and its original nature totally changed, while it is paſſing through the alimentary canal.

EXPERIMENT 2.

INTO the ſame three phials which were made uſe of in the foregoing experiment I put, firſt, the ſimple fermentative mixture; 2, the ſame, with one third freſh lemon-juice; 3, the ſame, with one third claret.

* Dr. *Black*. In his *Diſſertatio Med. Inaug. De Humore acido a Cibis orto*, he is ſo far from believing that the aliment naturally ferments in the ſtomach, that he looks on ſuch fermentation, when it does happen, to be the cauſe of many, and thoſe very dangerous diſeaſes. See p. 8 and 9 of the *Theſis* above-mentioned.

THE phials were all placed in the pan as before, and the water drawn out by ſuction. The phial, No. 1, preſently began the motion, the ſolid part all riſing to the top; and as it fermented, I found that more air was extricated than there had been from No. 1 of the preceding experiment, which I aſcribed to the tenderneſs of the mutton which was uſed in this preſent mixture, as having been longer kept than ſome beef that I had mixed up for the former trial.

No. 3, with the claret, did not begin to move until it had ſtood 24 hours; and No. 2, with the lemon-juice, after remaining thirty-ſix hours, ſhewed no ſigns of motion at all; ſo that here the proportion of lemon-juice was too great; and it appears to have acted as a pure acid, which, as well as fermented liquors, we find reſtrains the alimentary fermentation.

EXPERIMENT 3.

AT the end of thirty-ſix hours, I threw out theſe mixtures, and filled the phials again, with, 1, the ſimple fermentative mixture, and an ounce of green herbs; (*viz.* onions, water-creſſes, and garden creſſes,

creſſes, *aa p. æ.)* 2. The fermentative mixture, with an ounce of lemon-juice and half an ounce of *ſaliva*; 3. The mixture, with two drachms of very ſtrong rum.

THE mixture, No. 2, with the lemon-juice and *ſaliva*, began to ferment immediately; and, before two hours were expired, all the ſolid ingredients had riſen; No. 1 began ſoon after; but it was not till after ten hours, that the mixture with the rum ſhewed any ſigns of motion.

HERE we have another ſtrong inſtance of the fermentative power of the *ſaliva*, which being compared with thoſe in the ſecond table, plainly ſhew that *Boerhaave* and *Hoffman* were both in the right, when they aſcribed this quality to it.

WHEN the mixture with the lemon-juice had ceaſed from working, I dropt *Lixivium Tartari* into ſome of the liquor, but not the leaſt ebullition enſued, which ſhews, how intirely the fermentatory motion changes the nature of the ſubſtance fermented; for here was one third of this mixture, a ſharp acid liquor, which would have effervefced violently before the fermentation began; and hence we may conclude, that acids, even independant of their

their mixture and dilution by the native animal juices, muſt be neutralized by the mere force of fermentation in the firſt paſſages, if the digeſtion proceeds as it ought to do.

IN the mixture with the herbs, the ſmell of the onion was ſtill very ſtrong, even after the fermentation was over; which agrees with what every body muſt have perceived, with regard to the fermentation of things of this ſort in the ſtomach; ſome of this tribe, ſuch as garlick, retain their peculiar ſmell, even after they have undergone ſo much of the action of the body, as to become perſpirable matter.

ALTHOUGH the mixture with the rum was the lateſt in beginning, yet, after the motion began, it was more briſk, and finiſhed its career ſooner, than either of the other two phials; but not above half the quantity of air was extricated that there was from the ſimple mixture, No. 1, of the foregoing experiment.

EXPERIMENT 4.

TWO of the phials were placed in the pan and covered with the glaſſes; one having two ounces of a caudle, made of oaten gruel,

gruel, Liſbon white-wine, and ſugar, with a little lemon-juice; and the other, the ſame quantity of the caudle, and two drachms of *ſaliva*.

THE phial which had the *ſaliva*, began the fermentatory motion immediately, but it never became briſk, and in about 14 hours intirely ceaſed; a ſmall quantity of air was extricated at firſt, but the mixture ſoon went on to the abſorbent ſtate, for by the time that the fermentation had ceaſed, the water in the cylindrical glaſs was raiſed half an inch *above* the mark.

THE other phial without the *ſaliva* never ſhewed any ſigns of motion.

HENCE we ſee the reaſon, why this ſort of caudle ſits ſo light with people whoſe bowels are apt to give too much way to diſtending *flatus*; ſuch as lying-in women, and perſons in feveriſh diſorders.

EXPERIMENT 5.

I filled the three phials, 1, with juice of turneps alone; 2, the ſame juice, with two drachms of *ſaliva*; and, 3, bread and water, with two drachms of ſaliva, and as much ſpirit of vitriol as gave the mixture a conſiderable degree of ſharpneſs, and made it it effervefce fmartly upon dropping in *oil of tartar*.

THE phial, No. 2, with the *faliva*, began to fhew figns of motion immediately; and, in five or fix hours, the fimple turnep juice was likewife in motion, and both the one and the other fermented very brifkly.

BUT No. 3, though it fhewed figns of motion very early, never became brifk; fo much had the acid deftroyed the fermentative power of the *faliva*. However, what little motion it did undergo, fo far altered the ftate of the acid, that it would not effervefce, upon adding the fixed alkali.

EXPERIMENT 6.

INTO one of the phials I put three ounces of the fimple fermentative mixture, and a drachm of the *cortex* in powder; into the fecond phial I put the fame quantity of the mixture, and a drachm of *carraway-feeds* in powder; the third had nothing but three ounces of the mixture, to ferve as a ftandard to the other two.

THE phial with the *bark* began to fhew figns of motion as foon as it became warm, and the other, with the feeds, in two hours

hours after; the ſimple mixture was not in motion till three hours later.

THE *cortex* fermented very briſkly, as did alſo the carraway-ſeeds; but there was at leaſt one half more air extricated from the latter than from the former, which ſhews that many of the carminatives may generate air in the bowels, as well as expel it: And if theſe things were given in large doſes, we might account for their action, by ſaying, that it is the ſudden extrication of their air which ſtimulates the muſcular coat of the ſtomach, and enables it to throw off the offending flatus.

BUT as they are always given, and indeed can only be taken in ſmall quantities, it is upon the hot oil with which theſe aromatic ſubſtances abound, that their carminative virtue depends; for we ſee that ardent ſpirits, which neither contain much air themſelves *, nor facilitate the extrication thereof from any thing they are mixed with, are yet very powerful carminatives, which muſt therefore be owing ſolely to their power as ſtimulants.

* "I found very little air in 54 cubick inches of "brandy." *Hales's Stat*. vol. i. p. 181.

EXPE-

EXPERIMENT 7.

I HAD, on a former occaſion, made up mixtures with ſugar, wort, and honey, but as the progreſs of that experiment was interrupted, I reſolved to repeat it.

THREE mixtures were made accordingly:

1. Of boiled mutton (without any bread) ℥ſs, water ℥ij, and freſh wort, or infuſion of malt, ℥ij.

2. The ſame quantity of mutton and water, with two ounces of a ſtrong ſolution of brown ſugar (about four to one).

3. The like quantity of mutton and water, with two ounces of ſtrong ſolution of honey.

THESE phials were not placed in the pan, as in the foregoing experiments, but ſtood in a ſand bath, heated by a lamp.

THE mixture, No. 1, with the wort, was the firſt that began the fermentatory motion, and that very early, in leſs than an hour after the phial became warm; the ſugar began next, about two hours later; but the honey was not in motion until it had ſtood above eight hours.

I FREQUENTLY ſhook all theſe mixtures, and found the fermentation greatly accelerated thereby.

THUS it appears, that honey is not ſo fermentable, when mixed with animal ſubſtances, as ſugar; nor ſugar ſo prone to fermentation as the common infuſion of malt; and perhaps thoſe diſturbances in the bowels, which are often obſerved in people of delicate and very irritable conſtitutions, after the uſe of honey, are occaſioned by this refractory quality, ſince it may lie a conſiderable time undiſſolved in the ſtomach, and there act as a ſtimulating ſalt.

UPON the ſame principle, this may guide us in directing ſugar and honey in the diet of ſick perſons: Where the nature of a diſeaſe requires a diet of the moſt eaſily fermentable kind, ſugar muſt be preferable to honey; unleſs ſomewhat of a laxative nature be likewiſe demanded, when honey, unleſs the patient has a peculiar diſlike to it, will have the advantage.

EXPERIMENT 8.

WHILE theſe mixtures were in fermentation, I ſuſpended a little thin bit of very putrid mutton in the neck of the phial with the wort, and left it there during the night;

night; in the morning it was found to have loſt the putrid ſtench, having now no ſmell but that of the mixture.

EXPERIMENT 9.

I ALSO fixed one extremity of a bended glaſs tube into the neck of the phial with the ſugar, and the other into a little bottle containing a drachm, or thereabouts, of the ſpirit of *ſal ammoniac* made with *quick-lime*, (as repreſented in the third figure). After they had remained in this ſituation twenty-four hours, I ſeparated the phials, and dropping in ſpirit of vitriol on the volatile alkali, found it efferveſce very ſmartly.

AFTERWARDS, I transferred the air from a ſimple fermenting mixture (*i. e.* Bread, fleſh meat, and water) into the ſame cauſtic volatile alkali; as I did likewiſe from melaſſes waſh * in fermentation, and from a mixture of *cortex* and putrid bile, which fermented briſkly, and ſweetened

* Melaſſes waſh, as it is termed by the diſtillers, is a liquor brewed from melaſſes and water, and afterwards fermented by the means of yeaſt; in order to diſtil, and make what are uſually called ſugar-houſe ſpirits.

the

the putrid gall, all with equal ſucceſs; in every one of theſe inſtances the ſpirit of *ſal ammoniac* effervefcing very ſmartly, after having been ſupplied with air from the ſubſtances in fermentation.

WHICH ſhews, that the air ſet free during the fermentatory proceſs, although it reſumes its elaſticity immediately upon being thrown off, is yet capable of returning inſtantly to a fixed ſtate, provided it meets with any ſubſtance greedy of air, and which hath a power to receive it.

BUT here I find that I have been proceeding rather too faſt, unleſs the reader ſhould happen to be perfectly well acquainted with Dr. *Black*'s very ingenious paper on the *magneſia*: if he is, I ſhall be underſtood; if not, I ſhall appear to have talked in a language altogether unintelligible.

IT is ſufficiently known, that the *volatile alcaline ſpirits*, when made by the admixture of *quick-lime* in the diſtillation, (which they for the moſt part are, in order to render them more pungent) *do not efferveſce* upon the addition of an acid; and that no ſalt, in a concrete form, ever rifes with the phlegm when the procefs is carried on in this manner.

BUT it was never well underftood what occafioned thefe peculiarities, until Dr. *Black* publifhed his experiments.

THAT gentleman has fhewn very plainly, that *calcareous earths* have a ftrong degree of *affinity* with *fixed air*, and that in their natural ftate they abound with it; that by *calcination* they are *deprived* of their *air*; and that it is on account of this deprivation that they acquire fo great a degree of *caufticity*, and become *foluble* in water; and that, on the other hand, this caufticity is deftroyed, and the quick-lime rendered *mild*, and *infoluble*, by *reftoring* its *fixed air*.

QUICK-LIME, therefore, when joined with *fal ammoniac*, in order to make the volatile fpirit, not only detains the *acid*, but likewife the *fixed air* of the crude falt, and thus fuffers nothing but the volatile alcali to rife along with the phlegm in the diftillation. This fpirit, fo raifed, having *no fixed air* in its compofition, cannot effervefce upon the addition of an acid; for effervefcence is nothing more than the fixed

fixed air of the mixture flying off, and reſuming its elaſticity, while the acid and alcaline particles are ruſhing into cloſe union *; neither can the ſaline particles of the volatile ſpirit run together, and form chryſtals, becauſe *air* is the *bond of union* in ſalts †.

NEUMAN imagined, that "perhaps "the quick-lime abſorbs, and detains the "earthy matter, which is the baſis of the "volatile ſalt, and on which its ſolid form "and its effervefcence with acids depend. "And he relates, that on keeping ſpirit "of ſal ammoniac, made with quick-lime, "for ten years, it loſt almoſt all its vola"tility and ſubtility, and in this ſtate ef"ferveſced ſtrongly ‡."

BUT there is not the leaſt occaſion for waiting ſo long to produce this change in the nature of the *cauſtic volatile alcali*, ſince it may at any time be brought about in ten minutes by transferring the air from ſome other ſubſtance into the *non-efferveſcent* ſpirit; as any one may eaſily ſatisfy

* Vide *Boerhaav. Element. Chemiæ*, tom. i. p. 531, & tom. ii. p. 398.

† *Hales's Stat.* vol. i. p. 298.

‡ *Neuman's Chemiſtry by Lewis*, p. 223.

himſelf by the following exceedingly pretty and conclusive experiment, which is the contrivance of Dr. *Black*, and communicated by him to my very ingenious friend Dr. *Francis Hutcheſon*, *lecturer of chemiſtry* in the univerſity of *Dublin*.

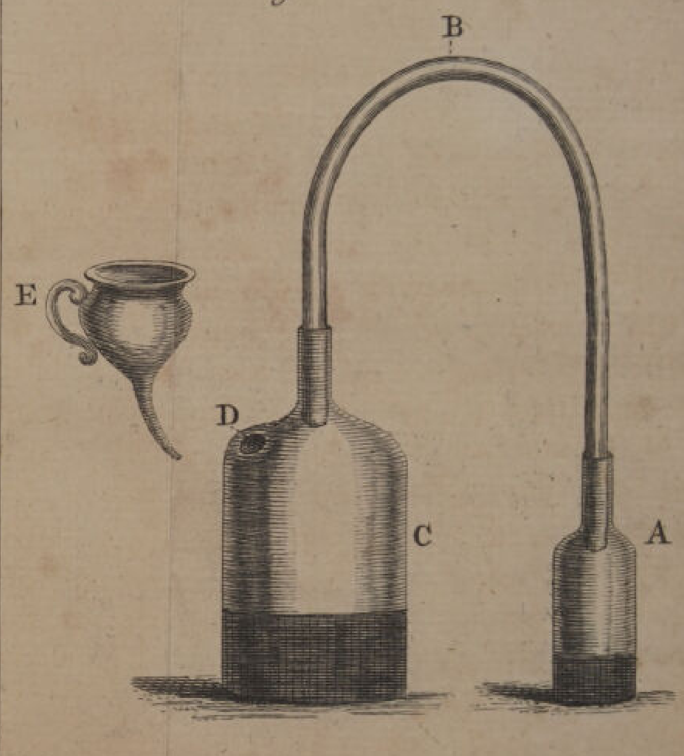
PUT a ſmall quantity of the volatile ſpirit made with quick-lime into the little phial marked A, in figure 2, and fix cloſely into its neck, ſo as that no air may eſcape, one leg of the bended glaſs tube (B), and inſert the other, and likewiſe lute it well, into the mouth of a larger phial (C), into which ſome alcaline ſalt hath been previouſly put. This phial muſt have a little hole drilled in the upper part of it, as at D, that through this aperture, and by means of the ſmall glaſs funnel (E) an acid may be gradually dropt in.

THINGS being thus fixed, pour in ſpirit of vitriol, or any other acid, that an effervescence may enſue; and while that is going on, the little hole (at D) is to be ſtopt occaſionally, in order to force over the extricated air into the phial A. An ounce of alcaline ſalt * expended in this

* *Potaſh* is the *alcali* which I generally make uſe of for this experiment, on account of its cheapneſs.

facing p. 52.

Fig. 2.



manner will ſerve to ſupply a like quantity of *cauſtic* alcaline ſpirit with a ſufficiency of air to make it effervеſce very ſmartly, when the phials are ſeparated, and an acid dropt into the one which contains the (before) *non-effervеſcent ſpirit*.

EXPERIMENT 10.

MANY of the preceding experiments have ſhewn, in the ſtrongeſt light, the fermentative power of the *ſaliva*: I determined, however, to try it once more, and to compare it with the *bile*, in regard to this quality.

I THEREFORE mixed an ounce and half of bread and water, beat up thin, with half an ounce of *ſaliva*; and the ſame quantity of bread and water, with half an ounce of *ox-gall*.

THE firſt mixture ſhewed ſigns of motion from the very beginning, and, in leſs than an hour after it became warm, the motion was briſk; the ſecond, with the gall, was not ſo ſoon in motion, it being three hours before the bread had all fairly riſen to the ſurface; but the fermentation continued twice as long, and the motion was more briſk than in the mixture with the *ſaliva*.

AND thus it appears very plain that the *bile* has a power, like other animal fluids, to raiſe a fermentation, when mixed with vegetable ſubſtances.

EXPERIMENT 11.

Two drachms of boiled mutton, perfectly ſweet, were beat up with an ounce of water, and put into one phial; the ſame quantity of the mutton beat up with half an ounce of *ſaliva*, and as much water, were put into another phial; and both of them left in the common temperature of the air, which was cool for the ſeaſon (beginning of June), the thermometer being at 60.

IN thirty-ſix hours, the contents of the firſt phial became putrid; the other, which had the *ſaliva*, remained ſweet for forty-eight hours; but both of them fermented; that is to ſay, an inteſtine motion took place, the ſolid part all roſe to the ſurface, and bubbles of air repeatedly formed, and continued diſcharging themſelves, for ſeveral hours before any putrid ſmell was perceivable.

EXPERIMENT 12.

A DRACHM of boiled mutton, perfectly ſweet, beat up with an ounce of water, was put into one phial; the ſame mixture was put into another, and a bit of thread being dipt in ſome putrid liquor which lay about rotten beef, about the tenth part of an inch of this thread was cut off, and thrown into the phial.

IN twenty-four hours, the contents of the ſecond phial, after undergoing the inteſtine motion, were found putrid; the firſt did not betray the leaſt putrid ſmell until it had ſtood twelve hours longer.

I REPEATED this with *bile*, and found the phial into which I had put the bit of putrid thread began to ſmell ſeveral hours ſooner than the other, which contained *bile* and water only.

THESE experiments confirm the eighteenth of Dr. *Pringle*'s, and plainly ſhew, that bodies in a ſtate of putrefaction are *exciting ferments* to ſuch as are ſweet.

EXPERIMENT 13.

IT has appeared from the 6th of theſe experiments, that the *cortex* ferments very readily when joined with a mixture of animal and vegetable matters, and even ſeems to promote that fermentation; but I was deſirous to know how it would operate when joined only to the *ſaliva*.

WITH this view, I mixed up a drachm of the *bark* in powder, with half an ounce of *ſaliva*, and as much water. At firſt, there did appear ſome ſigns of motion, but they preſently went off, and at the end of eighteen hours I found the mixture perfectly at reſt, notwithſtanding it had ſtood the firſt ſix hours of this time in a moderate degree of heat; for the laſt twelve, indeed, it had been ſuffered to cool.

I NOW added half an ounce of *ox-gall*; but no motion enſued till twenty hours more were elapſed: Then I found the ſolid part getting up to the ſurface, and the air-bubbles collecting and diſcharging; but it is to be obſerved that the phial, all this while, remained in the cold.

FINDING the motion begun, I placed the mixture in a moderate degree of heat, and then the fermentation became extremely briſk, and continued ſo for twenty-four hours, throwing off great quantities of air; after which it ceaſed, owing,

as

as I conjectured, to the frequent agitation of the phial, which, as hath been before obſerved, conſiderably haſtens and ſhortens the periods of this kind of fermentation.

SINCE this moſt valuable drug ferments in this manner, when ſo little aſſiſted by heat, we may ſafely conclude that it will ferment with very great eaſe, when lying in the warm ſtomach, ſoftened and opened by the diſſolvent power of the digeſtive fluids; and, as will hereafter appear, there is good reaſon to believe that great part of its medicinal virtues depend on this fermentative quality.

EXPERIMENT 14.

IN order to cloſe this ſeries of experiments, I thought it would not be improper to try the ſeveral common *farinacea*, and to compare them with each other, in regard to their reſpective fermentative qualities; as this might be of uſe in determining which of them are eaſieſt of digeſtion.

HAVING made up four mixtures, of wheat, barley, oats, and rice, all previouſly freed from their outward ſhells or huſks, and well boiled, ſo as to burſt the grain, and

and beat up with the ufual proportion of water and flefh meat *, they were then fe-verally put into phials, and placed in a moderate degree of heat, about twelve hours after they were firft mixed.

IT was not eafy to fay whether the rice or the barley began firft, for both of them were in brifk motion by the time that they had ftood an hour in the warmth; the mixture with the oats was not in motion till about four hours after it became warm, and the one with the wheat was three or four hours later than it.

THEY all fermented very brifkly, and being often agitated, ran through their firft ftage in about forty-eight hours.

THUS we may infer, that crude barley † and rice will prove light and eafily digefti-ble food; oats next to them; and wheat the moft ftubborn and indigeftible of all. But at the fame time we fee, that this pro-perty in wheat renders it by much the fitteft of all the *farinacea* for the making of bread; as it appears to have firmnefs

* Boiled veal was ufed in this experiment.

† The barley here ufed was what is commonly termed pearl-barley.

ſufficient to enable it to bear ſome degree of fermentation in the baking, and yet retain enough of its ſubſtance to undergo the alimentary fermentation afterwards in the body.

By this time I had ſufficiently ſatisfied myſelf with reſpect to the manner in which digeſtion is carried on in the human body; being now fully convinced that it is neither more nor leſs than a true fermentatory proceſs: For ſince all mixtures of animal and vegetable ſubſtances, if furniſhed with the requiſite quantity of water, and kept in the proper degree of heat *, naturally and ſpontaneouſly run into fermentation, without the aſſiſtance of any *exciting* ferment, how is it poſſible but that the ſame kind of mixtures muſt ferment in the body, when at their very firſt entrance they meet with a fluid, which, even if their own natures were averſe from fermentation, would immediately bring it on? And as they paſs farther on, into the *ſtomach* and *duodenum*, they ſtill meet with more fluids, endued with the ſame power, in an equal,

* Even heat, we find, is not always neceſſary; ſo prone are many of this ſort of mixtures to ferment.

or perhaps ſuperior degree: Can it be imagined then, that theſe ſubſtances, when ſo circumſtanced, will not undergo the changes natural to them? and that a fermenting motion will not inſtantly commence, and continue ſo long as they remain in a place where they are free to act, uninfluenced by any more powerful ferment; that is to ſay, ſo long as they remain within the confines of the *ſmaller inteſtines?* But ſoon after the *valve* of the *colon* is paſſed, and that the alimentary mixture, which as yet is only in its *firſt* ſtage, comes into contact with the *acido-putrefactive* contents of the larger inteſtines, then is its ſweetneſs deſtroyed, and it proceeds on to the *ſecond* and *third* ſtages, and thereby acquires a degree of ſharpneſs and corruption *, which is now become as neceſſary as it was that the ſweetneſs ſhould continue while the food remained in the firſt paſſages.

* It is to be obſerved, however, that the putrefaction of the *fæces alvinæ* is of a peculiar kind; and is never, excepting in ſome morbid caſes, ſo complete as to furniſh a *volatile alcali*, on being committed to diſtillation.

EXPE-

EXPERIMENT 15.

A DRACHM of ſalt of wormwood being put into one of the cylindrical glaſſes deſcribed in page 34, and which was uſed to cover the phials, and an ounce, or thereabouts, of juice of lemons, being poured on the ſalt, the mouth of the glaſs was ſtopt, while the ebullition continued, in order to confine the air which was extricated from the mixture.

WHEN the effervеſcence ceaſed, a *live ſparrow* was thrown into the glaſs, and in leſs than half a minute expired.

THUS we ſee, that the air which is extricated from bodies by effervеſcence, as well as that which is ſet free in the firſt ſtage of fermentation, and conſtitutes the *gas ſylveſtre*, hath the deleterious quality of ſuffocating animals.

BUT *ſal abſynthii*, and *ſuccus limonum*, are often given during the act of ebullition, and, I believe there can be no inſtance ſhewn of any perſon's being deſtroyed by it, notwithſtanding what we have juſt now ſeen in regard to the ſparrow which was ſuffocated by the vapour ariſing from ſuch a mixture; therefore, the action of this extricated

tricated or factitious air is very different, when applied *directly* to the *lungs*, and when pent up in the *bowels* of a living animal.

THE fear which the *physiologists* conceived of this deleterious quality in the *subtile gas*, and their not well knowing how to dispose of the great quantities of *air* which must necessarily be thrown off, if the aliment were supposed to ferment, seem to have been the chief obstacles that prevented them from embracing the doctrine of alimentary fermentation.

BUT it seems now proved, that we have nothing to apprehend with regard to the first; and in respect of the latter objection, the experiments above-recited, particularly the 8th, 9th, and 10th, plainly shew, that the air which is set free, either from a *fermenting*, or from an *effervescent* mixture, although it be at first truly *elastic*, yet is of such a surprizing nature as to be capable of returning to a *fixed*, or *non-elastic state*, the moment it meets with any absorbent body that has power to receive it.

AND if we consider that this *air* which is extricated from the food * has the whole

* Sed is etiam aer, qui *princeps gluten est partium solidarum animalium*, emergit ex intimis, elementa relin-

quit

extent of the alimentary canal to ſpread and diffuſe itſelf through, we ſhall find that it never can create any uneaſineſs *, excepting when ſome acrimonious matter, or other ſtimulus, though more remote, (as in *icteric*, *hyſteric*, and *nephritic* caſes) occaſions a ſpaſmodic conſtriction in ſome part of the tube, and prevents thereby the free and equable diffuſion of the elaſtic vapour.

quit abſque vinculo. Idem liberatus, diſtendit ventriculum magis quam cibi moles. *Halleri Prim. Lin.* ſect. 632.

* In habits where the whole ſyſtem of ſolids is too much relaxed, whether from intemperance, profuſe evacuations, or previous diſeaſe, the muſcular fibres of the ſtomach are apt to yield too freely to the elaſtic vapour, which is thrown off in the commencement of the digeſtive proceſs, which muſt neceſſarily bring on immediate diſtreſs, from the over-diſtenſion thus created; but the parties thus afflicted generally have recourſe to a ſpeedy, though otherwiſe dangerous, remedy, ſpirituous liquors: Drams, when ſwallowed ſoon after the meal, not only encreaſe the muſcular power of the ſtomach, but alſo retard the alimentary fermentation, and thereby give time, before it be far advanced, or that much air is ſet free, for the food to paſs on into the inteſtines, where the elaſtic vapour having ſo much more room to diffuſe itſelf, no uneaſineſs or oppreſſion will enſue.

ON the contrary, the uſual, natural, and gentle degree of diſtenſion is of the greateſt importance to the animal œconomy; for it ſtimulates the muſcular coats of the ſtomach and inteſtines, and thereby excites, and keeps up, their periſtaltic motion, and enables the *lacteal*, and other minute veſſels, to *abſorb* freely; neither of which (the motion nor abſorption) could be well carried on, if the ſides of this long canal had been ſuffered to collapſe.

THEN, ſo much of it as is left unabſorbed (for we have ſeen that the fermenting mixtures, after a certain time, reſorb the air, which at firſt flies off in an elaſtic ſtate), entering the compoſition of the chyle *, it ſtimulates the veſſels appropriated to the carrying of that liquor, and promoting their oſcillatory motion, enables them to pour their contents, in a very ſhort ſpace of time, into the general maſs of blood.

* It is not by any means intended here to inculcate, that bubbles of air paſs with the chyle into the lacteals. What is meant is, that ſome portion of the air which enters the compoſition of the chyle, is ſtill in an active, repellent ſtate, and that all the vapour which was thrown off during the fermentation of the food is not as yet deprived of its elaſticity.

HERE the inteſtine motion is communicated by this active principle, the *elaſtic air*; while every moment it meets with new powers *, which reduce the requiſite proportion to a *nonelaſtic ſtate*, and leave the remainder in poſſeſſion of its *elaſticity*; which is neceſſary, to maintain the inteſtine motion, and to ſerve as a counterpoiſe to the preſſure of the atmoſphere.

I AM well aware, that this aſſertion concerning *elaſtic air* in animal fluids is directly contrary to the doctrine of *Boerhaave*, who, in expreſs terms, condemns the theory of *Borelli*, in relation to this matter.

* This is aſcribed, by Dr. *Hales*, to the ſulphur which is in bodies; and he ſeems to have been led into this opinion from obſerving, that the fumes of common ſulphur have a prodigious power to abſorb and deſtroy the elaſticity of air.

But whether it be in reality the ſulphur-principle, or phlogiſton, as it is now more generally termed, that has the property of fixing, and reducing to a ſtate of non-elaſticity, this air, which we find is thrown off from bodies while they are reſolving into their ſeveral component parts, cannot poſſibly be determined from any diſcovery hitherto made. See *Hales's Stat.* vol. ii. p. 108.

THAT great man taught, that the air which is found in bodies of all kinds, and particularly in animal fluids, is there in ſuch a ſtate as to be altogether incapable of acting as air: He thought, that it was divided into ſuch extremely minute parts, that its particles were *ſolitary*, and that, while they remained in this divided and ſolitary ſtate, they had no power to exert any of the properties of air; but that when two of theſe particles came within the ſphere of each others action, then they acquired the *repulſive power*, and became *elaſtic*; and being joined by a third, a fourth particle, and ſo on, they then burſt forth in the form of genuine bubbles of air.

BUT as theſe particles are kept in their *ſolitary ſtate* by the weight and compreſſion of ſurrounding matter, or by the preſſure of the atmoſphere, and as they never break looſe but when the texture of bodies is deſtroyed, by fire, effervеſcence, fermentation, or putrefaction; or by removing, almoſt entirely, the weight of the atmoſphere, he contended, that the air in animal fluids, ſhould not be regarded as air; neither ſhould we expect it to exert any of its ufual properties; feeing that, while life continues, no fuch changes as thofe above fpecified, ever do happen*.

BUT *Hoffman* and Dr. *Hales* are as explicit on the other fide of this argument; and fome of the experiments of the latter fully authorize him to be fo. His opinion is, "that there is a confiderable quantity of "air in vegetables upon the wing, and in "a very active ftate;" and that this elaftic air invigorates the juices of both animals and vegetables, while it continues in this ftate of activity†.

INDEED there appears to be an abfolute neceffity for admitting the exiftence of *elaftic repellent air*, in *animal*, as well as *vegetable fluids*; for, without it, it feems impoffible to comprehend how the *inteftine*

* Quin et ratum eft, aera latentem in liquoribus, non habere illas vires phyficas quas poffidet dum extra liquores unitus exiftit. Igitur in chylo, lacte, &c. adeft aer naturaliter, fed ita diffolutus, atque proinde tandiu non agens ut aer. *Boerhaav. Elem. Chemiæ*, tom. i. p. 519, 524, 525. *Corroll.* 6, 7, & 8. Vide quoque *Prælectiones Academicas*, tom. ii, p. 199.

† See the Experiments in the third chapter of the firft volume of the *Staticks*; and alfo p. 216, 315, of the fame volume.

motion can be kept up, or how the canals can be preferved in a conftant ftate of permeability: for as all thefe canals are more or lefs flexible, and fubject to the preffure of the atmofphere, which is in a perpetual courfe of variation, if there were not a quantity of *elaftic* matter mixed with the fluids contained in them, to ferve as a counterpoife to the external air, an entire ftop muft be put to their circulation; or were this *internal air* in an *unvariable* ftate, with regard to elafticity, and were it not upon every occafion to preferve the *fame tenour* with the *external air*, the fides of the canals muft frequently burft afunder. Since even the common changes of the atmofphere, in its ufual variation, within the compafs of three inches of the barometer, would make fuch an alteration of preffure as no living body could endure *.

BUT when we are told, that the atmofphere is fo light on the tops of exceedingly high mountains, that it is fcarce able to fuftain a column of *mercury* of fixteen

* This difference is calculated by Dr. *Wainewright* to amount to more than a ton and a half (3982 ½ pounds Troy weight.

inches;

inches*; and ſo heavy in the bottom of deep mines, that it can ſupport a column of *thirty* inches; and when we know from experience, that a man may *aſcend* in the one caſe, and *deſcend* in the other, and yet feel no great inconvenience, we may be certain that the *elaſticity* of the air in his fluids diminiſheth, or increaſeth, in the very ſame proportion that the weight of the air which ſurrounds him doth diminiſh or increaſe; the elaſticity of air being always found equal to its denſity.

AND had not an *equilibrium* been kept up in this manner, the veſſels muſt have burſt, in both caſes: In the firſt, becauſe of the expanſive force of the air contained

* "Le Mercure qui ſe ſoutenoit dans le vuide au "bord de la mer, à 28 pouces 1 ligne, ſe ſoutenoit en "haut, environ 1 ligne au deſſous de 16 pouces: les "elaſticites de l'air, s'y trouverent encore exactement "proportionelles à ſes condenſations, de meme qu'en "bas, & qu'en Europe. *Voyage de Meſſ. Bouguer, & de la Condamine, pour determiner la figure de la Terre,* p. 39.

Theſe gentlemen found the mercury to riſe ſeldom above twenty inches, at the city of *Quito*. At firſt they felt ſome uneaſineſs in their breathing, and ſuch of their company as had weak lungs ſpat a little blood; but theſe complaints gradually wore off.

in them; and in the fecond, by means of the immenfe weight of atmofpheric air preffing *upon* them. The difference between the weight which preffeth on the body of a man in one of the *Newcaftle* coal-pits, and what would prefs upon the fame man if he were on the top of one of the *Andes*, being calculated to amount to fomething about eight tons *.

MANY of the phyfiologifts have imagined, that the animal fluids are furnifhed

* The mechanical phyficians account for this matter by faying, that the impetus of the heart increafes as the refiftance to the circulating force of the blood increafes.

"The weight of the air increafing, the lungs will "be more forcibly expanded, and hereby the blood "more intimately broken and divided, fo that it be-"comes fitter for the moft fluid fecretions, fuch as "that of the animal fpirits, by which the heart will "be more ftrongly contracted. The blood's motion "to the furface of the body being obftructed, it will "pafs in greater quantity to the brain, where the pref-"fure of the air is taken off by the cranium, and upon "this fcore more fpirits will be feparated, whereby the "heart will be fo ftrongly contracted as to carry on "the circulation through the paffable canals, whilft "fome other are obftructed." *Wainewright on the non-naturals*, p. 92.

with

with air by the lungs; but the objections* againſt this opinion are ſuch as cannot eaſily be ſurmounted; they muſt therefore be ſupplied by the way of the *chyliferous canals*, and that in no ſmall quantity; for the air, like all other animal fluids, will require to be perpetually renewed: old particles will every moment fly off, and new ones muſt of courſe ſucceed.

THE air appears to be thrown off by urine, but chiefly by perſpiration.

IT can be demonſtrated that the urine contains much air, but I do not know of any experiment to ſhew that the perſpirable matter contains air; however, I apprehend it may be aſſerted with great ſafety, that this fluid, which is the lighteſt of all animal fluids, is the principal vehicle of the effete and uſeleſs air †.

BUT there are many ways of proving the exiſtence of air, in every other part of an animal body.

* They may be ſeen at large in *Haller Elementa Phyſiologiæ*, tom. iii. and in *Hoffman*, in the chapter *de Sanguinis Circulo per Pulmones*.

† Experiments were afterwards thought of, and made, which demonſtrate the preſence of air in the ſweat and perſpirable matter. The reader will meet with them in the fifth Eſſay.

Dr. *Hales* found, that " a cubick inch " of hogs blood, diſtilled to dry ſcoria, " produced 33 cubick inches of air, which " air did not arriſe till the white fumes " aroſe," *(Exp.* 49.*)*

" Less than a cubick inch of tallow, " being all diſtilled over into the receiver, " produced eighteen cubick inches of air." *(Exp.* 50.*)*

" Half a cubick inch of the tip of a " fallow deer's horn being diſtilled, pro- " duced 117 cubick inches of air, which " did not begin to riſe till the white fumes " aroſe." *(Exp.* 51.*)* " Thus it ap- " pears, that the coheſion of animal ſub- " ſtances was not diſſolved, even in the " blood, without conſiderable violence of " fire; though it is ſometimes done to a " fatal degree, in our blood, by that " more ſubtile diſſolvent fermentation *."

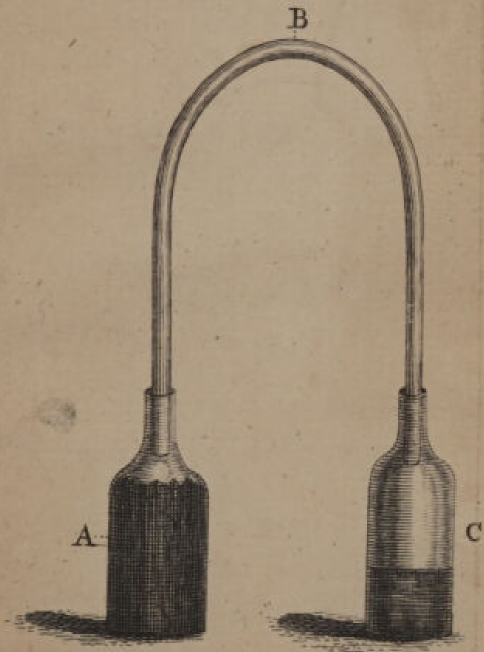
" Sixteen cubick inches of ſheep's " blood being put into a bolt-head, with " a little water to make it ferment the bet- " ter, in eighteen days generated 14 cu- " bick inches of air." *(Exp.* 80.*)*

* As Dr. *Hales* held putrefaction to be only a degree of fermentation, he therefore uſeth the terms promiſcuouſly.

So

facing p. 73.

Fig. 3.



So far Dr. *Hales*; but I was deſirous of knowing whether the *fixed air* would paſs from a putrefying, animal ſubſtance, into the *cauſtic* volatile alcali, ſo as to make the ſaid alcali become *mild* and *effervеſcent*.

EXPERIMENT 16.

IN order to try this, I filled the two-ounce phial (A) fig. 3, with freſh mutton, cut into ſmall pieces, and poured in as much water as ſerved to fill up the interſtices; into the neck of the phial, one leg of the bended glaſs tube (B) was inſerted, and cloſely luted; and the other fixed into a little phial (C) containing about a drachm of the ſpirit of *ſal ammoniac* made with *quick-lime*.

THE phials thus joined together, were hung up in the common temperature of the air. In four days the elaſtic vapour, in the larger phial, had ſo expanded itſelf, that the liquor was raiſed ſome inches in that leg of the tube which belonged to it, but upon agitation it ſubſided: And this agitation I was afterwards obliged to repeat ſeveral times, otherwiſe the putrid liquor would have run over into the ſmall phial.

WHEN

WHEN they had remained in this ſituation for a fortnight, and that I ſaw the mutton was become highly putrid, I took off the ſmall phial with the alcaline ſpirit, and found, upon dropping in ſpirit of vitriol, that a violent efferveſcence enſued. So that here was a *demonſtration*, that during the progreſs of putrefaction, there is continually ſome volatile matter flying off from the putrifying ſubſtance, and that this fugitive principle is *air*, which is now extricated, and thrown off, from a *fixed* and *non-elaſtic* ſtate, into one that is *volatile* and *elaſtic*; but which, immediately upon meeting with a proper recipient, returns again to its former nature.

WHETHER a communication with the external air be abſolutely neceſſary to the extrication of the fixed air, is a matter in which I am not altogether ſatisfied: The common notion concerning putrefaction, which is univerſally taught, and as generally believed, is, that bodies become putrid becauſe that *air* hath *acceſs to them*, and communicates ſomewhat; and few people ſeem to have any *idea* that putrefaction enſues in conſequence of the *loſs* of ſome principle; which, however, appears to to be the real caufe. For it will be fhewn hereafter, that the methods to preferve bodies from putrefaction and decay depend, almoft in every inftance, on *reftraining the flight* of the *fixed air*; for, as this principle *cements* and *binds together* the conftituent particles of bodies, rottennefs, or putrefaction, which confifts in the *refolution* and *difunion* of thefe particles*, will not take place while the *cementing principle* is prefent.

BUT, in order to determine fomewhat, if poffible, concerning this affair, I made the following experiment.

EXPERIMENT 17.

IN the beginning of June, the thermometer being then about 60, I took three little pieces of frefh mutton (of about ℥i) one was put into a tea cup, and melted fuet poured all around, fo as to cover it in-

* We muft obferve here, however, that to conftitute putrefaction there muft not only be a refolution and difunion of the feveral conftituent particles, but there muft alfo be a different difpofition, and a new combination of thefe particles; barely withdrawing the fixed air, only deftroys the cohefion of bodies. See the 26th experiment of this prefent Effay.

tirely;

tirely; the ſecond was placed under a cupping glaſs, which reſted upon a piece of wet leather lying on the cover of a book; and all the air that could be exhauſted was pumped out of the glaſs, by means of the little air-pump belonging to it; and the third piece of the mutton was left expoſed to the open air of the chamber.

AT the end of ſixty hours, the piece in the open air, though a good deal dried, was found to have grown evidently putrid. I then went to examine the piece in *vacuo*, and could plainly perceive by its aprearance through the glaſs, that it was become highly putrid, for it had grown mouldy; and upon lifting up the cupping glaſs, which was now looſened from the leather on which it reſted, the ſmell ſufficiently confirmed this appearance, for the putrid ſtench was by many degrees more offenſive and ſtrong than in the piece which had been expoſed to the open air.

UPON uncovering the bit of mutton which lay involved in the ſuet, it was found perfectly ſweet.

EXPE-

EXPERIMENT 18.

I RESOLVED, however, to repeat this experiment, and that with a ſtill greater degree of accuracy and attention; and for this purpoſe having provided a tight *air-pump*, I took *four* little pieces of freſh beef; the firſt being weighed, its weight was found to be exactly 458 grains: this piece was placed at eight in the evening (thermometer being at 70) under a ſmall receiver, and all the air that could be exhauſted was pumped out; the ſecond piece, weighing 431 grains, was covered with an inverted glaſs of the ſame capacity with the receiver, and reſted on a piece of wet leather, ſpread over the bottom of a China plate; the third piece of the beef, which was nearly of the ſame bulk with the other two, I put into a cup, and poured melted ſuet all around, and over it; and the fourth piece of the beef was hung up in the open air, on the north ſide of the houſe.

WHEN twenty-four hours were elapſed, I took out the piece of beef which had lain in *vacuo*; it had fairly got the offenſive putrid ſmell, and being weighed, was found

found to have loſt between ſeven and eight grains.

THE piece, No. 2, which had lain under cover, was ſtill perfectly ſweet, and had loſt only two grains and a half.

THE piece in the open air was almoſt dry, and perfectly ſweet.

THE piece covered over with ſuet was not examined, as I intended it ſhould remain in that ſituation for ſome days longer.

HAVING placed No. 1 again under the receiver, and exhauſted the air, it was left there till morning; when being again examined, it was found quite putrid, and wanted fifteen grains.

No. 2 had now likewiſe got the putrid ſmell, and being weighed, was found to have loſt but five grains in all; ſo that the piece which had lain in *vacuo* loſt upwards of $\frac{1}{10}$, while the other wanted only $\frac{1}{30}$ part of its original weight.

THIS loſs I looked upon to be chiefly air, for both the pieces appeared and felt as ſoft and moiſt as they did at firſt; and as they had lain both of them upon wet leather, which is but little adapted to abſorb watery vapours, I did not imagine that much of the aqueous part could

have

have been exhaled from either; but the difference of loſs between the two muſt have conſiſted entirely of air, ſince the circumſtances of both pieces were exactly alike, with regard to the exhalation of their water, both of them being incloſed in veſſels of the very ſame ſize, and both of them alike excluded from communication with the external air.

THE piece which had been expoſed to the open air was found, in thirty-ſix hours, to have grown perfectly hard and dry; but was quite ſweet, and remained ſo, being now rendered incapable of putrefaction, by reaſon of the ſuddden exhalation of its acqueous part; for, as hath been elſewhere obſerved, there can be no fermentation, and conſequently no putrefaction, without the requiſite quantity of water; for water, by giving fluidity to bodies, allows the other principles to ſhift their places, and to exert their ſeveral peculiar attractive powers, which they cannot poſſibly do in a ſtate of too much dryneſs.

AND hence we ſee the plain and obvious reaſon why a moiſt atmoſphere promotes putrefaction; for, independent of the pu-

trefactive

trefactive *miaſmata*, which are ſometimes contained in it, and which act upon bodies as ferments, at the ſame time that the eſcape of the fixed air is favoured by the ſmaller degree of preſſure, all the water of the putreſcent ſubſtance is left behind; and even in ſome caſes this very water is increaſed, which adds to the fluidity, or ſoftneſs of the body thus expoſed.

HAVING ſuffered the piece which was covered with melted ſuet to remain untouched for three whole days and a night, I opened it, and found the beef perfectly ſound, ſoft, and ſweet; but it grew very putrid in eight or ten hours after it was uncovered, and that a way was made for the fixed air to eſcape.

EXPERIMENT 19.

I REPEATED this experiment again with two pieces of freſh mutton; the weight of the firſt piece, which I put under the exhauſted receiver, was 573 grains; the other, which was covered by the inverted glaſs, weighed 554 grains.

AFTER remaining twenty-four hours, I found them both tainted, the weather being at this time very moiſt, as well as warm;

warm; but upon weighing, the proportion held nearly as before; for No. 1 loſt more than five grains, while No. 2 wanted only two.

EXPERIMENT 20.

I THEN took two freſh eggs, which had been laid the ſame day, and put one of them under the receiver, where it was kept for a week, and the air-pump wrought generally once in the day, in order to keep it as much exhauſted as poſſible; the other egg was left in the open air. At the end of the week, I broke them both, and found the one which had been under the receiver, though it could not be ſaid to be rotten, yet had acquired ſome degree of *fœtor*, and the yolk did not appear near ſo firm as the one which had been expoſed to the open air.

THE broken eggs happening not to be thrown out, I found the one which had been kept in the receiver of the air-pump quite putrid and offenſive, on the following morning, while the other remained perfectly ſweet.

IT is univerſally known, that eggs, when coated over with melted ſuet, or ſome ſuch unctuous matter, will remain freſh and ſound for many months.

EXPERIMENT 21.

WITH the apparatus belonging to an air-pump, there are generally two hemi-ſpheres of metal, contrived to join cloſely together, ſo as that when the air is pumped out of the cavity, the two remain firmly united by the mere preſſure of the atmoſ-phere.

IT did not at firſt occur to me, that it would be beſt to incloſe the pieces of meat that I wanted to make the experiments on, in this hollow globe, which promiſed to exclude the external air more effectually than was done in the former way.

HAVING therefore incloſed a piece of ſweet and freſh mutton in this ſphere, and left another, of the ſame bulk, under co-ver of a glaſs, they were both ſuffered to remain in thoſe ſituations for forty-eight hours.

UPON examination, the piece which had been incloſed in the hollow ſphere was found ſweet, and the other putrid.

THIS being a more complete *vacuum* than any I had been able to make in the

glaſs

glaſs receivers (for they generally looſened in twelve or fourteen hours) I found that the aſſertion, "that bodies do not readily "become putrid, when perfectly ſecluded "from the external air," may nevertheleſs be true, notwithſtanding what has been ſeen in the four preceding experiments *; which, however, prove inconteſtably, that removing the preſſure of the atmoſphere to a certain degree, does facilitate the eſcape of the fixed air from bodies; though perhaps a total cutting off all communication between the putreſcent body and the external air, may render the flight of this *cementing principle* more difficult †.

DR.

* I am ſenſible that the experiments above-recited were not made with ſufficient accuracy to determine the point in queſtion. The putreſcent ſubſtances ought to have been incloſed in receivers, cemented to a plate of metal, or glaſs; and theſe receivers ought alſo to have included a mercurial gage. This was the method practiſed by Mr. *Boyle*; who relates, that he found oranges, lemons, and ſour grapes, with their ſeveral juices, free from putrefaction or mouldineſs, at the end of three years; but a liquor, ſuppoſed to be frog's ſpawn, was found black and fetid at the three years end.

† It was the opinion of *Boerhaave*, that there is a conſent between the atmoſpheric air and the air incloſed

DR. *Pringle* having found the *teſtacea*, and abſorbent earths, to be promoters of putrefaction, this ſeemed the proper time for repeating thoſe experiments.

EXPERIMENT 22.

ACCORDINGLY, I began with chalk, and the *pulv. e chelis cancrorum comp.* of the ſhops; two phials, each with half a drachm of theſe powders, mixed with an ounce of water, had ſeverally a ſmall bit of freſh beef put into them; a third phial, with nothing but water and a bit of the ſame freſh beef, ſerved as a ſtandard.

IN thirty-ſix hours, the two phials with the abſorbent powders had both got the putrid ſmell; in three hours afterwards, the piece of beef in the third phial became likewiſe fetid.

in the ſubſtance of bodies; and that, as the external air is in a perpetual courſe of variation, ſo likewiſe is this internal air; therefore, when all communication is cut off, the motions of the one are not followed by the other. "Hinc forte fit quod omnes præcipuæ actiones naturales abſolvuntur in aere communi non in vacuo Boyleano." *Elem. Chem.* tom. i. p. 539.

EXPE-

EXPERIMENT 23.

A LIKE quantity of the chalk and *pulvis e chelis* was put into two phials, with an ounce of water in each, and half an ounce of fresh ox-gall. A third phial, with nothing but gall and water, served as a standard.

IN thirty-six hours, the two first phials were found putrid; the third maintained its sweetness for about six hours longer.

EXPERIMENT 24.

HALF a drachm of the earth of allum, mixed with an ounce of water, and a little bit of fresh mutton, were put into one phial; half a drachm of *magnesia alba*, mixed with an ounce of water, and a bit of the same mutton, were put into a second phial; a third bit of the mutton was left in a cup, with common water, for a standard.

IT was about three in the afternoon that these mixtures happened to be made; they were all sweet at bed-time on the succeeding night, after having stood thirty hours; but next morning, the mutton, in both the *magnesia* and the standard, was found putrid, but the *magneſia* rather more ſo than the ſimple water.

THE earth of allum preſerved its piece of the mutton twelve hours longer, and rendered it ſomewhat hard; poſſibly, ſome ſmall remains of the acid adhered to the earth, which gave it this ſlight degree of antiſeptic power.

DR. *Pringle's* conjecture about the manner of operating of theſe abſorbents, is, that they deſtroy the *latent acid.*

THIS *latent acid* is ſuppoſed to enter into the compoſition of animal bodies, and is conceived to be one of the chief ingredients in the cement between the particles that conſtitute the fibres; *chalk* and *teſtacea,* therefore, act as diſſolvents, by being the proper abſorbents thereof.

THIS *latent* principle, however, is allowed to be ſo much out of the reach of demonſtration, that the doctor ſays, "It "may be hard, or even impoſſible, to pro- "duce it in a ſimple form."

BUT there is another principle in animal bodies, of whoſe exiſtence there can be no doubt, the *fixed air*; and *this* makes the *chief* ingredient in the *cement* which binds together the particles that conſtitute the fibres.

CALCAREOUS earths have a very ſtrong affinity with this fixed air; and though, in a natural ſtate, they abound greatly in this principle, yet from their action of haſtening putrefaction, it appears very plain, that they are not ſo replete with fixed air, but that they are ſtill capable of extracting ſome from an animal ſubſtance, and thereby promoting the inteſtine motion. For the extraction of *ſome portion* of the fixed air ſeems ſufficient to throw the remainder of that element into action, and thereby to raiſe the inteſtine motion; becauſe, when the fixed air flies off ſpontaneouſly from any ſubſtance, it always reſumes its *elaſticity*, or *repulſive power*, in the *inſtant* of its extrication; and this *repulſive power* it is that puts the other principles into motion.

BUT when the *whole* of the *fixed air* is withdrawn from a body, by any ſubſtance having a ſtronger affinity therewith, ſuch as *quick-lime*, then the *fixed air*, ſo attracted or abſorbed, does *not regain* its *elaſticity*, but paſſeth, in a *non-elaſtic* ſtate, from one body to another; and hence enſues the *diſſolution*, but not the *putrefaction*, of the body whoſe fixed air is ſo carried off.

EXPERIMENT 25.

I PUT half a drachm of quick-lime into an ounce of water, and immerfed therein a little bit of frefh mutton. This mixture kept off the putrefaction, but it intirely diffolved the flefh, in about a week; not the leaft ill fmell, however, was to be perceived, although I kept the mixture for three weeks in all.

SEEING then, that *dead bodies* become putrid from the *lofs* of their *fixed air**,

* I have juft met with a book publifhed at *Vienna* in 1762, wherein the author endeavours to eftabifh a very extravagant theory concerning putrefaction and contagious difeafes.

He infifts, that bodies which are vulgarly fuppofed to putrefy, or to rot, are devoured by myriads of *animalcula*; that the *fætor* arifing from fuch bodies arifeth from the excrements of the faid *animalcula*; and that contagion is fpread by their *ova* being wafted through the air, and carried from place to place.

Hence he attempts to account for the appearances in the fmall-pox, meafles, fcarlet-fever, and all other contagious or infectious difeafes; alledging the caufe of all thefe to be a *materia animata*, or *feminium verminofum*.

The confequence of this theory is, that *mercury*, and the bitter *anthelminthics*, are the only things whereby we are to expect to do fervice in thefe difeafes. *Marci Anton. Plenciz Opera Medico-Phyfica.*

may

may not the immediate cauſe of putrefaction in *living* bodies be the detachment of too large a proportion of their *fixed air ?*

IN order to ſee what foundation there may be for this conjecture, let us take a view of the appearances which attend the putrefaction of animal fluids.

DR. *Pringle* remarked, "That both "the ſerum and craſſamentum of human "blood yielded air, after ſtanding ſome "time in the lamp furnace, before any "offenſive degree of putrefaction was per-"ceived."

"I HAVE known (ſays Dr. *Huxham* *) "the whole body ſwell vaſtly, even to the "ends of the fingers and toes, with a ca-"daverous lividity, though almoſt quite "cold, and an intolerable ſtench, even "before the perſon was actually dead; "blood iſſuing at the ſame time from the "ears, noſe, mouth, and guts: And this "too where the pulſe had been very weak "and ſmall, though exceeding quick from "the very beginning. Was not this from "much air generated by the inteſtine mo-"tion, heat, and putredity, which are

* In his *Treatiſe on the Malignant Sore-Throat*, p. 61.

"well

"well known to generate air? Is not the "*emphysema* obſervable in ſome ſphacela- "tions, from the ſame cauſe?"

MANY ſymptoms of this ſort, in the ſcurvy, and other highly putrid diſeaſes, evidently ſhew that the air is actually detached from the blood in theſe terrible caſes.

LET us now obſerve the known cauſes of that degree of putrefaction, which often takes place in the *living body*.

FIRST, a long continuance in an *over-moiſt air* is known moſt certainly to bring on the putrefactive *diatheſis*.

AN atmoſphere full of watery vapours obſtructs perſpiration, not only by leſſening the force of the relaxed ſolid fibres, and thereby hindering them to propel the uſual and natural proportion of perſpirable matter to the ſurface of the body, but ſo much of this matter as is driven on, when it arrives at the proper out-lets, finds an *atmoſphere already loaded* with *water*, and conſequently ill adapted, and little capable of abſorbing much of the ſame kind of vapour; an animal body, therefore, in this ſtate of the weather, may be ſaid to be

nearly

nearly in the condition of a wet cloth hung out on a damp day.

BUT the perſpirable matter conſiſts of other principles beſide *water*; its taſte proves it to contain a large ſhare of *ſalt*; and the reaſon of the thing may warrant us in aſſerting, that it has ſome portion of *earthy* and *phlogiſtic*, or oily matter, in its compoſition; and, in particular, that it carries off a great deal of air *.

THE lighteſt and moſt fugitive part of this excrementitious fluid, that is, its *aerial* part, may be carried off, notwithſtanding the moiſt ſtate of the atmoſphere will *not allow* the *aqueous* part to be exhaled: A great ſhare of the water, therefore, and the three other principles joined to it, being left behind, now they are deprived of their air, are in a *putrefactive ſtate*, and conſequently may be become *ferments* to the remaining maſs of fluids.

* Cum totum corpus noſtrum innumeris tubulis & poris pervium atque vaſculoſum ſit, per quod, continuo & perenni motu, æſtuantes humores circumferentur, non mirum eſt, ingentem copiam tenuiſſimorum corpuſculorum *aqueo-aereorum*, & *ſulphureo-ſalinorum*, modo ſub forma vaporum, modo humoris, per illud evehi. *Hoffman. Med. Syſt. Rational.* pars iii. cap. vii. ſect. 11.

IF

IF we attend to the known methods of preſerving health, while the body is expoſed to too great a degree of moiſture, the above hypotheſis will appear the more rational; ſince experience teacheth, that this is moſt effectually done, 1, by keeping the body well covered, and wearing ſuch kind of apparel as will moſt readily abſorb the watery part of the perſpirable matter which the atmoſphere cannot abſorb; 2, by uſing ſuch a courſe of diet as will afford the animal fluids more than uſual ſupplies of air, to make up for the extraordinary waſte, ſuch as recent vegetables, fruits, ſugar, and aromatics; 3, by eating ſparingly of animal food, which yields a ſmall proportion of air, and by abſtaining from the *immoderate* uſe * of ardent ſpirits and fermented liquors, which check the alimentary fermentation, and hinder the free extrication of air from the ſubſtances fed upon.

SECONDLY, if the circulatory motion of the fluids be very much increaſed, either

* The moderate uſe of theſe liquors may be found of ſervice as ſtrengtheners, to encreaſe the power of the ſolids, and thus enable them to keep up a due degree of perſpiration.

by

by too violent exercife, or by a fever, and this extraordinary motion be continued, putrefaction moft certainly enfues.

IT is evident, that the immediate effect of this extraordinary motion and violent agitation of the blood, muft be a difunion of its component parts; here then, the *aerial* part will be the readieft to fly off, and will be carried in great quantities to the furface of the body; there it muft efcape, and when it does efcape, we know what muft be the confequence *.

THIRDLY, *mercury*, and many of the poifons, deftroy the texture of the fluids.

THE action of *mercury* may be confidered either as breaking down the particles of the blood by its extraordinary weight, and the force of mere mechanical attrition, or it may be fuppofed to act in confequence of its having a power to change the natural laws, which obtain among the repulfive and attractive powers of the feveral

* Hence the propriety of the practice, fo much infifted on and recommended by *Sydenham*, in the firft five or fix days of the fmall-pox, and in the commencement of putrid fevers; namely, not to overheat the patients, either by diet or medicine, or by fuffering them to lie continually in bed.

con-

conſtituent particles: And this laſt ſeems to be the moſt plauſible way of accounting for its operation; ſince the quantity of *mercury*, when rendered active by its being joined to ſome ſaline body* which is found ſufficient to melt down the blood, is ſo extremely ſmall in many caſes, that no mechanical action, ariſing from its weight, can be deemed equal to the effect. The action of poiſons, to which are to be referred infectious *miaſmata* cauſing putrid diſeaſes, cannot well be accounted for, on any other principle, than by recurring to a power of this laſt-mentioned kind; ſeeing their quantity is ſo exceeding ſmall, that, let them be ſuppoſed to conſiſt of the ſharpeſt of all poſſible darts or *ſpicula*, they

* The reaſon that mercury becomes ſo extremely active, when joined to ſaline bodies, I take to be this: It is now rendered capable of the moſt immediate and intimate mixture with the animal fluids, becauſe of the affinity between water and ſalt; and being thus mixed with the maſs of blood, can change the repulſive and attractive powers in ſuch a manner as to produce a new combination among the conſtituent particles.

It is impoſſible to demonſtrate this aſſertion by experiment; but a variety of circumſtances in chemiſtry may ſerve to give an idea of the manner in which it may be brought to paſs.

never

never could occaſion ſuch alterations, or deſtroy the texture of the fluids in ſuch a manner, as experience ſhews may be done, in a very ſhort ſpace of time, by the introduction of theſe ſubtile and active matters into the blood.

FOURTHLY, a diet conſiſting entirely of animal food, excepting in very cold climates *, is followed by a putrefactive diſſolution of the fluids.

THE fleſh of animals undoubtedly contains oil and ſalt, of a more ſharp and exalted nature than are to be found in the ſubſtance of the eſculent vegetables; therefore, a diet conſiſting wholly of fleſh cannot fail of producing chyle replete with theſe acrid principles; but animal food appears likewiſe to yield but little air, as may be inferred from remarking the ſtructure

* The natives of *Greenland*, together with the *Eſkimaux Indians* about *Hudſon's Bay*, and many of the *Tartar* nations, feed wholly upon fleſh or fiſh, and ſome of them do not ſo much as dreſs it.

But in theſe very cold climates, the waſte of air by perſpiration muſt be conſiderably leſs than it is within the tropics, where it would be impoſſible to live in this manner for many days without bringing on ſome putrid diſeaſe.

of

of the alimentary canal in carnivorous animals, which is much ſhorter, has fewer *rugæ*, and does not at all ſeem adapted to the different degrees of diſtention, which the ſtomach and inteſtines of the creatures who feed altogether on vegetables, or on a mixed diet, are capable of.

IT will appear hereafter from experiments, that *air* actually has the power of *correcting* putrid acrimony, when formed; and therefore, it can be no unfair inference to preſume, that it has the power to *prevent* this acrimony from taking place: Hence every ſort of food, that affords not the due proportion of this element, is always found to promote putrefaction; as many inſtances in the hiſtory of diſeaſes abundantly prove; where ſome of the moſt deſtructive putrid diſeaſes appear evidently to have been occaſioned by feeding on damaged vegetables, which are incapable of fermentation, and conſequently incapable of producing the requiſite quantity of air; for this it apparently is that invigorates the chyle, and enables it to ſupply good and wholeſome blood.

BUT if wanting the due proportion of air be ſufficient to induce the putrefactive

diatheſis,

diathesis, what muſt a total want of this ſalutary principle produce? Accordingly, in thoſe melancholy inſtances where people have periſhed through hunger, the humours have been found highly putrid; for the action of the body *diſpels* all the lighter *aqueous* and *aerial* part, while the *oily* and the *ſaline* are left behind.

THE mechanical phyſicians think they give a juſt idea of putrefactive acrimony when they tell us, that it conſiſts in the letting looſe of certain ſharp pointed particles, which either exiſt naturally in the fluids (but, in a healthy ſtate, are prevented from doing any harm, by ſheaths or *involucra* which cover them); or, that theſe pointed particles ariſe from the breaking of the globules, which thus become ſharp and angular, like the others before-mentioned; and, like them, are now capable of tearing, irritating, and deſtroying every thing they meet with*.

THE *ſoundneſs* and the *corruption* of animal fluids ſeem to depend more upon *chemical mixture*, than on *mechanical action* †; and

* Vide *De Gorter de Perſpiratione*, in cap. vii. p. 42.

† That is to ſay, animal fluids do not contain ſharp

pointed

and yet thofe chemifts who made putrefaction and alcali much the fame thing, and, in confequence thereof, were to cure all putrid difeafes by acids, have not, by this theory, added much to the true improvement of medical knowledge.

BUT a very eminent practitioner, and admired writer, who has thrown great light on this part of medicine, finding that fyrup of violets was not changed to a green colour by the ferum of putrid blood; that this ferum did not make any effervefcence when fpirit of vitriol was poured on it; that water, in which corrupted flefh had been fometime infufed, neither effervefced nor changed the colour of the fyrup; and that alcaline falts, both fixed and volatile, powerfully oppofe putrefaction; can by no means bring himfelf to believe that putrid

pointed or angular particles, that are capable of being obtunded, or brought into the globular form, by merely rubbing againft each other in the courfe of circulation. But thefe fluids confift of particles which all have their feveral peculiar affinities, or attracting and repelling powers, with regard to each other, whereby they are capable of forming a great variety of combinations, in a manner fimilar to what is obfervable in chemical mixtures.

animal

animal ſubſtances ſhould be regarded as alcaline.

HAVING made ſeveral experiments in order to ſatisfy myſelf in this matter, I ſhall here lay an account of them before the reader.

EXPERIMENT 26.

HUMAN blood being left in a phial well corked, at the end of two months was found highly putrid; it had not ſeparated into diſtinct parts of *ſerum* and *craſſamentum*, but was all alike thick, being of the conſiſtence of ſyrup, and of a dark red, or rather blackiſh colour.

SPIRIT of vitriol being dropt into ſome of this putrid blood, raiſed a ſmart effervеſcence, and converted it into a hardened ſpongy kind of ſubſtance.

EXPERIMENT 27.

SIX ounces of this putrid blood being put into a ſmall retort, with two ſpoonfuls of water, were diſtilled by a very gentle heat; about an ounce and half of a tranſparent liquor having come over, the receiver was taken off, and the liquor found to be a phlegm, with a very pungent, and peculiar fetid flavour, not like that of the blood from which it was obtained, but rather more approaching to the ſmell of rotten fiſh.

THIS ſpirit effervefced violently, with the acid of vitriol.

IT changed the juice of rhadiſh ſcrapings to a bright green*.

IT threw down a white precipitate, from a ſolution of corroſive ſublimate.

IT turned a ſolution of copper in an acid to a bright blue.

AND when ſaturated with the acid, and its pungency thereby deſtroyed, when ſome fixed alcali was dropt in, the volatile putrid alcali immediately began to fly off, and ſtruck the noſe with the peculiar ſmell, as ſtrong as at firſt.

So that here are all the plain and diſtinguiſhing characters of the volatile alcali.

* The ſcrapings of radiſhes afford a blue juice, which anſwers much better to try acids and alcalies than ſyrup of violets: The moſt convenient way is to dip little bits of linnen-rag in the juice, and having dried them, lay them by for uſe.

EXPE-

EXPERIMENT 28.

WITH regard to the putrid bile, the *fœtor* here is not at all like, nor indeed ſo pungent or offenſive, as the ſtench of putrid fleſh, or putrid blood; having an oily ſmell, not unlike ſtinking olive oil.

PUTRID bile (it was ox-gall that was tried) ſhews no ſign of alcali; it neither efferveſceth with acids, nor does it change the colour of the blue juices; neither does it throw down any precipitate from the ſolution of the corroſive ſublimate.

EXPERIMENT 29.

TWO ounces of this putrid bile, being diſtilled by a gentle heat, and two or three drachms of a tranſparent liquor having come over, the receiver was taken off, and the produce found to be a volatile ſpirit, with a peculiar fetid ſmell, and a conſiderable degree of pungency; this ſmell differs from that of the putrid bile itſelf, but approacheth nearly to that of the ſpirit obtained from the putrid blood, though not ſo pungent.

BUT this ſpirit made no efferveſcence with acids; and when mixed with the ſolution of the ſublimate, it threw down but little precipitate, even leſs than freſh urine did, when mixed with the ſame ſolution; neither did it turn the blue juice to a green colour; ſo that here there were ſcarce any ſigns of an alcali: The only circumſtance wherein it manifeſted the alcaline nature, was when ſaturated with ſpirit of vitriol; for when its pungency and *fœtor* were deſtroyed, by the power of the acid, upon adding the fixed alcali, the peculiar ſmell of the biliofe ſpirit immediately returned.

IT being ſummer when I was engaged in the above-mentioned experiments, I could not conveniently get any *human bile*, but when winter came on, and the diſſections began at the anatomical theatre, I ſeized the opportunity of collecting a quantity of that fluid; and having ſuffered it to remain in a corked phial for two months, I then made the following trials.

EXPERIMENT 30.

1. I poured ſtrong ſpirit of vitriol on ſome of the putrid bile, but found it raiſe no ebullition.

HAVING put an ounce of the putrid bile into a little retort, and placed it in a lamp

furnace,

furnace, I drew off about two drachms of a tranſparent liquor, with a conſiderable degree of pungency, and a fetid diſagreeable ſmell, like the ſpirit obtained from the ox-gall.

2. Some of this ſpirit being dropt into ſyrup of violets, immediately changed the bluiſh colour of the ſyrup into a pale green.

3. When dropt into a ſolution of corroſive ſublimate, it inſtantly threw down a *white* precipitate.

4. And when dropt into a dilute ſolution of blue vitriol, it cauſed the ſolution to grow turbid, and heightened the blue colour.

5. And yet, notwithſtanding all theſe ſtrong tokens of the *alcaline* nature, the effervefcence was but very obſcure when ſtrong ſpirit of vitriol was poured on the bilioſe ſpirit.

EXPERIMENT 31.

THE putrid liquor which lay about rotten fleſh changed the colour of the blue juices to a dark green. It occaſioned a ſmall precipitation when added to the ſolution of corroſive ſublimate, but it did not effervefce with the acid, until air was tranſferred into it, from a mixture of acid and alcali: This method of treatment, not only made it effervefce, but alfo deftroyed much of the putrid fætor.

EXPERIMENT 32.

WHEN the fætor of this putrid liquor was deftroyed, by pouring vinegar upon it, it returned immediately, on the addition of fpirit of *fal ammoniac*.

EXPERIMENT 33.

THE fame thing happened when the fætor was deftroyed by the pouring of weak fpirit of vitriol on the fame putrid liquor, and afterwards dropping in *lixivium tartari* *.

AND thus we find, that as the *fixed alcali* is ftrong enough to difpoffefs the *volatile*, fo *both* of them have power to expel the *fimple putrid alcali*.

FOR, upon the whole, we may fafely join with *Neuman*, in faying, that as foon as an animal fubftance begins to putrefy, it

* The acid fpirit muft here be pretty much diluted, otherwife it will raife a more difagreeable *fætor*, inftead of conquering the original putrid ftench.

it begins to difcover an alcaline quality, and this volatile matter, now produced in it, may be feparated by diftillation in a very gentle warmth.

WHEN I made the experiments on the putrid blood, related in No. 26 and 27, I had not obferved Dr. *Lewis*'s note upon the above-recited paffage in *Neuman:* and therefore was greatly furprized to find that very ingenious gentleman declare, " That " this general doctrine of the chemifts did " not appear to be ftrictly juft; and that " they feemed to have been mis-led by ap- " plying to all animal fubftances what they " had found to obtain in one, but what a " farther examination fhews to obtain in " very few, if any befides, at leaft in any " confiderable degree."

" PUTRID urine (fays he) gives plain " marks that it contains a volatile alcali, " already generated; but *putrid blood* and " *flefh* are *not fenfibly alcaline*, and yield *no* " *alcali* on diftillation, till after the phlegm " has arifen *."

AFTER reading this note, from fo experienced a chemift, I began to call in

* *Neuman's Chemiftry*, in the note, p. 485.

queftion

queſtion the evidence of my own ſenſes; and had almoſt concluded that, ſome way or other, (though in what I could not poſſibly gueſs) the proceſs had been miſmanaged.

I THEREFORE determined to repeat it, and that with the utmoſt caution and exactneſs.

EXPERIMENT 34.

Two quarts of human blood were put into a retort, which being ſtopped, was ſuffered to remain five or ſix weeks, at the end of which time the blood was found highly putrid; a receiver was now luted on, and the fire raiſed.

THE very firſt drachm or two of the liquor that came over was immediately poured out, in order to examine it.

IT had preciſely the ſame ſmell of the ſpirit obtained in the former proceſs; it *efferveſced* with the *acids*, and ſhewed all the other alcaline properties already mentioned*.

SOME

* The volatile alcali obtained from putrid ſubſtances is not exactly ſimilar to that obtained by violent heat from animal ſubſtances not putrid.

SOME gentlemen of knowledge in chemiſtry were preſent during the diſtillation, and were all thoroughly ſatisfied, that in this matter Dr. *Lewis* himſelf hath been mis-led; and, very poſſibly, in the ſame way that Dr. *Pringle* appears to have been; for ſince *alcalies reſiſt* putrefaction, it was reaſonable to conclude, that putrid animal ſubſtances were little, if at all, alcaline.

BUT the principle on which this action of *alcaline ſalts* depends, has nothing to do, in particular, with *alcali*, being, as will be ſhewn immediately, *common* to all *ſaline bodies* whatſoever.

It differs remarkably in the flavour, which is nauſeous and diſagreeable, is not ſo pungent, and is much weaker, than the common volatile alcali; ſince this laſt, as we have juſt now ſeen, is capable of diſpoſſeſſing the putrid alcali, and of driving it off from any body to which it hath been united.

ESSAY

E S S A Y III.

ON THE

RESPECTIVE POWERS,

AND

MANNER OF ACTING,

Of the different Kinds of

ANTISEPTICS.

Although the arguing from experiments and observations by induction, be no demonstration of general conclusions, yet it is the best way of arguing which the nature of things admits of; and may be looked upon as so much the stronger, by how much the induction is more general. NEWTON.

ESSAY III.

ON THE

RESPECTIVE POWERS, and MANNER of ACTING, of the different Kinds of ANTISEPTICS.

IT was never imagined, until Dr. *Pringle* ſhewed it, that the *Antiſeptic Power* is ſo extenſive; but it appears from the experiments made by that very judicious and learned phyſician, that *ſalts of every kind*, whether *acid*, *alcaline*, or *neutral*, *fixed* or *volatile*, as well as the *aſtringent* and *gummy-reſinous* part of vegetables, all of them reſiſt, and moſt of them, correct putrefaction; and he purſued this branch of enquiry ſo far as to enable him to form a table, ſhewſhing the comparative antiſeptic forces of theſe ſeveral ſubſtances.

HIS being ſo very particular on this head rendered it unneceſſary to repeat the experiments, with regard to all theſe different

ferent ſubſtances; but as I had got into the habit of experimenting, and found great ſatisfaction from this method of acquiring knowledge, I reſolved to try ſome of them; and accordingly began with the *acids*, which, from ancient preſcription, claim the right of being placed at the head of this claſs.

EXPERIMENT I.

HAVING diluted the *acids* of *vitriol*, of *ſea-ſalt*, and of *tartar*, together with *vinegar*, and the *juice of lemons*, all, as nearly as I could judge, to the ſame degree of weakneſs, leaving them juſt ſo ſtrong as to be fairly ſenſible to the taſte, as to change the blue juices into red, and to effervеſce plainly, upon the addition of an alcali; I then put ſome ounces of each into *five* phials, and in every one of them immerſed a little bit of freſh mutton; and a ſixth phial, with nothing but water and a bit of mutton, ſerved as a ſtandard.

THEY were all placed in a moderate degree of heat (on the top of the furnace, along with the fermenting mixtures of the ſecond table) and ſuffered to remain for four days.

Table III. ACIDS diluted tried as ANTISEPTICS.

ACIDS.	AFTER STANDING 24 Hours.	48 Hours.	3 Days.	4 Days.
(1) of Vitriol.	Sweet.	Sweet.	Sweet.	Sweet.
(2) of Sea-falt.	Sweet.	Sweet.	Sweet.	Sweet.
(3) of Tartar.	Sweet.	Sweet.	Beginning to putrify.	Putrid thrown out.
(4) of Vinegar.	Sweet.	Sweet, and much fwelled.	Sweet.	Sweet.
(5) of Lemons.	Sweet.	Sweet, and much fwelled.	Sweet.	Sweet.
(6) Water, as a Standard.	Smell grown offenfive.	Very fetid.	Putrid, and foft.	

IT appears by the foregoing table (the 3d), that they were all, excepting the one in the *acid* of *tartar*, and the ſtandard, ſweet at the end of four days. I hung up all the ſweet pieces in the open air, where they ſoon became dry, and remained ſweet.

THUS it appears that acids, even when greatly lowered, have a ſtrong degree of power to reſiſt putrefaction.

EXPERIMENT 2.

ALONG with this parcel of *acids*, I tried the *fixed* and *volatile alcalies*, diluted to the ſame low degree; but though the *volatile alcali* preſerved the piece of mutton immerſed in it, as well as any of the *acids*, yet the *lixivium tartari* did not keep its ſweetneſs much longer than the ſimple water which ſerved as a ſtandard.

I RESOLVED, therefore, to try the *alcalies*, without lowering them ſo much; and, at the ſame time, was deſirous of ſeeing what ſhare of *antiſeptic power* was poſſeſſed by a *neutral* mixture.

EXPERIMENT 3.

FIVE bits of freſh mutton were put into as many phials, with, 1, *lixivium tartari*; 2, *ſpirit*

2, *ſpirit cornu cervi per ſe*; 3, *ſpirit ſalis ammoniaci cum calce viva*; 4, *ſpiritus mindereri*; and, 5, *water*, as a ſtandard.

THE four firſt were all diluted with water, in the proportion of four to one; and all were left in the common temperature of the air.

THE phials were examined every day, for eight days; and all of them, the ſtandard excepted, which grew putrid in three days, found ſweet; the pieces of mutton in the *alcalies*, grew ſoft and white, like freſh fiſh, but the one in the *ſpiritus mindereri* always preſerved the natural redneſs of the fleſh.

I NOW left off examining them every day, and having laid the phials aſide for three weeks, found all the bits of mutton as ſweet as they were on the firſt day.

THE power of the ſaline bodies was alſo tried, in another manner.

EXPERIMENT 4.

I PUT four pieces of freſh mutton into as many cups, and poured on them ſeverally, 1, *weak ſpirit of vitriol*; 2, *ſpirit of hartſhorn*; 3, *lixivium tartari*; and, 4, a *neutral mixture*, of *fixed alcali* and *vitriolic* *acid*; and having ſuffered them all to remain about ten minutes, by which time they appeared to be thoroughly ſoaked and penetrated, I then threw them all into glaſſes with water, and ſet them by, in the common temperature of the air. The annexed table, No. 4, ſhews how long each of them preſerved their ſweetneſs.

Thus the power of *ſalts in general*, to keep off putrefaction, was moſt ſatisfactorily proved; and as this power belongs to ſaline bodies *in general*, it certainly muſt depend on ſome property which is *common* to them *all* as *ſalts*, ſince we plainly ſee that *acid* and *alcali* have nothing to do here.

With regard to *aſtringents*, Dr. *Pringle*'s experiments ſhew them to be poſſeſſed of a very great degree of antiſeptic virtue; for *allum*, *galls*, *green tea*, and *red roſes*, were all found to reſiſt putrefaction, with a power greatly ſuperior to *ſea-ſalt*.

And the *gum-reſins*, ſuch as *myrrh*, *aſa fœtida*, *aloes*, and *terra japonica*, together with decoctions of ſuch vegetable ſubſtances as abound in *gummy-reſinous* parts, *virginian ſnakeroot*, *pepper*, *ginger*, *ſaffron*, *coutrayerva root*, *ſage*, *valerian root*, and *rhubarb*, *with mint*, *angelica*, *ſenna*, and

common

Table IV. SALINE BODIES as Opposers of Putrefaction.

Spirit of Vitriol.	Spirit of Hartshorn.	Lixivium Tartari.	Neutral Mixture.	Water, as a standard.
Remained sweet 28 Days.	Remained sweet 8 Days.	Remained sweet 4 Days.	Remained sweet 14 Days.	Was putrid in 36 Hours.

common wormwood, all of them ſhewed great antiſeptic power; but none of them came up to *camphire*, in this reſpect, which Dr. *Pringle* thinks may be allowed to keep off putrefaction, with a power *three hundred* times greater than *ſea-ſalt*.

MANY of the common eſculent vegetables, *horſe rhadiſh*, *muſtard*, *carrots*, *turneps*, *garlic*, *onions*, *celery*, *cabbage*, and *colewort*, were likewiſe found to keep back putrefaction.

BUT I do not know how it happened to Dr. *Pringle* *, that he ſhould find *lime water*, " only, to make ſome ſmall reſiſtance to putrefaction," ſince *lime-water* has been univerſally known, to be very powerful in this reſpect; and the late Dr. *Alſton*, who was a man of very great candour and veracity,

* See his 27th experiment.

Dr. *Pringle*, however, may be juſtified in not allowing lime-water to be an antiſeptic; for, in order to conſtitute a true antiſeptic, it is not only requiſite that there be a power to prevent the inteſtine motion, but alſo to preſerve the firmneſs and coheſion. Now lime-water, though it prevents the inteſtine motion, and conſequently hinders the generation of the putrid alcali, yet, by abſorbing the fixed air, it deſtroys the coheſion of the conſtituent particles.

relates

relates a number of experiments, in his Diſſertation on Quick-lime, which put the matter beyond all poſſibility of a doubt; ſo that I am inclined to think, either, that Dr. *Pringle* cut his pieces of fleſh ſo large that the lime-water could not penetrate them, or that his lime-water has been made from ſhells, or chalk, not thoroughly calcined, which might have given the water a diſagreeable ſmell, that was miſtaken for the putrid *fœtor*.

EXPERIMENT 5.

IN order to ſatisfy myſelf in regard to this matter, I put a bit of freſh mutton, of two drachms weight, into an open glaſs, containing ſome ounces of *lime-water*: It was left there for a fortnight, and at the end of that time was found perfectly ſweet; it had indeed grown quite tender, and when it it was cut into, and ſome *ſpirit* of *vitriol* dropt on it, an effervefcence enſued, from the particles of the *quick-lime*, which had penetrated the ſubſtance of the fleſh, and *there* being ſaturated with the *fixed air*, were now returned to their original ſtate of a *calcareous earth*.

THIS circumſtance of the efferveſcence, will, if I miſtake not, lead us to the *true theory* of the *antiſeptic power*, and will ſhew us on what it immediately depends.

WE have ſeen, by the 17th experiment of the preceding eſſay, that putrefaction enſues in conſequence of the *eſcape* of the *fixed air*; therefore, whatſoever hath the power to *reſtrain* the flight of this element, or *hinder* the *inteſtine motion*, will *prevent* putrefaction.

CALCAREOUS *earths*, in their native ſtate, have a ſtrong *affinity* with *fixed air*, and we have ſeen, that upon this account, when they lie in contact with an animal ſubſtance, they attract ſome of this element, and thereby accelerate putrefaction: For here they *cannot penetrate* the ſubſtance of the putreſcent body; they only *ſurround* it: But when theſe earths are calcined, and converted into *quick-lime*, *then* a certain portion of them is rendered *ſoluble* in *water*; the earthy particles, thus minutely divided, are *now* capable of *pervading* the ſoft texture of animal and vegetable bodies; where, as hath been juſt now ſeen, they immediately join themſelves to the *fixed air* of thoſe bodies: So long therefore, as the particles of *lime* remain in this ſituation, ſo long will the *fixed air* remain in a non-elaſtic ſtate, and ſo long will the inteſtine motion, and that particular combination of the inſenſible parts which conſtitutes putrefaction, be kept at a diſtance.

ALL *ſaline* bodies * have a ſtrong *affinity* with *fixed air*; and likewiſe *reſinous bodies* † are moſt *tenacious* of *fixed air*, for they are only ſoluble in water when deprived thereof; and *hence* the *antiſeptic virtue* of *all* theſe ſubſtances; for they are all of them capable of ſuch extremely minute diviſion, that their particles can moſt eaſily pene-

* "For ſince upon the diſſolution of the conſtitu- "ent parts of ſalt by fire, it is found, upon ſeparating "and volatilizing the acid ſpirit, that the air-particles "do in great abundance ruſh forth from a fixed to an "elaſtic ſtate, it muſt needs be that theſe particles did, "in their fixed ſtate, attract the acid ſpirits." *Hales*, vol. i. p. 294.

See alſo *Boerhaav. Elem. Chemiæ*, tom. i. p. 531; where there are further proofs that ſalts have a very great affinity with, and are very tenacious of, fixed air.

† That is to ſay, completely ſoluble; ſince we find that ſome portion of the reſinous part of vegetables diſſolves in water, by means of its ſtrict union with the gummy or mucilaginous part.

trate into any animal, or vegetable body, and *there*, immediately join themſelves to the *fixed air* of thoſe bodies, *where* remaining, they do, like the lime, when divided and diſſolved in water, keep back putrefaction by *preventing* the *inteſtine motion*, and *reſtraining* the *flight* of the *fixed air*.

IF we attend to all the methods that are uſed to prevent bodies from putrefaction and decay, we ſhall find that they moſtly tend to this ſingle point: Timber is covered over with paint, or ſome ſuch unctuous and tenacious matter; fruit *, and other green vegetables, are preſerved the year round, by ſlightly ſcalding them (which thickens their external coats, naturally formed to prevent the eſcape of their air) and then drying them well, and putting them into bottles cloſely ſtopped; the larger kind of ſeeds, ſuch as cheſnuts and acorns, have been preſerved by Mr. *John Ellis*, ſound, and in a condition to grow, for nine months, by rendering their natural, tough, and compact coverings, ſtill more firm, from a thick coat of bees wax and ſuet; fleſh meat of all ſorts is preſerved

* Such as apples and gooſeberries for baking.

on the ſame principle, and may be kept for many months, without much ſeaſoning, provided it be well roaſted or baked, and then covered over with lard, butter, or ſuet; and eggs, it is well known, will remain freſh for a long time, if their ſhells be coated over with melted ſuet, or the like tenacious ſubſtance.

ANIMAL fluids, likewiſe, if the air is not ſuffered to eſcape from them, remain for a great while, without growing putrid; ſurgeons often meet with large collections of extravaſated blood, or ſerum, which, after lying for years, in their own firm and compact cyſts, do not betray any thing putrid on their being firſt let out; but in a very ſhort time after the opening is made, and there is a way for the air to fly off, the diſcharge grows intolerably fetid; and we alſo find, where wounds are made in fleſhy parts by ſimple inciſion, and are ſo circumſtanced as to lay under no neceſſity for frequent dreſſing, that, when carefully kept covered, and the eſcape of the air prevented, they heal in a very ſhort time, without any ſign of ſuppuration, which is a certain degree of putrefaction.

THE

THE principle upon which *aſtringents* become *antiſeptics* is eaſily comprehended.

THE action of *aſtringents* conſiſts in their corrugating, or criſping up the animal fibres, whence the ſolid particles of theſe fibres are brought to a nearer approach, and the power of their coheſion conſiderably increaſed; conſequently, the ſubſtance of the body, ſo acted upon, muſt become more firm, and compact, and this of courſe muſt hinder the *inteſtine motion*, without which there can be no putrefaction.

ALL bodies poſſeſſed of this *aſtringent power*, with regard to the *fibres*, and which, at the ſame time, have a ſtrong *affinity* with *water*, muſt be *antiſeptics* on a double account; accordingly, we ſee whence it ariſes, that *ardent ſpirits*, and the ſtrong *mineral acids*, eſpecially the *vitriolic*, reſiſt putrefaction ſo very powerfully: For theſe not only abſorb the *water* from the putreſcent ſubſtance, but likewiſe criſp up its *fibres*, and thereby render it ſo hard and durable, that no change of combination will take place for many years.

So far in relation to the virtue of things *oppoſing* putrefaction; let us now proceed to conſider thoſe which have the power of

reſtoring

restoring sweetness to substances actually putrid.

EXPERIMENT 6.

HAVING put a number of small pieces of mutton into a phial with water, and placed it in a moderate degree of heat, in order to make them putrefy the sooner, I found them, after standing four days, sufficiently soft and putrid; I then put *five* of these bits of putrid mutton into as many cups, and poured, on the first, *spirit of vitriol*; on the 2d, *spirit of sea-salt*; on the 3d, *vinegar*; and on the 4th, *fresh lemon-juice*; the 5th cup contained only water, and was left as a standard, by which the others were to be compared *.

To have a synoptical view of the changes from day to day, I formed the annexed table, No. 5, and at the expiration of twenty-four hours, found the several appearances exactly as set down in the first column thereof; after forty-eight hours, the appearances were agreeable to the second

* The mineral acids in this experiment were diluted so as to reduce them, as nearly as could be judged, to the strength of the vinegar that was used.

column

Table V. ACIDS tried as Correctors of Putrefaction.

ACIDS of	24 Hours.	48 Hours.	3 Days.	4 Days.
Vitriol.	The bit of putrid fleſh was found hard, ſhrivelled up, and almoſt ſweet.	Entirely ſweet; very much ſhrivelled and hardened.	As on the day before.	As on the day before.
Sea-ſalt.	Not ſo much hardened as in the Sp. Vitrioli, nor ſo much ſweetened.	More ſweet than on the preceding day, but not entirely ſweet.	No change ſince yeſterday.	Putrid ſmell returned.
Vinegar.	Softened ; greatly ſwelled, and entirely ſweet.	No change ſince yeſterday.	No change.	Grown livid, but ſtill ſoft and ſweet.
Lemon-juice.	Softened ; greatly ſwelled, and entirely ſweet.	No change ſince yeſterday.	No change.	Grown perfectly white, but quite ſweet.

column of the table; at the end of three days, things ſtood as in the third; and after four days, the ſeveral bits of the mutton were found in the condition expreſſed in the fourth column.

BEING thus ſatisfied of the power of *acids* to *correct* putrefaction, I threw out all the pieces of the mutton but the 5th, which had ſerved for a ſtandard; reſerving it for another experiment.

THUS it appears, that the *vitriolic* acid has a more powerful antiſeptic virtue than the *marine*; and that both of them ſhew an *aſtringent* quality, by their hardening animal fibres, though in a different degree; and the effect of the *vegetable* acids, in ſo remarkably ſoftening and relaxing the ſolid fibres, gives room to expect great things from their power as reſolvents, when outwardly applied.

SINCE *acids* both *reſiſt* and *correct* putrefaction, it was very reaſonable to expect that all putrid diſeaſes ſhould yield to them, when given in the way of medicine; but *experience*, the only thing on which the *practice* of *phyſic* muſt always reſt, abundantly ſhews that their power in this reſpect is pretty much limited; and that

where

where the putrid matter to be corrected lies beyond the firſt paſſages, *acids* are found quite inſufficient to conquer it.

EXPERIMENT 7.

BUT the *alcaline* ſalts even exceed the *acids*, in regard to the power of correcting putrefaction; for two ſmall pieces of putrid beef, after lying a night in the *volatile alcali* *, diluted with water, in the proportion of four of the latter to one of the former, were found perfectly free from the putrid ſtench; but they were ſo fully charged with the liquors in which they had lain, that not even boiling could deſtroy the peculiar ſmell of the *volatile alcali.*

EXPERIMENT 8.

THE *fixed alcali* likewiſe ſweetens very powerfully: A little bit of putrid beef, from lying twenty-four hours in *lixivium tartari*, diluted with an equal quantity of water, became hard and firm, and was

* Both the mild and the cauſtic alcalies were tried; *viz.* Spiritus cornu cervi per ſe, & Spiritus ſalis commoniaci cum calce viva.

found

found to have no ſmell, but that which is peculiar to the *lixivium*.

EXPERIMENT 9.

BUT the *neutral mixture* does not give ſweetneſs: *Spiritus mindereri*, if made in ſuch manner as to be *perfectly* neutral, ſeems to have no power to correct putrefaction; if the *volatile alcali* is allowed to predominate, the mixture will ſweeten in proportion, for, as hath been juſt now related, the *volatile alcali* is very powerful in driving off the putrid ſtench.

EXPERIMENT 10.

SPIRIT of *vitriol* and *lixivium tartari* being mixed to the point of ſaturation, and a bit of putrid beef being left in the liquor for twenty-four hours, was found not at all ſweetened.

EXPERIMENT 11.

A STRONG decoction was prepared, from equal parts, *tormentill root*, *balauſtines*, *pomegranate peel*, and *red roſes*, and a bit of putrid beef was immerſed in the liquor; the *fœtor* ſeemed rather increaſed than diminifhed, by lying twenty-four hours in this decoction.

EXPERIMENT 12.

THE fame thing happened with *lime-water*, which, notwithftanding it *refifts* putrefaction fo ftrongly, appears to have no power to *correct* it.

EXPERIMENT 13.

NEITHER have *ardent fpirits* the leaft power to deftroy the putrid ftench, any further than as it is, in fome degree, obfcured by their own peculiar flavour.

EXPERIMENT 14.

STRONG decoctions of the *bark*, and of *valerian*, together with ftrong infufion of *chamomile flowers*, were alfo tried as fweeteners. After fuffering three fmall pieces of putrid flefh to lie thirty-fix hours in thefe liquors, I could fcarcely take upon me to fay they were fweetened; the putrid ftench indeed was rendered more tolerable, by the fmell of the liquors, but did not feem to be much conquered.

FOR unlefs the decoctions be frequently renewed, as was done by Dr. *Pringle*, fo as as by repeated affuſions the viſcid particles of the gum-reſin may be applied in ſuch quantity as will wholly entangle and fix the volatile particles of the *putrid alcali*, the effect is but ſmall; excepting the putrid body is allowed to remain long enough in the decoction or infuſion for a *fermentation* to begin, which will indeed effectually change the ſtate of the mixture, and produce ſuch a new combination as will maintain its ſweetneſs for a conſiderable length of time.

THIS power of *fermenting mixtures* to *reſtore* ſweetneſs was diſcovered by Dr. *Pringle*; but as I have made ſeveral experiments in relation thereto, I ſhall here lay them before the reader.

EXPERIMENT 15.

WHILE the 6th experiment, with regard to the power of acids in correcting putrefaction, was going on, I one evening took a bit of the mutton out of the *ſtore phial*, which was grown, by that time, exceedingly ſoft and putrid, and having faſtened it to a thread, immerſed it, at eight o'clock, in a vat of *melaſſes waſh*, at the diſtillers, then in a degree of fermentation, rather upon the decline. Next day at noon, I took it out, and having washed it in water, in order to free it from the smell of the liquor in which it had been lying, found it perfectly sweet and firm.

As this piece had been rendered so intirely sweet and firm, and, to all appearance, sound, for it looked like a bit of meat that had been slightly fried, I conjectured that it might not be necessary for it to lye so long as sixteen hours; I therefore obtained a gallon of the wash from my friend the distiller, that I might examine the progress at home, and at my leisure.

EXPERIMENT 16.

I plunged into this gallon of fermenting liquor the very identical piece of mutton that had served as a standard in the 6th experiment, on the acids; and which, from lying in an open cup for several days, was grown so soft that I was obliged to tie it round with a piece of thread, (for, when the thread was passed through it, the flesh was so tender that it would not hold) and so extremely putrid that the stench was intolerable.

IN *one* hour the putrid ſmell was much abated, and at the end of *five* entirely gone, the meat being now firm, and perfectly ſweet; it was hung up in the open air, where it ſoon became dry, and remained ſweet ever after.

EXPERIMENT 17.

IN order to ſee whether this change depended on the liquor, or on the vapour, I ſuſpended a thin bit of putrid mutton, from the *ſtore phial*, in the mouth of the veſſel wherein the *waſh* was fermenting, but ſo as not to touch the liquor, and left it there during the night; in the morning it was found plumped up, ſweet, and firm.

THIS experiment I frequently repeated, and always with ſucceſs; but whoever chuſes to try it, muſt take care that the pieces of putrid meat be cut thin, ſo as the vapour may have power to pervade them, otherwiſe the ſweetneſs will not be completely reſtored; whereas, when the experiment is made with the liquor, and the pieces of putrid fleſh are ſuffered to lie ſoaking in it, they may then be cut of any ſize that the party pleaſes; for if time be given, the ſubtile *gas* will penetrate, and produce its effect.

EXPERIMENT 18.

Even *acids* will ſweeten pretty large pieces; two bits of putrid beef, of an ounce weight, were left ſeverally in *diſtilled vinegar*, and in *melaſſes waſh*, juſt as it had done working.

The firſt was found very much, though not entirely, ſweetened, after lying twenty-four hours; but the ſecond was rendered perfectly ſweet. In order to ſee if they were thoroughly penetrated, and ſweetened to the heart, I boiled both the pieces, and was ſurprized to ſee the one which had lain in the *acid* go all to pieces in the boiling, which I thought the more odd, as it had been rendered hard and firm; an effect wherein the *diſtilled* vinegar differs widely from that which is *not* diſtilled. This diſſolution I aſcribed to the peculiar *diſſolvent quality* of the vinegar, and did not believe, until I tried it, that a *mineral acid* would produce the ſame effect.

EXPE-

EXPERIMENT 19.

BUT an ounce of putrid beef, after lying twenty-four hours in *dilute ſpirit* of *vitriol*, and coming out perfectly hard, ſweet, and contracted, upon being boiled, fell all to pieces, exactly as did the one which had lain in the diſtilled vinegar; and when rubbed between the fingers, it melted away like ſo much wet paſte. To be certain that nothing of this was owing to too much boiling, I put a little bit of beef, of a drachm weight, that had been ſweetened by the *volatile alcali*, into the veſſel along with it, and ſuffered it to remain the whole time of the boiling; but it came out white and firm, and, as hath been mentioned already, ſtrong of the *volatile alcali*.

FOR the *alcalies* cannot be ſaid, with *propriety*, to *reſtore* ſweetneſs; they only drive off a *weaker* alcali: As the *fixed* alcali can diſpoſſeſs the *volatile*, ſo both of them have the power to drive off the *ſimple putrid* alcali; and thus the putrid ſubſtance becomes the *baſis* of a *ſtronger*, inſtead of a *weaker*, alcali*.

* See the 27th, 29th, 31ſt, and 32d experiments of the preceding eſſay.

THE manner in which *acids* ſweeten putrid fleſh ſeems alſo pretty plain; for their action appears to conſiſt in *ſaturating* and *fixing* the *putrid alcali*, and by thus deſtroying its *volatility*, they hinder the putrid *fœtor* from flying off, and ſtriking the organs of ſmell; but at the ſame time that *acids* do this, they *diſſolve* the *elementary earth*, and thus deſtroy the texture of that ſubſtance whoſe ſoundneſs they were ſuppoſed to reſtore. Whereas, the peculiar excellence of the fermenting liquors is, to reſtore ſweetneſs to the fluids, and firmneſs to the ſolids.

EXPERIMENT 20.

Two pieces of linnen rag were dipt in the putrid liquor of the *ſtore phial*; one was ſuſpended over the *waſh* in fermentation, and the other was hung up in the open air. In two hours the one expoſed to the *vapour* became almoſt ſweet, the other remaining as offenſive as at firſt; and in ſix hours, the firſt piece of rag had no ſmell but that of the vapour; while the other, though now grown dry, ſtill ſtrongly retained the putrid ſtench.

As

As ſugar is an antiſeptic, in conſequence of its ſaline nature, I did not know but ſomewhat of the virtue of the *melaſſes waſh* might depend on this circumſtance.

IN order to determine this, I immerged one ſmall bit of putrid fleſh in a mixture of bread and mutton, with lemon-juice, and ſuſpended another in the neck of a phial containing a fermenting mixture, with ſpinnage; and found, after eight hours, that both of them had loſt the putrid ſtench, and had now no other ſmell than that of the mixtures; which, as hath been elſewhere obſerved, was ſweetiſh, and not unlike fenugreek ſeed. The like experiment was tried with another fermenting mixture, as the reader will find by turning back to the 47th page.

Dr. *Pringle* ſeems to think, that the putrid ſmell in theſe mixtures is deſtroyed by the *acid* which is produced in the courſe of the fermentation. Relying on his authority, I was for ſome time of the ſame opinion, and looked on the *ſubtile gas* as ſomewhat of the nature of a *volatile acid*; for I had *then* the *ideas* of *acid* and *antiſeptic* ſtrongly connected together in my mind:

mind: but, upon enquiry, this notion was found to be void of foundation.

EXPERIMENT 21.

FOR one piece of linnen rag dipped in *lixivium tartari*, and another tinged *blue* by the ſcrapings of *rhadiſhes*, were expoſed for eight and forty hours to the vapour ariſing from a large vat full of melaſſes waſh, in high fermentation; yet the firſt was not at all ſaturated, nor the laſt in any, even the ſlighteſt degree, changed red.

AND in all the fermenting mixtures that I tried, none of them became ſour, excepting one (No. 6, table 1), for ſeveral days after the firſt ſtage of the fermentation had ceaſed *.

EXPE-

* In order to ſee how long theſe kinds of mixtures would preſerve their ſweetneſs, I reſerved three of the 14th experiment of the ſecond eſſay; to wit, thoſe with the barley, the rice, and the oats.

Into the phial with the barley I put about half an inch of a thread which had been dipped in a putrid animal fluid; into the one with the rice I poured a tea-ſpoonful of vinegar; the third, with the oats, was left without any addition.

All the three mixtures were now at reſt, having run through their firſt ſtage, and being every one perfectly ſweet,

EXPERIMENT 22.

Two drachms of the *cortex* in powder, and half an ounce of *ſaliva*, were added to a mixture of *ox-gall* and *water*, which was grown *putrid*, for it had been uſed

ſweet, they were left in the common temperature of the air; the phials not cloſely ſtopt. (This was in the month of *July.*)

For three weeks, no alteration was perceivable in any of them; but at the end of that time, the mixture into which the putrid ferment had been put began the inteſtine motion, which continued, in a gentle degree, for ſeven or eight days before the mixture became fully putrid.

The phial into which the vinegar had been thrown, began, at the three weeks end, to ſhew ſome ſmall ſigns of inteſtine motion; a thick, white ſcum formed on the ſurface, and it did not grow putrid until it had ſtood, in all, ſix weeks.

The third mixture, to which nothing had beed added, remained quite at reſt, without ſhewing any ſigns of motion for two months; then it was found to have grown ſour, and had contracted acidity ſufficient to curdle milk, and to raiſe an ebullition when ſome ſalt of hartſhorn was thrown into the phial.

I now corked the phial, and ſet it aſide for three months; and then, having diſtilled the mixture by a very gentle heat, I obtained a *volatile alcaline ſpirit*, of a peculiar ſmell, not unlike that obtained from the putrid blood formerly mentioned.

as a ſtandard to two mixtures of gall and *teſtacea.*

UPON the firſt mixture, the *fœtor* increaſed greatly, and the bark ſeemed to act on the putrid bile in a manner not unlike the action of *lime*, or *fixed alcali*, when mixed with *crude ſal ammoniac*, in order to drive off the *volatile alcali*.

THE mixture was now laid by for twenty-four hours, at the expiration of which I found the putrid ſmell much abated, and a fermentation beginning; I now ſuſpended a little bit of putrid fleſh in the neck of the phial, and placed it in a moderate degree of heat. When twenty-four hours more were elapſed, I again examined the mixture, which was ſtill in briſk motion, and found that it had entirely loſt the *fœtor*, having now acquired a new and peculiar ſmell, which was not only ſweet, but agreeable, and different from the original ſmell, either of freſh bile, or of the *cortex*.

THE bit of putrid fleſh was found ſweetened; having removed it, I fixed the bended glaſs tube as deſcribed formerly, and, by means thereof, joined a ſmall phial, containing a drachm of *non-efferveſcent*, *volatile*

volatile alcaline ſpirit, to the phial which held the fermenting mixture: They were left in conjunction for twenty-four hours, and when ſeparated, ſome *ſpirit of vitriol* being dropped into the ſmall phial, raiſed a ſmart ebullition.

IT has been ſhewn in former experiments, how readily the *bark* runs into fermentation out of the body, and it was then hinted, that there is great reaſon to expect that it will be ſtill more prone to ferment in the body, when opened by the digeſtive fluids; and the preſent experiment ſhews plainly, that when opened by fermentation, the *cortex*, like the *melaſſes*, and other things that were tried, gives out ſome ſubtile matter, which hath the power of reſtoring ſweetneſs to putrid animal ſubſtances: Is it not agreeable, then, to reaſon as well as experiment, to account for its *antiſeptic* virtue upon this principle?

IF we attend to the nature of the diſeaſes wherein the bark is found moſt uſeful; and, on the other hand, remark thoſe caſes wherein it either does harm, or proves of no effect, we ſhall find ſome ground for eſtabliſhing this *hypotheſis*.

FIRST, the *cortex* is of the higheſt ſervice in *gangrenes*, where the veſſels are relaxed, and the blood diſſolved; 2, in wounds and ulcers, where the ſolids and fluids are in the ſame weak and diſſolved ſtate; 3, in the low ſtate of malignant fevers, and ſmall-pox, where the humours are evidently putrid; 4, in intermittent fevers, where almoſt every ſymptom betrays evident marks of a putrefactive acrimony.

IN theſe laſt it ſeems to be the moſt plauſible opinion, that the cauſe is ſeated originally in the flexure of the duodenum *; here the *cortex* comes into immediate contact with the putrefactive *colluvies*, and *preſently* † running into fermentation, ſoon throws off a quantity of the ſubtile vapour, ſufficient to ſaturate the acrimonious matter; which being thus

* See *Hoffman*, in the chapter *de conſenſu partium nervoſarum generatim & ſigillatim cum ventriculo. Pringle*, p. 330. And *Cleghorn's Diſeaſes of Minorca*, p. 161 & 183.

† The putrid matter will encreaſe the tendency to putrefaction. Thus we ſee how well it is adapted to work out its own cure, provided it be ſupplied with proper materials.

rendered

rendered mild and ſweet, the febrile commotion, which would have enſued had this irritating cauſe not been removed or corrected, is now prevented.

IN this caſe, we have ſuppoſed the general maſs of fluids to be untainted; but, even in caſes where the putrefactive acrimony has made further advances, and has actually taken place in the conſtitution, if the medicine be continued, and given in large quantities, its ſalutary effects will preſently appear, and will ſhew that the *antiſeptic vapour* can reach the blood, and *there* reſtore its conſiſtence, and correct its ſharpneſs.

BUT this valuable drug has another great advantage. Beſide its readineſs to ferment, and being able to yield a large proportion of the *antiſeptic vapour*, it hath alſo a remarkable power of bracing up and ſtrengthening the vaſcular ſyſtem; thus enabling the powers of the body to concoct the morbific matter, and expel it by the proper emunctories: For it is obſervable, that, after a liberal uſe of it, profuſe evacuations of urine and ſweat often enſue, and ſometimes beneficial diſcharges by ſtool; then, when the offending matter is ſo thrown off or corrected, the aſtrictive quality of the bark braceth up and ſtrengthens the ſolid fibres, which had been relaxed and weakened by the putrefactive acrimony.

BUT in diſeaſes where there is an inflammatory tendency, where the veſſels are full, the fibres tenſe and rigid, and the blood thick and ſizey, then is the bark hurtful and dangerous; becauſe, it throws *much air*, and *no water*, into the blood, and conſequently muſt highly increaſe the morbid diſpoſition of the fluids, while, at the ſame time, its aſtringent virtue muſt add to the *tenſion* of the *living ſolids*.

FOR this *ſubtile antiſeptic vapour* appears to conſiſt chiefly, if not altogether, of the *fixed air* of the fermenting ſubſtances; ſince I have found, by experiment, that as as the *fixed air* thrown off by *efferveſcence* agrees with the *gas ſylveſtre*, in *ſuffocating animals*, ſo does it agree with the ſame *gas*, in the property of *reſtoring ſweetneſs*.

EXPERIMENT 23.

A SMALL piece of putrid beef, taken immediately from the liquor in which it lay, was put into a cup with ſome *lixivium tartari*,

tartari, and on it was poured by degrees, a ſufficient quantity of *ſpirit* of *vitriol*.

THE moment the ſaturation was complete, the bit of beef was taken out, and found to have almoſt entirely loſt the putrid *fœtor*; what ſmell it now had, was rather to be termed muſty than putrid; on waſhing it in clean water, this muſty ſmell went off, and a very little of the putrid was again to be perceived.

EXPERIMENT 24.

ANOTHER bit of the ſame putrid beef was put into a cup, with ſome *ſalt* of *hartſhorn*, and on them vinegar was poured, to the point of ſaturation: Immediately on the ceſſation of the ebullition, the piece of fleſh was taken out, and found to have *entirely* loſt the *fœtor*, having now no ſmell but that of the neutral mixture, which is not unlike the ſmell of burnt horn; but upon waſhing the beef, this ſmell went off in great meaſure, and not the leaſt of the putrid ſtench was to be perceived. This bit of beef was much ſofter than the one in the foregoing experiment, where the effervеſcence was not near ſo violent, and did not laſt ſo long, as in this preſent mixture;

ture; and hence I concluded, that this ſaſt piece of the putrid fleſh was ſo much more ſweetened, becauſe of its having an opportunity to *abſorb* a much greater quantity of *air* than the other one had.

BOTH theſe pieces were boiled, and both came out perfectly firm; the laſt piece, upon being cut into, was found ſweet to the very heart; but the other was found not to have been ſo thoroughly pervaded, as it diſcovered a little of the putrid ſmell on being divided.

EXPERIMENT 25.

A BIT of putrid fleſh, of about a drachm, was put into the phial C, as in figure 1, which previouſly had a drachm or two of *ſal cornu cervi* thrown into it, the glaſs tube was fixed cloſely into the neck of the phial, and the other extremity of the tube inſerted into a ſmall phial, with half a drachm of the putrid liquor that lay about the rotten fleſh; vinegar was now poured through the funnel, to raiſe an ebullition. When the ſalt was all diſſolved, and the efferveſcence at an end, the phials were ſeparated; the bit of beef was now found ſweet, and the putrid liquor, which before

fore ſhewed no ſigns of ebullition upon dropping an acid into it, *now* efferveſced plainly, on the addition of *ſpirit* of *vitriol*; and it had beſides loſt much of the putrid *fœtor*.

AND thus we ſee, that fermenting and efferveſcent mixtures are the moſt powerful of all known *antiſeptics*.

SOME ſhare of this power remains in liquors after they have run through their firſt ſtage of fermentation, which is different in different liquors; as may be ſeen in the annexed table (No. 6), and ſeems to depend on the quantity of the ſubtile vapour which is left in the liquor, ſince thoſe that are moſt ſparkling and briſk, are found to poſſeſs the greateſt ſhare of antiſeptic power *.

THE *fixed air*, when transferred from a ſound body into one that is putrid, appears

* "When, by fermentation, the conſtituent parts "of a vegetable are ſeparated, part of the air flies off "into an elaſtic ſtate; part unites with the ſalt, oil, "and earth, which conſtitute the tartar; the remainder, which continues in the fermented liquor, is "there, ſome of it in a fixed, and ſome of it in an "elaſtic ſtate." *Hales*, vol. i. p. 300.

Table VI. COMMON FERMENTED LIQUORS tried as Sweeteners of Putrid Flesh.

Claret.	Lisbon White Wine.	English Cyder, (bottled.)	Common Dublin Ale.	Melasses Wash, (newly fermented.)	Sugar and Water, (not fermented.)
At the end of 30 hours, the bit of putrid meat was found perfectly sweet and firm.	At the end of 12 hours, the bit of meat was found perfectly sweet.	At the end of 8 hours, the bit of meat was found quite sweet.	After 24 hours, not at all sweetened. *N. B.* This kind of ale is but of the weaker sort, and generally not very brisk.	In 12 hours, the bit of putrid meat became perfectly sweet.	After 24 hours, not at all sweetened.

to reſtore to that body the *principle* that had been deſtroyed or loſt *.

BUT here it may be demanded, what can theſe experiments prove with regard to the reſtoration of putrid fluids, in a living body; is it poſſible to ſaturate theſe humours with ſuch a quantity of air as will be ſufficient to *correct* their *ſharpneſs*, *reſtore* their *conſiſtence*, and *bring back* their *ſweetneſs?*

To this it may with ſafety be replied, that it is not only poſſible, but that it is, perhaps, the only way by which this change can be produced.

FOR we have ſeen that there is a deception, in regard to both *acids* and *alcalies*, when we ſuppoſe them to reſtore ſweetneſs to a putrid animal ſubſtance; that the *firſt*, ſo far from giving ſoundneſs to ſuch kind of ſubſtances, do in reality deſtroy their *texture*; and that the *ſecond* only change the nature, but do not reſtore the original ſweetneſs.

* The manner of acting of air, when transferred into a body whoſe texture is broken and diſſolved, will be better comprehended from ſome experiments hereafter to be mentioned in the 5th Eſſay; the thing being, in ſome degree, rendered viſible.

BUT *acids*, we have likewiſe ſeen, are *neutralized**, during the alimentary fermentation, and therefore they cannot act as acids, by ſaturating any thing of the *alcalious* kind that they meet with in their courſe of circulation. The power of *acids* therefore, is confined; and we are not to expect, that they are to pervade the minute branches of the vaſcular ſyſtem; indeed, it is evident, that they *ought not* to be allowed to paſs into the *blood* in their *acid form*, ſince it is plain, that, from their diſſolvent nature, the body muſt be deſtroyed, and its moſt ſolid parts melted down to a jelly, if *naked acids* were to be received into the general maſs of fluids †: Their action, therefore, cannot extend beyond the limits of the alimentary canal, where they may come into contact with, and correct the ſharpneſs of a putrid colluvies. In theſe caſes they may, and actually do, exert very notable powers, as is

* See the 3d and 5th experiments of the 2d Eſſay.

† In thoſe deplorable caſes that now and then happen, where all the bones become ſoft, a manifeſt acidity hath been diſcovered in the fluids; a thing never obſerved in other morbid caſes. See *Haller. Element. Phyſiolog.* tom. ii. p. 94.

often

often experienced, by their preventing ſickneſs and nauſea, and reſtraining vomitings; and by neutralizing, as it may be termed, the putrefactive matter, thus prevent it from carrying into the blood its peculiar deſtructive quality.

IT is a point not yet thoroughly ſettled, whether *alcalies* do in reality promote putrefaction in *living bodies*; there can be no doubt of their power to reſiſt and correct putrefaction, in *dead bodies*; but whether, upon the preſumption of this virtue, they can be given with propriety, as antiſeptics, is not ſo clear.

A VERY eminent and ſucceſsful practitioner is of opinion, "That the exhibition "of volatile alcalious ſalts to the ſick, in "putrid diſeaſes, is adding fuel to the fire; "for they certainly diſſolve or break the "globules of the blood, and thence more "ſpeedily bring on the general putrefac- "tion." And he relates a ſingular caſe, where an uncommon quantity of *ſalt of hartſhorn* being taken by a young gentleman, and the uſe of it continued, "An "hectic fever enſued, as alſo vaſt hæmor- "rhages from the inteſtines, noſe, and "gums; every one of the teeth dropped "out, and the patient could eat nothing "solid; he wasted vastly in his flesh, and "his muscles became as soft and flabby as "those of a new-born infant; and broke "out all over his body in pustules, which "itched most intolerably, so that he "scratched himself continually, and tore "his skin with his nails in a very shock- "ing manner; his urine was always exces- "sively high-coloured, and very fœtid*."

ASTRINGENTS, as hath been shewn, prevent putrefaction very powerfully, but we find that they have not the least degree of power to correct it.

BUT putrefactive acrimony first takes place in the *fluids*, and it is on account of *their* indisposition, and the destructive and

* *Huxham on the Sore Throat*, p. 67 & 68. The acrimony in this case, however, appears to have been what *Gaubius* terms, "*Acre alcalescens volatile purum*;" which, though a component part, is not to be confounded, or looked on as the same, with the real and genuine putrid acrimony.

Gaubii Init. Patholog. sect. 310 & 312. Putrid acrimony seems to consist in an over-proportion and irregular combination of the saline and phlogistick or oily particles of the blood; these particles being left at liberty to run into this destructive combination from the want of their *bond of union*, the *fixed air*.

irregular

irregular combination of *their* particles, that the texture of the *ſolid fibres* is weakened, and their coheſion impaired; therefore, bracing up and ſtrenghtening the ſyſtem of ſolids, while the maſs of fluids continues in the morbid ſtate, can avail nothing; it is beginning the cure where it ought to be concluded.

ASTRINGENTS, therefore, as *antiſeptics*, can only be of importance in thoſe caſes, where, from extreme relaxation and reſolution of the ſolids, the diſſolved fluids are ſuffered to tranſude, and either form ſpots of different hues, or run off by actual hæmorrhage; here indeed, the *acid* of *vitriol*, as an *aſtringent*, *not* as an *acid* (for *vinegar* would do nothing in this caſe) is found of great uſe, in *gaining time*; either, till the powers of the animal œconomy correct the morbid diſpoſition of the fluids, or that the ſame thing is brought about by the virtue of ſome efficacious *antiſeptics*, ſuch as the *cortex*, which is the thing uſually joined with the *ſpirit* of *vitriol*, and that with the greateſt propriety, on account of its own aſtrictive quality, as well as extreme readineſs to run into fermentation;

tion; which is the circumſtance that conſtitutes a true and genuine antiſeptic.

THE phyſician who gives aſtringents in theſe caſes, and with theſe views, acts not unlike a ſurgeon who ſecures and ties the blood-veſſels that are divided in the beginning of an operation, in order to allow himſelf ſufficient time to finiſh it with ſafety and regularity.

INDEED, the credit that *acids* have gained as *antiſeptics*, hath reſted much on the ſucceſs that has attended their exhibition in the circumſtances above-mentioned; but that they act in theſe caſes as *mere aſtringents*, may be found from a cloſe attention to the progreſs of the cure.

LET any one read the very remarkable caſe in Dr. *Huxham*'s Treatiſe on Fevers, (p. 62) and it will plainly appear that the *acid* of the *vitriol* braced up the fibres, checked the tranſudation of the diſſolved blood, and thus obtained a truce until the repeated doſes of the *cortex*. "The *rice*, "the *panado*, the *ſago*, the *hartſhorn-jelly*, "well acidulated, and the *toaſt* out of *cla-* "*ret* and *red port wine*," generated enough of the *antiſeptic vapour* to ſaturate and correct,

correct, in ſome degree, the putrefactive acrimony, whereby the patient was enabled to get upon his legs, when exerciſe, and a proper diet, reſtored him to his perfect health *.

AND to ſhew this ſtill further, in a caſe no leſs deplorable, I ſhall give the following, communicated by Dr. *Archer*, phyſician to *Stevens's Hoſpital* in *Dublin*.

THOMAS BROWN, a robuſt countryman, of about twenty-four years of age, was admitted, the firſt of February, 1762, a ſurgical patient into Dr. *Stevens's Hoſpital*, for an *Herpes exedens*, which extended from the nape of the neck to the inferior part of both *ſcapulæ*. After having been purged, on the 5th he was ordered to take ten grains of the blue pill every day, which he did until the 25th; ſo that in this time he had taken near two hundred grains of *mercury*, without any appearance of ſalivation †.

ON

* There is a caſe in *Sydenham* equally ſtrong in regard to this point; it was communicated by Dr. *Goodall*, and is to be found in the Letter to Dr. *Cole*, concerning the ſmall-pox and hyſteric diſeaſes.

† This blue pill uſed in Stevens's hoſpital conſiſts of

 nothing

ON the 26th, he complained of ſickneſs in his ſtomach, entire loſs of appetite, and great warineſs; the ulcer had not mended; he was therefore confined to his bed, and ordered to drink plentifully of warm diluting liquors. The 27th, there appeared numerous *petechiæ* on his whole body. The 28th, the number of theſe increaſed, and appeared livid. The 1ſt of March, he had a hæmorrhage from the noſe, which was attempted to be ſtopt by different ſtyptics; but theſe cauſing him to ſneeze, rather increaſed the bleeding: The ſame evening he was ordered a vomit, which he took, and another next morning; by theſe the bleeding likewiſe encreaſed.

THE apothecary of the houſe (it not being the phyſicians' viſiting-day) then ordered him three ſpoonfuls of the following mixture, to be taken every two hours.

℞. *Aq. Menth. vul. Sim. Tinct. Roſar. cum triplici quant. Elix. Vitriol. Acid.* aa *uncias tres Tinct. Cort. Peruv. uncias duas.*

nothing but crude mercury, and as much Venice turpentine as is ſufficient to extinguiſh the quickſilver.

Tinct.

Tinct. Martis in Sp. Salis, Sescunciam M.

THIS, he ſaid, reſtrained the hæmorrhage; but, on the 3d, blood came away abundantly in his urine.

HE continued the above mixture until the 4th, when I was deſired to ſee him: I found him greatly exhauſted, his pulſe quick and weak, frequently ſpitting black coagulated blood, his urine the colour of blood, his body thickly covered over with *petechiæ*, red and livid, which here and there ran into *vibices*, as if he had been ſeverely ſcourged.

I ORDERED him to take a drachm of the *cortex* every hour, waſhing it down with four ounces of the *infuſum amarum* of the London diſpenſatory, with thirty drops of the *acid elixir* of *vitriol* in each doſe.

AFTER taking a few doſes, he imagined himſelf better; and therefore, of his own accord, took it every half hour. The 7th, the blood diſappeared from his urine, and greatly abated from his mouth and noſe; the livid *petechiæ* changed to red, and the *vibices* into diſtinct *petechiæ*. The 11th, all the hæmorrhages ceaſed, and the pete-

chiæ

chiæ had almoſt diſappeared. On the 15th, they were entirely gone. He continued his medicine, however, until the 27th; on which day, his *herpes* was completely ſkinned over. During this time, *viz.* from the 3d to the 27th, he took *fifteen ounces* and ſix drachms of the *cortex*.

THE antiſeptic virtue of the other gummy reſinous vegetables, if we may judge of them all by this capital one, the *cortex*, appears alſo to depend on their fermenting in the body; and as theſe ſubſtances contain a large proportion of the *fixed air*, they muſt part with much of it in the courſe of their fermentation: For now that we have taken a view of the ſeveral kinds of *antiſeptics*, and have ſeen how much the action of *ſalts*, and of *aſtringents*, is limited, we find that the only dependance muſt be on thoſe things that throw a *great quantity* of *air* into the blood, if we expect to work a complete change on the whole maſs.

IF we attend alſo to the things that *prevent* putrefaction in *living* bodies, we ſhall ſtill find that the dependence is on the quantity of *air*.

THERE

THERE can be no doubt but that it is the vegetable part of our food which yields by far the greateſt ſhare of the air, that enters the compoſition of the animal fluids; and *vegetable food* moſt certainly prevents the *putrefactive diatheſis.* Dr. *Pringle* aſcribes it, and with great juſtice, to the frequent uſe of freſh vegetables and ſugar, which now make up ſo great part of the diet of the *European nations*, that we at this day ſo ſeldom hear of the dreadful putrid diſeaſes which formerly ſwept off ſuch multitudes, every thirty or forty years, and generally went under the name of plagues *.

THE effects of being deprived the uſe of freſh vegetables, are ſtrongly manifeſted in the fatal ſcurvies, fevers, and dyſenteries, to which ſeamen, and people pent up in garriſons, are often ſubject: In ſhort, this matter is ſo well known, and every body is ſo ſenſible of it, that it would be a treſpaſs on the reader to inſiſt on every particular inſtance; I ſhall therefore only requeſt, that he may obſerve, in general, the kind of diet which is moſt wholeſome

* See alſo *Hoffman*, in the chapter *de Venenis in Aere Contentis*, &c. ſect. 26.

in hot climates; that it muſt, in order to preſerve health, conſiſt very much of vegetables, and of thoſe kinds which produce the greateſt quantities of air, in order to afford a ſufficient ſupply of *antiſeptic vapour*, to make up for the extraordinary waſte of air which is carried off from the fluids by profuſe perſpiration; and that thoſe people muſt inevitably fall into putrid diſeaſes, who eat much animal food, which produceth but little air, who drink much ſpirituous liquors, that contain no air themſelves ſcarcely, and prevent the ready extrication thereof from the aliment, during the digeſtive proceſs, and who incautiouſly expoſe themſelves to a moiſt atmoſphere, which hinders any thing but the *aerial* part of the perſpirable matter to be carried off.

ON the other hand, in the cold climates, we may more ſafely indulge in animal food, and in ſpirituous and fermented liquors, becauſe, in theſe, the expence of air by perſpiration is ſo much leſs.

TAKING the matter in this light, we may poſſibly aſſign reaſons,

1. Why carnivorous animals perſpire but little? A fox, though hunted almoſt to death, never ſweats.

2. Why animals, whoſe food conſiſts entirely of vegetables, perſpire ſo much? Horſes and cows, for example; how often are theſe creatures ſeen involved in a cloud of their own vapours, and covered over with froth?

3. Why animals, whoſe natural food is vegetables, can be kept alive and in health, in very cold climates, by feeding upon animal ſubſtances? Cows in *Norway* and in *Iceland* are fed, in winter, upon fiſh-bones.

THIS general and well-known *antiſeptic* quality in *vegetable food*, is commonly accounted for by ſaying, that it produceth *aceſcent chyle*; but *alcaleſcent* or *putreſcent* vegetables are equally powerful, in this reſpect, with the aceſcent; therefore, the antiſeptic quality muſt depend upon ſomewhat that is general, and common to all vegetables *.

INSTEAD

* By far the greateſt ſhare of the vegetables uſed in common diet, if we except the *fruits* and *farinacea*, are alcaleſcent or putreſcent; witneſs all the different kinds of *braſſica*, the *naſturtia*, *onions*, *leeks*, *garlick*, *horſe-rad-*

diſh,

INSTEAD of calling *chyle* produced from a vegetable diet *acefcent*, we fhall fpeak with more propriety, as well as approach much nearer the truth, by terming it a fluid compofed of animal and vegetable juices, in the *firft* or *fweet* ftage of *fermentation*, impregnated and fully charged with a fubtile, active, and penetrating fpirit, which is highly antifeptic.

THIS notion of *acefcent chyle* has fuch an influence on the practice of phyfic, that it is apt to prefent *acids alone* to the confideration of the phyfician, in *putrid cafes*, and too often diverts from thofe things that are the true oppofers and genuine cor-

difh, muftard, raddifhes, fpinnage, endive, purflain, lettuces; not one of thefe things can be called acefcent, and yet they preferve the humours from putrefaction, or correct it when prefent, as effectually as forrel or lemon-juice. We fometimes find in fyftematic writers, laid down among the general caufes of the *putrefactive diathefis*, the too liberal ufe of fuch fort of vegetables; but I apprehend there are few, if any, inftances of a putrid difeafe arifing from the ufe of any found, fermentable vegetable.

Indeed, where people have been obliged to feed on fuch vegetables as were unfound, and incapable of the alimentary fermentation, there it will readily be granted, that the very worft of putrid difeafes have enfued.

rectors of putrefaction, namely, fresh vegetables, and other fermentable matters, which readily yield a large proportion of *air*, since *this*, upon comparing all the circumstances, will be found the *grand antiseptic* *, which not only has the power to *preserve* animal fluids from corruption, but can also *restore* them, after having undergone some degree of putrefaction.

BUT what proves, almost to a demonstration, the antiseptic power of *air*, is the cure of the *sea-scurvy*. This disease, wherein the whole mass of fluids is dissolved and corrupted, cannot be cured by any other means than by throwing in a large quantity of *new air*; and this must be done in the way of diet; it must be furnished from things that can be taken into the body by pounds, not in ounces or drachms; and therefore that vegetable is found to be the most powerful antiscorbutic of which the patient can take the largest

* I doubt not but the saying that air is the *grand antiseptic* will sound oddly at first; but I desire that it may always be remembered, that *air* is the *bond of union*, the *vinculam elementorum primarium*; and that *putrefaction* consists in a *resolution* and *disunion* of the several constituent particles.

quantity, without occaſioning ſickneſs, or other diſturbance.

IN the *ſcurvy*, the *digeſtive organs* luckily preſerve their full powers, and therefore they can turn the fermentable ſubſtances, taken into the body, to their own proper advantage; and hence this diſeaſe ſcarce ever fails of being cured, provided the requiſite materials be ſupplied.

BUT in *acute* diſeaſes, ariſing from putrefaction, the caſe is far otherwiſe; every thing, here, is thrown into ſuch confuſion, that none of the animal proceſſes can be carried on with regularity; and, on this account, the moſt powerful antiſeptics, as well as every thing elſe, too often loſe their power.

As the cure of the ſcurvy, then, ſeems to depend ſo very much on the *fermentative quality* in the remedies made uſe of, it is not impoſſible but other things, as well as *perfectly freſh vegetables*, may be found to anſwer this ſalutary purpoſe.

I IMAGINE that I have found out ſuch a ſubſtance; I have had no opportunity, indeed, of putting it to the trial; but as I am firmly perſuaded that it will be found of great ſervice, not only in the *ſcurvy*,

but

but in other *putrid diſeaſes*, at ſea, where freſh vegetables are not to be had, I cannot refrain from throwing out a propoſal for trying *new methods* of preventing, and poſſibly curing, thoſe deſtructive diſeaſes that take their riſe from putrefaction, in ſituations where the unhappy patients are deſtitute of the moſt proper means of help; but as this requires a particular conſideration, it ſhall be made the ſubject of another *Eſſay*.

HOWEVER, I will, in the mean time, recommend the trial of an experiment in that very deſtructive diſeaſe, the *putrid yellow fever* of the *Weſt Indies*. And if theſe papers ſhall happen to fall into the hands of any practitioner in thoſe climates, I requeſt that it may be tried.

IT is, to give the patients repeated doſes of the *alcaline ſalts*, in freſh *lime-juice*, or the like, and let it always be ſwallowed during the act of efferveſcence; and let the patient's drink be ſomewhat of the highly fermentable kind; I would even propoſe the juice of the *green ſugar-cane*, diluted, and acidulated with ſome of the recent ſour juices *.

* A ſurgeon, who was ſome time at *Goree*, on the

POSSIBLY, by throwing in ſuch a quantity of air as would be furniſhed from this kind of materials, the putrefactive acrimony, which at firſt ſeems to be lodged in the biliary ſyſtem, might be corrected and ſaturated.

THE principle upon which the ſaline mixtures, when given during the ebullition, perform their action of ſweetening and deſtroying the putrefactive acrimony, the reader can be no ſtranger to, or if he does not recollect it, he has only to turn back to the 23d, 24th, and 25th experiments of this preſent eſſay.

I FIND that Dr. *Lind* often prevents the fit of an ague, by giving theſe mixtures in the manner above-mentioned *. And *Riverius* uſed to check vomitings therewith in an inſtant; from what the diſcontinu-

coaſt of *Africa*, tells me, that the natives give in theſe fevers, with very good ſucceſs, a drink prepared by macerating in water a fruit of the plumb kind, that grows there in great plenty.

* Which very much ſtrengthens the *hypotheſis* which I have laid down, in order to account for the operation of the cortex in the like caſes; both the one and the other appearing to ſaturate, and ſweeten the putrefactive *colluvies*, which is lodged in the *ſtomach* and flexure of the *duodenum*.

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ance of this practice hath arisen, I cannot undertake to say, unless that some passages in *Boerhaave* are so construed as to discourage it *; but I am informed, that it was in great repute at *Edinburgh* about thirty years ago, and I am persuaded that the exhibition of these effervescent mixtures is not only perfectly safe, but, in many cases, will be attended with great and immediate advantages.

* Particularly one in tom. i. p. 528. Though I do not find *Boerhaave* any where absolutely and expressly forbid this practice, yet I find that he used to do so in his lectures, if a manuscript that I have seen, of his *Collegium Publicum de Aere*, be accurately taken.

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ESSAY IV.

ON THE

SCURVY;

WITH A

PROPOSAL for trying NEW METHODS

TO

Prevent or Cure the ſame, at Sea.

--------- *Si quid novisti rectius istis*
Candidus imperti. HORATIUS.

ESSAY IV.

ON THE

SCURVY; with a PROPOSAL for trying NEW METHODS to prevent or cure the ſame, at Sea.

FOR ſome time, even before I engaged in the courſe of experiments which have been ſet forth in the three preceding eſſays, I was firmly of opinion, that the cure of the *ſea ſcurvy* depended chiefly, if not altogether, on the *fermentative quality* * of

* Although the ingenious Dr. *Lind* aſcribes ſomewhat to the fermentative quality, yet his theory reſts chiefly on the *ſaponaceous*, *attenuating*, and *reſolving virtue*, which, according to him, "is the chief, and moſt "eſſentially requiſite quality, in the antiſcorbutic mix- "ture." P. 304 of his Treatiſe. 1757 — p. 250

But when we conſider, that the diſeaſe conſiſts in a *reſolution* of the blood's fibres, we muſt plainly ſee that it *never* can be cured on the above-mentioned principle.

The theory, which makes the cure to depend on a change

↔ putrefaction. Scurvy i.e. putrid. disease

of the *fresh vegetables*; which are found, by experience, to be the only things that, with certainty, conquer this destructive disease. And in consequence of this persuasion, it occurred to me, that as there are vegetable substances, which, though not perfectly recent, are yet capable of fermentation, such in particular as *common malt*; that this, if taken in the way of medicine, would, in all probability, produce effects similar to those produced by green vegetables, and consequently cure the scurvy; and as *malt* can be preserved sound, for a considerable length of time, it might be carried to sea, and there kept, in order to make *wort* occasionally as it might be wanted; and thus prove a remedy, always in readiness, against that fatal disease.

Such was the scheme that I framed to myself; and the more I thought of it, the more I became convinced of the likelihood of its succeeding.

change produced in the diseased fluids, in consequence of the fermentation of the fresh vegetables in the stomach and bowels, was first taught (as I am informed) by Dr. *Cullen*, the celebrated professor of chemistry at *Edinburgh*, but was suggested to me by Dr. *Hutcheson*.

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I soon mentioned this affair to a ſet of medical friends, who having formed themſelves into a little ſociety, meet once a fortnight for their mutual improvement; and they thought the reaſons on which my expectations were founded ſo plauſible as to deſerve the trouble of an experiment: So that all that was now wanting was an opportunity of putting it to the fair trial.

But as the *ſcurvy* * is a diſeaſe very rarely to be met in this city (Dublin), and as I had not any acquaintance at the places where caſes of this ſort occur moſt frequently, I drew up my reaſons for thinking that the *wort* would prove a remedy, in the form of a letter, and addreſſed it to my very worthy friend Mr. *George Cleghorn*, lecturer of anatomy in the univerſity of *Dublin*, with a deſire that he would ſend it to ſome of the leading medical people in *London*, in order to engage them in an application to the gentlemen who have the care of the naval hoſpitals, that trial

* The genuine putrid ſcurvy, ſo fatal to ſeamen, and to people ſhut up in garriſons without ſupplies of freſh vegetables, is the diſeaſe every where meant throughout this Eſſay.

might be made of its effects at thoſe places.

Among the gentlemen to whom Mr. *Clegborn* tranſmitted copies of the letter, were Dr *Hunter*, and *Henry Tom*, Eſq; one of the *commiſſioners* for taking care of *ſick* and *wounded ſeamen*, whoſe zeal in the proſecution of this affair, and in endeavouring to get the propoſal carried into execution, demands a publick acknowledgement; ſince it was through their application, that the *lords* of the *admiralty* did, in the month of May, 1762, give orders to have the *wort* tried in the naval hoſpitals at Portſmouth and Plymouth.

But as it was abſolutely neceſſary, in order to determine the genuine effects of the remedy propoſed, that the patients ſhould, during the time of trial, be entirely debarred from any ſort of recent vegetable, this reſtriction was deemed ſo ſevere, and looked ſo like retarding men's cures for the ſake of experiment, that it occaſioned a general murmur and diſguſt, and, of courſe, put a ſtop to the further exhibition of the *wort* at the hoſpitals. Orders were then iſſued to have it given on ſhip-board, while at ſea, where no temp-

tations

tations of fresh vegetables would offer to make the men uneasy, and where it was expected that the patients would chearfully submit.

But hitherto *, no return has ever been made to the offices, either of the good or bad effects of the *wort*; whether this hath arisen from disobedience, or inattention, is not easy to determine; possibly, each may have had its share; for, of all men, those who use the sea, are the most averse from innovation and experiment.

But neverthelefs, as I am now, in consequence of those experiments which have been already made known to the reader, more than ever convinced that the cure of *putrid* diseases in general, and that of the *scurvy* in particular, depends greatly on

* In a letter dated 17th Feb. 1763, which I was favoured with from *Commissioner Tom*, I was told, that at that time none of the navy-surgeons had reported any thing concerning the Wort; but Mr. *Tom* engaged to acquaint me of the particulars, as soon as a return should be made to the office.

But as I have never had the pleasure of hearing from that gentleman since (it is now 4 March, 1764), I take it for granted that nothing has been done in consequence of the admiralty's order, nor any report ever made.

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the quantity of *new air* thrown into the blood from eafily fermentable fubftances; I fhould deem myfelf wanting of common humanity if I did not communicate this to the public, and make it my requeft, that fuch people as are concerned in long voyages may embrace fome opportunity of giving the *wort* a fair trial; for until it is difproved by actual experiment, I fhall ftill continue to think, that this liquor bids as fair to cure the *fcurvy* as the juice of any recent vegetable. The experiment can occafion no poffible danger, will be attended with very little expence or pains; and, if it fucceeds, will make ample amends, in producing a difcovery of infinite advantage to the feafaring part of mankind.

If it be true what was publifhed in December, 1762, taken, as is fuppofed, from returns made to the houfe of commons, that of *one hundred* and *eighty-five thoufand* men, raifed for the fea fervice, during the late war, above an *hundred* and *thirty thoufand* perifhed by difeafes, and that two thirds of this number may be fafely charged to the account of difeafes which take their rife from putrefaction; furely, every motive

tive of policy and humanity ſhould excite men to endeavour at finding out ſomewhat to check this fatal and deſtructive *diathesis*; for if ſeamen could be preſerved from it, few other kinds of diſeaſes would endanger them.

For a ſea-life, ſimply conſidered, is ſo far from being productive of diſeaſes, that it is found to be a remedy againſt ſome of the moſt dangerous kinds *; and though habitual intemperance, and incautiouſly expoſing themſelves to heat and cold, may, and frequently do, cut ſhort the lives of ſeamen, yet the great mortality to which the crews of the king's ſhips are too often ſubject, ariſeth from infectious diſeaſes, owing to ſuch numbers being crowded together, and living in circumſtances leſs cleanly than is uſual in the merchants ſervice, where the men breathe a purer air, and are in general cleaner, and better cloathed, though by no means better, nor perhaps ſo well, fed, as in the royal navy.

Whoever has read Dr. *Lind*'s excellent treatiſe on the *ſcurvy*, muſt be convinced

* See *Gilchriſt*'s ingenious diſcourſe on the *uſe of Sea-Voyages in Medicine.*

that the *principal* and *main predifpofing caufe* is *too great* a *degree* of *moifture* in the *atmofphere*, whether hot or cold, but more efpecially the latter; and that the ufe of falt diet, bad water, or foul air, can only be reckoned as fecondary caufes, which will not of themfelves produce the difeafe.

THE manner in which *exceffive moifture* brings on the *putrefactive diathefis*, we have already attempted to explain; and have endeavoured to point out the moft effectual methods of preferving the body from its ill effects.

IT has been alledged, that this depends very much on keeping the furface of the body always warm and dry, by wearing enough of clean apparel to abforb the *aqueous* part of the perfpirable matter; and, at the fame time, making ufe of fuch diet as will fupply a fufficient quantity of *new air*, and which is known, from experience, to correct the morbid difpofition, or tendency to putrefaction.

BUT here a queftion naturally prefents itfelf; where are the bulk of the crew, the poor common failors and marines, to get fuch kind of diet? or how are they to be always kept clean, dry, and warm, who,

for

for the moſt part, have not a ſecond ſuit, but are obliged frequently to lie down in wet cloaths, and go to ſleep in damp hammocks?

To this it may be anſwered, let the men in the *navy* be cloathed in the ſame regular, exact, and uniform manner as they are in the *army*; and let them be allowed, *while at ſea*, a daily portion of *ſugar*; and I will venture to promiſe, that, in a time of war, we ſhall annually ſave ſome thouſands of very uſeful lives.

When thinking on this ſubject, I have often lamented, that it has never been attempted to cloath the ſeamen in this manner. Such a ſcheme, as it would occaſion conſiderable changes in the preſent naval ſyſtem, could not be carried into execution without ſome difficulty; but if it were once eſtabliſhed, it would certainly be productive of great and ſolid advantages; for it would attach the men more firmly to the ſervice, and prevent a great deal of deſertion, by infuſing more powerfully that *eſprit du corps*, which binds people ſo ſtrongly together; and it would, without all manner of doubt, render the fleet much more healthy; for the greateſt ſhare of those terrible *putrid* diseases, that sweep off such multitudes of our seamen, take their first rise from a want of necessary cloathing; a species of distress which numbers of people, as things are now ordered on board the king's ships, must often labour under.

THE great importance of necessary cloathing may be plainly seen, by observing what happens to the commission, warrant, and petty officers, on board the fleet; together with such of the common seamen as are careful and provident, and pride themselves upon being always neat and well cloathed. These people are scarce ever seized with *acute* putrid diseases, excepting by mere infection, and they are very seldom known to become *scorbutic*, to any violent degree, unless the *general cause* (excessive moisture) be of a remarkably long continuance.

Now, the diet of all this set of men (the commission, and some of the warrant and petty officers excepted *) is precisely

* If these gentlemen fare better than the rest of the crew, it must be all at their own expence; for the government provides nothing better for the officers than it does for the meanest person in the ship.

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the ſame with the reſt of the crew, being nothing better than the common ſhip's proviſions; and many of the petty officers ſleep in a part of the ſhip, where the air muſt be even more confined than it is where the common men ſleep.

THE only circumſtances wherein the people of whom we have been ſpeaking uſually differ from the common run of the crew, are, that they are *well clad*, and, for the moſt part, never want a little ſtore of *ſugar*.

IT would lead me from my purpoſe to purſue this matter any further; but the importance of it is ſo obvious, that I moſt heartily wiſh that ſome perſon, whoſe rank in life would inſure him the public attention, would take the hint, and offer a plan for the regular cloathing of the ſeamen in the royal navy; the time being now come when ſuch a thing might eaſily be attempted: the naval eſtabliſhment being brought ſo low, and the ſeveral commanders fixed to their ſhips, for at leaſt ſome years, will give leiſure and opportunity for trying if ſuch a ſcheme can be carried into execution.

But altho' the cloathing ſcheme ſhould never take place, yet the other part of the propoſal may be eaſily adopted; and I ſincerely wiſh that *ſugar* or *melaſſes* may hereafter be allowed, as a part of *ſea-proviſions*.

The expence, even taken at the higheſt, is too trifling, when put in competition with preſerving ſo valuable a part of the community as our ſeamen; but I am convinced, that the government would rather be gainers by affording the ſeamen this allowance; for the ſavings at the hoſpitals, which would not then be crowded in the manner they have often been, would more than pay for all the ſugar expended *at ſea*.

The reader muſt have already perceived the principle upon which it is propoſed to cure the *ſcurvy* by the uſe of *freſh wort*; but as I do not imagine that any perſon will take the trouble of making the experiment, unleſs he is almoſt as fully perſuaded as myſelf, I am under the neceſſity of entering into a farther explanation of the reaſons which lead me to expect that this liquor will produce ſuch ſalutary effects.

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NOTWITHSTANDING the many impudent aſſertions every day publiſhed in the common news-papers, which, among other much-boaſted remedies, promiſe not a few as peculiarly ſpecific againſt the *ſcurvy* *, yet it may be laid down as a poſition, not eaſily to be controverted, that the *genuine, putrid ſcurvy* has never been known to yield to any other medicines than to ſuch as are compoſed of *freſh vegetables* †; and provided

* If any of theſe *noſtrums* be *ſpirituous tinctures*, the material from whence they are extracted, if it ever had any antiſcorbutic virtue, muſt be deprived of it by this manner of treatment; and the tincture itſelf muſt be ſo far hurtful, as every kind of ardent ſpirit is found to be extremely pernicious in this diſeaſe.

If they be *mineral acids*, they are ſufficiently known from experience to be uſeleſs, either as remedies or *prophylactics*.

But if they contain *mercury*, they muſt be as ſo much poiſon; for mercury breaks down the blood, and deſtroys its texture, in like manner with the ſcorbutic acrimony.

† The only places where I meet with any thing like a contradiction to the above aſſertion, are in *Biſſet's* Account of the Scurvy, and in the Hiſtory of the Voyages made by the *Ruſſians* in order to diſcover the *American* coaſts oppoſite to *Kamtſchatka*.

The firſt-mentioned author thinks that many people were cured at *Cumberland* Harbour, in the iſland of provided they be *fresh*, and of ſuch a nature as will allow them to be taken freely, it is almoſt no matter what they are. The *acid* and the *alcaleſcent*, the *mild* and the *acrid*, the *ſweet and the bitter*, all of them cure the *ſcurvy*; though their ſenſible qualities be ſo oppoſite, and their manner of affecting the body, in ordinary caſes, be ſo different.

THIS virtue, then, *muſt* be owing to ſome property which they *all* poſſeſs in *common*.

THE experiments of the three preceding eſſays will, as I apprehend, be allowed concluſive, in ſhewing that a property, *common* to *all freſh vegetables*, is, that when mixed with any *animal* ſubſtance, and placed in the proper degree of heat, they

Cuba, merely by feeding on *rice*, and before they were ſupplied with any recent vegetables. (See p. 83 of his Treatiſe.

And in the laſt-mentioned book the cure is entirely aſcribed to eating the fleſh of the ſea-cow. But the authors do not take notice, that the ſame ſpring-ſeaſon, and warm weather, that induced theſe animals to ſeek the land, muſt alſo have thrown up a variety of vegetable productions, which the ſcorbutic patients would moſt greedily devour, without waiting for the doctor's directions.

presently

presently run into *fermentation*, and, in the course of that fermentation, throw off an elastic *vapour*, or spirit, of surprising activity, endued with a power of *restoring sweetness* to *putrid* animal fluids.

This hath been so clearly and so abundantly proved already, that there cannot be the least necessity for repeating what hath been said of it in the three foregoing essays; I shall therefore only mention some circumstances with regard to the *cure* of the *scurvy*, which will afford almost a demonstration that it depends on the change brought about in the diseased fluids, by the action of the subtile, active, and penetrating spirit, which is generated during the fermentation of the fresh vegetables, carried on in the first passages.

First, the recovery of people in the very *last stages* of the *scurvy*, is brought about in a surprisingly short space of time, provided the patients are but fully supplied with *fresh* vegetables. This is sufficiently confirmed by every account of the scurvy that we meet with; and *John Woodall*, an old English surgeon *, who hath left us a very

* Although *Woodall* was a man of great eminence in his

very accurate description of the disease, paints this salutary change in a very striking manner, by saying, " That to any
" man of judgment it may seeme a won-
" der, how a poore miserable man, com-
" ing on lande from a long voyage, even
" at the point of death, namely, swolne
" sometimes to an exceeding greatnesse,
" not able to lift a legge over a straw, nor
" scarce to breathe, by reason of strong
" obstruction, yet, in a *few dayes*, shall

his day, and of no inconsiderable merit as a writer, yet his book appears to be very little known. The only places where I see it mentioned, are in *Wiseman*'s preface, and in the preface to *Turner*'s surgery; but it is not to be found in *Haller*'s catalogue, neither in *Heister's Bibliotheca Chirurgica*; nor, which is still more to be wondered at, in *Lind's Bibliotheca Scorbutica*; notwithstanding that *Woodall* hath left a very excellent discourse on the scurvy, his description of which appears to have been drawn from his own observation, and his method of cure founded on experience, for he served both at sea and in the army. For these reasons, I am persuaded that the reader will be pleased to see an extract from this part of his works, which consists of several discourses on medical, chemical, pharmaceutical, and chirurgical subjects, printed originally at different times, but all collected by himself, and re-published in a thin folio, in the year 1639, with a dedication to King Charles, under the title of *The Chirurgeon's Mate, or military and domesticke Surgery.*

" receive

"receive the fulneſs of former healthe, "yea, with *little* or *no medicine* at all."

Surely this change muſt be wrought by ſomewhat of amazing activity, and does not depend on a *ſaponaceous*, *attenuating*, or *reſolving* virtue; for in the *ſcurvy* the "*craſis of the blood is broken* and *deſtroyed* "by the *ſcorbutick putrefaction*," and certainly *never* can be reſtored to a ſound ſtate, by being *further* attenuated and reſolved; neither have we ſufficient time, in theſe caſes, "*for the putrefactive acri-* "*mony* to *be diluted, and obtunded* by *the* "*watery and mucilaginous* parts, *and car-* "*ried out of the body by the aperient qua-* "*lity of the vegetable juices.*" Nor does the mechanical action of "*ſcouring and* "*cleanſing the furred and obſtructed paſ-* "*ſages* of the *machine* *," at all correſpond or agree with the appearances that attend the progreſs of the cure; which is always found to depend on vegetables only ſo far as they are *freſh* and capable of yielding a large proportion of *air*; for although the dry *farinacea*, when mixed with the animal juices, ferment very readily, yet both

* See *Lind on the Scurvy*, p. 304, 306.

reaſon

reaſon and experiment ſhew, that they will not do it with ſo much eaſe, nor produce ſo much air, as the freſh ſucculent vegetables; therefore, notwithſtanding that bread, without any other vegetable aſſiſtance, will ſerve, in ordinary caſes, to raiſe the common and neceſſary alimentary fermentation, and produce enough of the antiſeptic vapour to *preſerve* the juices in a ſound ſtate; yet if a *putrid* acrimony hath once taken place in the conſtitution, the *crude* and *dry farinacea* are found quite inſufficient to conquer it; and there is then an abſolute neceſſity for throwing in a large quantity of *freſh vegetable juice*, in order not only to obtund and ſheath the putrefactive acrimony by its mucilaginous quality, but alſo, by its *fermenting* in the bowels, to generate a ſufficiency of the ſubtile ſpirit, which ſeems to be the only thing capable of pervading, in ſo ſhort a time, the moſt intimate receſſes of the whole vaſcular ſyſtem, and of totally changing the corrupted nature of the entire maſs of fluids.

SECONDLY, the liquors which have completed their firſt ſtage of fermentation, and thereby loſt much of their *fixed air*, though

though they are found uſeful as preſervatives, will none of them *cure* the diſeaſe: Cyder, which appears to have a greater degree of antiſcorbutic virtue than any of the common fermented liquors, is generally ſtopped ſooner in its career of fermentation, and contains the more *fixed air* on that account *.

THIRDLY, *acids* †, both mineral and vegetable, and *ardent ſpirits* ‡, which

* See the note in page 147.

Cyder was once carried to ſea, as part of the ſea-proviſions, on the recommendation of Dr. *Huxham*; who finding, "that the juice of apples did moſt certainly "cure the ſcurvy, imagined, that the ſame juice, when "become a vinous liquor, could not but be very ſalutary."

The cyder, however, was found to avail but very little, as may be learned from Mr. *Ives*'s letter, publiſhed by Dr. *Lind*. P. 194 of his Treatiſe.

It was not at that time ſuſpected, that the antiſcorbutic virtue of the apple-juice depended on a principle that muſt, in great meaſure, be diſſipated, during the action of that fermentation which makes it a vinous liquor.

† "Experience has abundantly ſhewn, that they "(*Sp. Salis*, *Elix. Vitrioli*, and *Vinegar*) have not been "ſufficient to prevent this diſeaſe, much leſs to cure it." *Lind*, p. 187.

‡ This is ſtrongly proved by the remarks of governor *Ellis*, in his account of the Voyage to *Hudſon's Bay*.

contain

contain little *fixed air* in themſelves, and check the alimentary fermentation, are found to be, the firſt, uſeleſs and inſignificant, and the ſecond extremely hurtful, in the diſeaſe.

Upon the whole, then, it may ſafely be repeated, that the *cure* of the *ſcurvy* depends on the *fermentative quality* in the remedies made uſe of.

And this being the caſe, we have only to find out a ſubſtance which may be preſerved for ſome conſiderable length of time, and yet ſhall contain materials for raiſing a fermentation in the bowels like that raiſed by freſh vegetables; and then, in all human probability, we ſhall have a remedy for the *ſcurvy* always in readineſs.

Such a vegetable ſubſtance, it is preſumed, is *common malt*.

Grain, after it is *malted*, differs widely from grain in the *crude ſtate*; by the germination, drying, and ſlight torrefaction, its natural viſcidity is deſtroyed, it acquires an agreeable ſaccharine taſte, and the farinaceous part is ſo attenuated as to be rendered ſoluble in water.

Fresh *wort*, or *infuſion* of *malt*, is a liquor ſimilar to the recent juices of the

ſweet

ſweet vegetables; fermenting readily like them, and being preciſely of the ſame mild, ſaponaceous, and aperient nature.

WHAT then ſhould hinder it from producing the very ſame effects? and, as it may be taken in as large a quantity, with as much ſafety, and with as little diſguſt, there can be no reaſonable objection to its being given. All that remains, then, is to put it to the fair trial; and this I certainly ſhould have done, long ago, if an opportunity had ever preſented itſelf.

BUT the ſame objections that were made at the naval hoſpitals, muſt always be made, as often as the experiment is attempted on ſhore; therefore, whenever it ſhall be fairly tried, it muſt be at ſea.

LET me then again requeſt, that ſuch of my readers as may have opportunities, will try the effects of this liquor *: and this is a matter of ſuch importance, as to render it well worth the beſtowing of ſome expence and pains; for if the *wort* ſhould

* The *Eaſt-India Company* would do well to order ſome malt to be carried out in their ſhips, and give poſitive directions to have trial made of it's effects, as there never fails to be abundance of opportunities during the courſe of theſe voyages.

be

be found to anſwer, it will undoubtedly be the means of ſaving the life of many a brave fellow.

For malt, as I am aſſured by the brewers, with proper care, may be preſerved ſound and good for years; ſo that if it were previouſly well dried, packed up in ſmall caſks, and ſtowed in the bread-room, or ſome very dry part of the ſhip, it might be carried to ſea, and kept for any length of time that would be required, even in the longeſt voyages; and as there need be no very large quantity carried, it would not incommode the ſhip by its bulk; ſince I do not mean, that it ſhould be given as a part of the common diet, in the way of preſervative, but only to ſuch as are actually ſick; when the *malt* is to be ground, and made occaſionally into *wort*, as it may happen to be wanted.

The method in which I would propoſe the *wort* ſhould be given, is, to boil it up into a *panado*, with the ſea-biſcuit, or ſome of the dried fruits that are uſually carried to ſea; then let the ſcorbutic patients make at leaſt two meals a-day on this palatable meſs, and let them drink a quart, or more, if it ſhall be found to agree, (al-

ways

ways beginning, however, with a ſmaller doſe, and gradually increaſing it) of the *freſh infuſion*, in the courſe of the twenty-four hours.

Its moſt likely effect will be to open the belly, a moſt agreeable circumſtance to the poor ſcorbutics (in whom obſtinate coſtiveneſs is a very common ſymptom), and exactly ſimilar to the *modus operandi* of the moſt powerful *green antiſcorbutics*.

But like them too, if taken too liberally, it may occaſion griping, and immoderate purging; when this happens, the doſe muſt be leſſened, and ſome drops of the *acid elixir of vitriol* may be given with it, in order to check the too great tendency to fermentation, and make it ſit eaſy on the ſtomach.

And it is not only in the *ſcurvy*, but likewiſe in *acute* putrid diſeaſes, that I expect the *wort* will be found of ſingular ſervice. In all ſuch where the putrefactive acrimony ſeems to be unaccompanied with any *peculiar peſtilential taint*, it promiſeth to produce very good effects, from the principles already laid down; for as moſt of theſe *ſimple putrid* diſeaſes ariſe from an accumulation of ſharp and corrupted matter, in the firſt paſſages, ſuch medicines as will *dilute*, *obtund*, and above all *ferment*, and, in that action, produce a ſufficiency of the *antiſeptic vapour* to ſaturate and ſweeten the putrefactive *colluvies*, bid the faireſt to give preſent relief.

In theſe caſes, the *wort* may make a principal part of the ſick perſon's diet; a thin panado for meat, and the plain infuſion, acidulated with lemon or orange-juice, if to be had, if not, with ſpirit of vitriol, for the common drink.

And this will bring things as near as the circumſtances and ſituation will allow, to the very ſucceſsful practice of the celebrated *De Haen*, at *Vienna*. In acute, continual, putrid fevers, his method is truly *Boerhaavian* and *ſimple*, conſiſting only in ſupplying the patients liberally with *oaten* or *barley* gruel, ſweetened with honey, and made of different degrees of thickneſs, according as he intends it for meat or for drink; though, in ſome caſes, they are indulged with fleſh broth, made very light and thin. If the belly is not made ſoluble by the gruel alone, he occaſionally mixeth a little *cream* of *tartar*, or *nitre*: His medicines are all of the freſh fermen-

table

table kind; *flowers, leaves, ſucculent-roots,* and *ripe fruits,* made into decoctions, or infuſions, according to the nature of the different materials: And his only cordials are decoctions of bread, made palatable by the addition of the more pleaſant kinds of fruit, when in ſeaſon, or, at other times, by the ſame, preſerved, and made into jellies, ſyrups, or what is uſually called *jam*; with now and then ſome ſmall doſes of the milder *antimonials*, or ſome of the *neutral ſalts*: Nor does he ever give his patients any of thoſe trifling and inſignificant mixtures which fill up the *German* diſpenſatories.

By theſe plain, ſimple, and pleaſant remedies, he finds the extraordinary ſickneſs and nauſea, which attend all theſe putrid fevers at the beginning, is preſently allayed; inſomuch, that he ſcarce ever thinks of giving an *emetic*. The tormenting thirſt is ſo effectually relieved, by theſe diluent, mild, and ſaponaceous drinks, that the patients very ſoon forget to complain of it; and by their power, likewiſe, the putrid acrimony which occaſioned the diſeaſe, is early obtunded and corrected, the diſturbed ſecretions are preſently reſtored to order, and the whole maſs of humours preſerved from corruption and diſſolution: Hence, patients with petechial and miliary eruptions, proceeding from a diſſolved ſtate of the fluids, are rarely to be ſeen in the hoſpital that *De Haen* has the care of; neither are his patients afflicted with violent vomiting or purging, the acrimonious matter being ſo early corrected, that even the appetite frequently returns, during the very courſe of the fever *.

DE HAEN, agreeable to the common theory, makes the virtue of all theſe things to depend on their producing *aceſcent chyle*; but how liable this way of accounting for it is to objections, the reader hath already been informed: It is on account of their *fermentative quality*, and on their producing much of the *antiſeptic vapour*, that all theſe things perform ſuch wonders; and if they actually do perform them, there is all the reaſon imaginable to expect that the *wort* will not come far ſhort: I do therefore again moſt earneſtly recommend a trial of it, in the *acute*, as well as in the *chronic*, putrid diſeaſes.

* *De Haen*, *Ratio Medendi*, in capite 1° & 2°.

It is known, from certain experience, that all theſe mild, fermentable ſubſtances, will cure a *chronic* putrid diſeaſe, as ſurely as *opium* will procure reſt; and, were it not for two reaſons, they perhaps would alſo cure all *acute* putrid diſeaſes.

First, in many of the acute diſeaſes, the acrimony is not *ſimply putrid*, but is often attended with a certain peſtilential principle, which being ſuperadded to the general putrefactive cauſe, induceth a peculiar morbid diſpoſition, not conquerable by any medicine yet known, but which muſt depend merely on the vital powers, to concoct and expel it, either in the form of ſome eruption, or by ſome critical evacuation.

And, ſecondly, even ſuppoſing the acrimony to be *ſimple* and *unaccompanied*, yet the ſeveral functions of the body are ſo early diſturbed, and ſo totally diſordered, by the *febrile* commotion, that although the patient be plentifully ſupplied with ſuch things as would infallibly correct the putrefaction, in circumſtances where the digeſtive organs could turn the remedies to their own proper advantage, yet here they are found to produce no ſenſible change;

either, becauſe the animal juices have loſt their power of raiſing the natural alimentary fermentation, or the lacteals, conſtricted by the frebile ſpaſm, obſtinately ſhut their orifices, and refuſe admittance even to the mildeſt and moſt ſalutary applications. And hence it is, that *acute* diſeaſes (excepting ſuch as are *purely inflammatory*) are, for the moſt part, found inflexibly to perſiſt in running through their ſtated periods, in ſpite of direct oppoſite methods of treatment *.

ALTHOUGH I have all along inſiſted on the *wort*, as thinking it comes the neareſt to the *freſh* juices, in every reſpect, yet, where *malt* is not at hand, I would recommend that *melaſſes*, *honey*, or *ſugar* †, may be

* This conſtancy of nature, in the progreſs of ſome diſeaſes, appears very remarkable in the tertian fevers of Minorca. See *Cleghorn*'s excellent diſcourſe on the diſeaſes of that iſland, p. 149.

† Dr. *Cullen*, who has very ſanguine *expectations* from the *wort*, thinks that *ſugar* bids fair to cure the *ſcurvy*, as well as the *wort*: And it certainly does ſo; for the ſame reaſons that lead us to expect that the one will prove a remedy, hold good, in almoſt every circumſtance, with regard to the other.

New ſpruce beer is known to be a moſt powerful antiſcorbutic;

be tried, diſſolved in a due proportion of water (about four to one) and given in manner as may be found moſt agreeable and convenient to the patients.

The method in which it is propoſed to prepare the *wort*, is, to take *one* meaſure (ſuppoſe a quart) of the *ground malt*, and pour on it *three* meaſures of boiling water; ſtir them well, and let the mixture ſtand, cloſe covered up, for three or four hours; after which, ſtrain off the liquor.

It muſt be brewed, in hot weather eſpecially, freſh every day; for if it be allowed to grow vapid, or ſouriſh, it will not only be unpleaſant, but uſeleſs, as it would not then run eaſily into fermentation; but

tiſcorbutic; but this virtue ſeems to depend chiefly on the melaſſes that is mixed therewith in order to make it ferment; for I apprehend that a decoction of *dried* fir-tops, alone, would no more cure the *ſcurvy*, than the decoction of any other dried vegetable, great variety of which have been tried, but always without ſucceſs.

Honey, on the ſame principle, muſt be a good antiſcorbutic, and, as ſuch, may be recommended to officers, and others who can carry it conveniently, to eat ſome daily, which would, in all probability, keep off the extreme coſtiveneſs to which people at ſea are ſo very liable.

 when

when perfectly fresh, there cannot well be a more palatable kind of drink, and I dare say, that, in general, it will sit light and easy on the stomach.

If what hath been urged shall be found of sufficient weight to engage any gentleman in a trial of the *wort*, all that I have further to request, is, that he will, previous to its administration, carefully and particularly note down the cases in which it is given; describing with accuracy the several symptoms, and relating fairly, and with candour, the progress and effects, from time to time; and let these observations be communicated, either to the public at once, or to the author at *Dublin*.

APPENDIX.

APPENDIX.

AN

EXTRACT from that Part of WOODALL's WORK which treats of the SCURVY.

HE prefaceth his difcourfe on the fcurvy with lamenting, " That " none of his countrymen had, out of " their experience, taken in hand fincerely " to fet down to pofteritie the true caufes, " fignes, and cure thereof; neither left " any caveats, inftructions, or experiences, " for the prevention or cure of the fame." He therefore declares his intention " of " informing the chirurgeon how he fhould " demean himfelf, to comfort his patient " at fea, in that moft dangerous difeafe;" which, he tells his reader, " is a difeafe of " the fpleene, whereby it is fometimes " wholly ftopped, and fometimes only dif- " tempered."

HAVING

Having beſtowed a paragraph or two on the different names of the diſeaſe, he goes on to treat of the cauſes, ſigns, and method of cure, expreſſing himſelf in the following terms.

"The cauſes are ſo infinite and un-"ſearchable, as they far exceede my ca-"pacity to find them out: Some men "conceive this diſeaſe happeneth unto "ſeamen only through their being long at "ſea without touching at land, as at their "coming on land they preſently grow "ſtrong again, and are, by the very freſh "aire, and freſh food, cured, without "much other helpe. The chief cauſe "thereof is the continuance of ſalt diet, "which is not to be avoyded at ſea, want "of ſufficient nouriſhment, and of ſweete "water; and alſo for want of *aqua vita*, "wine, beer, or other good water, to "comfort and warme their ſtomachs with-"all.

"Another cauſe of this diſeaſe, to "the ordinarie ſorte of poore men, is want "of freſh *apparel* to ſhift them with; "which, indeed, among poore ſailors, "eſpecially a ſorte of them that are care-"leſs and lazie of diſpoſition, is too fre-"quent;

" quent; partly alſo by not keeping their " apparell *ſweet* and *dry*, and the not " cleanſing and keeping their cabins ſweet; " this alſo ingendreth and increaſeth the " infection. Some charge biſket as a cauſe " of the ſcurvy, but I am not of their opi- " nion; ſome ſay inordinate watchings are " the cauſe thereof; ſome ſay, extreme " labour, wanting due nouriſhment; ſome " alſo affirm cares and grief to be the " cauſe thereof; others affirm, the very " heat of the aire, reſolving the ſpirits. " But what ſhall I amplify farther? for it " is alſo true, that they which have all the " helpes that can be had for money, and " take as much care as men can deviſe, " are, even by the *evil diſpoſition* of the " *aire*, and the courſe of nature, ſtrooke " with a *ſcurvie*, yea, and die thereof, at " ſea and land both.

" THE ſignes of the ſcurvie are many; " as, namely, a general lazineſs and evil " diſpoſition of all the faculties and parts " of the bodie, ſaving the ſtomach and " appetite, which oftentimes is greater " than ordinarie, with them, for a long " time.

" A DIS-

" A DISCOLOURING of the ſkin, as if
" it were fouler than ordinarie, with ſpots
" darker coloured than the reſt, and ſome-
" times alſo darkiſh blew ſpots.

" A FEVER at ſea commonly ends in
" the ſcurvy; wherefore, beware of too
" large bleeding, which oft increaſeth the
" griefe and maketh it incurable.

" ALSO itching, and aching of the
" limbs, are ſignes of the diſeaſe.

" SOMETIMES, alſo, the legges falling
" away and drying, and the calves of the
" legges growing hard and dry; as alſo
" immoderate ſwellings of the legges.

" ALSO the legges and thighes diſco-
" loured into frekells or ſpots, of a dirty,
" brown, ſad colour, much like the co-
" lour of a gangrenated or mortified
" member.

" STINKING of the breath, greate ob-
" ſtructions of the liver, or ſpleene, or
" both; and, in the exerciſe of their bo-
" dies, their limbs and their ſpirit failing
" them.

" SHORTNESSE and difficultie of breath-
" ing, eſpecially when they move them-
" ſelves, but lying ſtill, find little griefe
" or paine.

" THEIR

"THEIR eyes of a leady colour, or like "dark violets.

"GREAT ſwellings of the face, legges, "and all over the body; paleneſs, or a "foul pale colour in the face; ſwellings "in the gums, rotteneſſe of the ſame, "with the iſſuing of much filthie blood, "and other ſtinking corruption thence; "looſeneſſe of the teethe: Alſo ſome are "troubled with extreme coſtiveneſs, that, "for fourteen days together, they go not "to ſtoole once; alſo many have ſtop-"pings of the urine, or, at the leaſt, "making leſs water in two days than the "partie drinketh in one.

"A COLDNESSE and ſtiffneſſe of the "ſinewey parts chiefly of the legges; ſome "alſo have their muſcles, yea, and the "ſinewes of their thighes, arms, and "legges, ſo waſted away, that there ſeem-"eth to be left only the ſkin covering the "bones.

"ALSO it is manifeſt, that diverſe of "thoſe which have been opened after "death, have had their livers utterly rot-"ted; others have had their livers ſwolne "to an exceeding greatneſſe; ſome, the "ſpleene extreamly ſwolne; others have

"been

"been full of water; others have had the "lungs putrified, and ſtunk whilſt they "have lived.

"THESE and diverſe other ſignes, too "many for to be mentioned here, do af-"flict poore ſeamen, which are often paſt "man's helpe, in ſuch time and place as "they happen; the cure whereof only "reſteth in the hands of the almightie."

AFTER mentioning *Ecthius* and *Vierius* as writers on the diſeaſe, and taking notice of the indications of cure as laid down by them, he ſays, "he may ſpare his "labour, in writing what broths or "herbes can ſerve beſt, where no freſhe "food can be gotten:" He therefore goes on to direct the uſe of ſuch things as are uſually carried to ſea; namely, "wine, "ſugar, ſpices, and other comfortable "things, which the chirurgeon ought to "take care that the men have in due ſea-"ſon; and, moreover, he ought, morn-"ing and evening, to ſeeke for poore and "weake men in their cabins, or, ſo ſoone "as they are miſſing at their meſſes, to "enquire for them, and ſee that their ca-"bins be ſweet, and their proviſions ac-"cording.

"AND

" And whereas the firſt part of this " cure is in opening obſtructions, it is " therefore fit, in the beginning of the " griefe, to give an opening clyſter; then " the next day, if the party be ſtrong, " open a veine; but beware, as is ſaid, of " taking away too much blood at once."

If the diſeaſe be attended with ſwelling and fullneſs, he adviſes a purge, and then orders to make the patient ſome comfortable ſpoon-meat, namely, " an oatmeal " caudle, with a little beer or wine, the " yoke of an egge, and ſome *ſugar*; or a " broth, made with currants or other " fruite, with ſpices and *ſugar*; and, for " drink, barley water, with ſome juice of " lemons, if it may be had, if not, with " oyle of vitriol and *ſugar*.

" The juice of lemons is a precious " medicine, and well tried, being ſound " and good; let it have the chief place, " for it will well deſerve it. It is to be " taken twice a-day, a ſpoonful or two " with *ſugar*." In want of it, or the the juice of *limes*, oranges, or citron, or the pulp of tamarinds, give " oyle of vi- " triol, as many drops as will make a cup " of beer or water ſower a little, as it

" were,

" were, and add *ſugar*, or ſome ſyrup: A " decoction of biſket, and therein almonds " ground, with ſugar, and a little cinna- " mon or roſe-water, is a very comforta- " ble drink to be taken now and then to " refreſh the ſtomach."

He proceeds then to give directions how to ſweat the patients, and how to relieve extreme coſtiveneſs; next, he directs lo- tions for the rotten gums, and orders the ſwelled limbs to be fomented with a weak lixivium, boiled up with ſome of the diſ- cutient and warmer kind of herbs, and af- terwards to be rubbed with particular oint- ments that he mentions.

In the cure of ſcorbutic ulcers, he re- marks, that " until the obſtructions in the " liver and ſpleene, be removed, theſe " ulcers give no place to good healing;" and therefore adviſes " all ſharp and vio- " lent medicines to be ſhunned, and no- " thing but ſoft and anodyne things to be " applied, for otherwiſe, you will not only " ſtrive againſt the ſtreame, but put your " patient to needleſs diſquiet, and thereby " increaſe his diſeaſe.

" A poultice of biſket, boiled up in " beere or wine, applied warm, will won-

"derfully comfort a weak limb, and asſwage pain: But fattie things muſt be forborne in ſome caſes; namely, when the pain is ſharp and quick, leſt you cauſe putrefaction and ſuppuration of the humours againſt your will; yea, and rather uſe acetous medicines and anodynes."

THIS extract ſhews that *Woodall* was a man of ſome obſervation.

THERE are many good things for the time he wrote. In other parts of his book, his method of treating wounds, both common and gun-ſhot, was judicious and ſimple; his dreſſings being, for the moſt part, very plain, chiefly dry lint, and he condemns the uſe of tents and eſcharotic applications.

WITH regard to fractures, he was an enemy to long rollers, or tight bandages.

WHEN he amputated, he often made uſe of the croſs-ſtitch, to keep down the fleſh over the end of the ſtump; and he knew how to reſtrain the bleeding, by tying the veſſels.

HE was the inventor of the *trefine*, which he ſo named from its three extremities, *(a tribus finibus)* each ſerving a different

ferent purpoſe; and he was the firſt man who introduced the *enemata fumoſa* *; propoſing alſo to throw up, in this manner, powders, and the like, into the inteſtines, in order to cure obſtinate fluxes, and other diſeaſes of thoſe parts.

* It may not be amiſs in this place to inform the reader, that I have found, upon trial, that *tobacco-ſmoke*, thrown up in the way of clyſter, effectually and immediately deſtroys the *aſcarides*. And this I was induced to try upon the recommendation of Mr. *Turner*, ſurgeon, at *Liverpoole*. See his letter to Dr. *Fothergill*, in the ſecond volume of the *London Medical Obſervations*.

ESSAY

ESSAY V.

ON THE

DISSOLVENT POWER

OF

QUICK-LIME.

There are agents in nature able to make the particles of bodies ſtick together by very ſtrong attractions; and it is the buſineſs of experimental philoſophy to find them out.

NEWTON.

ESSAY V.

ON THE

DISSOLVENT POWER of QUICK-LIME.

THE experiments of the ſecond and third eſſays have ſufficiently ſhewn, that the coheſion of animal and vegetable ſubſtances depends *immediately* on the *fixed air*; but how far the influence of this principle extends into the mineral kingdom, is not yet certainly known.

HALLER ſeems to think that it is very general, being here alſo the *vinculum*, or *gluten verum moleculis terreis adunandis* *; though it does not appear that he has any actual experiment of his own to confirm this hypotheſis.

BUT ſince the publication of Dr. *Black*'s moſt ingenious paper on the *magneſia*, we

* *Prim. Lin.* ſect 244.

cannot help being convinced that the theory holds good, at leaſt with regard to the claſs of bodies which he hath examined; to wit, the calcareous earths.

THE reader may remember, that the doctor's theory of calcareous earths is, that theſe bodies have a very ſtrong degree of affinity * with fixed air, and, in a natural ſtate, are replete with it; that by calcination they are deprived of this element, and hence become cauſtic and ſoluble in water; but that, upon reſtoring the fixed air, they are again rendered mild and inſoluble.

ALL this is very ſatisfactorily ſhewn in the eſſay above-mentioned; but it occurred to me, that it might poſſibly be ſtill further proved, and that in a way which would afford an ocular demonſtration. I thought that perhaps the diſſolved quick-lime might be rendered viſible, and would precipitate upon transferring *fixed air* into *lime-water* †.

EXPE-

* And fixed air has a ſtronger affinity with calcareous earth than with any other ſubſtance yet known.

† In the manner deſcribed in the ſecond eſſay, and 10th experiment.

When

facing p. 215.

EXPERIMENT I.

I PRESENTLY ſet about the experiment, and found it anſwer fully to my expectations; for the lime-water, which was filtered, and perfectly limpid, became turbid in a few minutes after the effervefcence began, and that the air which was extricated from the mixture of acid and alcali, had paſſed over into the phial containing it. And it was highly pleaſing to ſee the particles of the quick-lime, which, but

When I found that by transferring air into different bodies, a variety of curious changes were produced, I laid aſide the glaſs tube, and had an apparatus prepared which rendered the performance of the experiments more eaſy. I cauſed a metal tube to be fixed on by a ſcrew to the neck of a phial, as repreſented in fig. IV. which tube could be occaſionally inſerted into the mouth of another phial, being previouſly wound about with ſoft leather, in order to prevent the eſcape of the factitious air.

But a very ingenious friend, who is remarkable for his ſkill in every part of natural philoſophy, but particularly mechanics, improved it further, by contriving the machine in fig. V. In the neck of the bottle A, which is the recipient, there is an *air-valve*, which allows the air to paſs into the bottle, but prevents its return; and this I found greatly to ſhorten and facilitate the proceſs.

two or three minutes before, were quite invisible, and dissolved in the water, all running together, and falling to the bottom, having returned to their original state of insolubility, the moment they were saturated with the fixed air.

WHEN the turbid mixture had stood long enough to allow the precipitate all to subside, I poured off the clear, and found some grains of calcareous earth, which effervesced violently with spirit of vitriol.

AND thus was the theory of Dr. *Black* placed beyond the reach of contradiction; since we must here be convinced, from what is seen to pass before our eyes, that the quick-lime became *soluble* in water from the want of its fixed air, because we find it grow *insoluble* the moment the *cementing principle* is restored.

FINDING, by the preceding experiment, that the lime, though so minutely divided, and so intimately mixed with the water, as to be reduced to a state of actual fluidity, might nevertheless be rendered solid, and brought immediately into view, by restoring the cementing principle, I began to think, that, by introducing air into the

the natural ſulphureous waters, as I had done into the lime-water, the ſulphur might be rendered viſible, as I conceived that this diſſolution of the ſulphur poſſibly may be brought about in theſe waters, from its being ſome way or other deprived of its fixed air.

BUT as I could not immediately procure a natural ſulphureous water, I reſolved to try the experiment with an artificial one.

EXPERIMENT 2.

IN order to do this, I boiled up ſome flowers of ſulphur with water and quick-lime (as directed for preparing the *ſulphur præcipitatum*); and having filtered the ſolution, which made it perfectly tranſparent, I put about four ounces of it into the phial uſed in the foregoing experiment, and transferred the air from an effervеſcent mixture contained in the other phial.

THE ſulphureous did not ſo ſoon loſe its tranſparency as the lime-water, but, in eight or ten minutes, a ſcum formed on the ſurface; and the whole ſolution immediately after becoming turbid, I could plainly

plainly perceive the ſolid particles collect-ing themſelves together.

WHEN I thought that there was a ſuffi-cient quantity of air thrown in, the phials were ſeparated, and the turbid contents of the firſt one poured into a tall drinking-glaſs. The liquor now ſent forth the ſtrong and peculiar ſmell which ſolutions of ſulphur always yield, when an acid is added to them.

EXPERIMENT 3.

HAVING ſoon after got ſome bottles of the *Lucan* water *, a few ounces of it were put into the phial, and air transferred from an effervеſcent mixture, as in the two pre-ceding experiments; but notwithſtanding a ſlight degree of milkineſs appeared at firſt, yet no precipitation enſued.

THESE experiments, however, pointed out a method of making a pure ſolution of ſulphur, which being diluted to the proper degree, gives an artifical ſulphure-ous water, perfectly reſembling the natu-ral, as to taſte, ſmell, tranſparency, and

* *Lucan* is a village within ſix miles of *Dublin*, where there is a ſpring of ſulphureous water.

want

want of colour, and not liable to grow turbid on the addition of acids, which all other artificial ſolutions of ſulphur, hitherto known, conſtantly do.

THE turbid ſolution of lime and ſulphur, as hath been already mentioned, was poured into a tall glaſs, and happening not to be thrown out, I found, after ſtanding thirty-ſix hours, that it did not become limpid, though I could plainly perceive a quantity of lime lying at the bottom, while the yellowiſh fluid remaining above, evidently ſhewed to be an equable and true ſolution of ſulphur, now left perfectly alone in the water: I immediately ſaw that there was nothing more to be done here than dilute this ſolution to a proper degree, and that it would then conſtitute a true ſulphureous water.

EXPERIMENT 4.

UPON trial, it actually did ſo; and although this preſent ſolution, from being ſo long expoſed to the open air, had loſt much of the ſtrong and peculiar ſulphureous ſmell, yet I found, on repeating the experiment, that a ſolution, freſh-made, and the lime, immediately ſeparated from it by the introduction of air, and then diluted, ſo as to leave the liquor colourleſs and tranſparent, yielded a water ſo nearly reſembling the natural [redacted], that, as to ſmell, taſte, or appearance, it was hard to perceive any difference.

But upon dropping *lixivium tartari* into the artificial water, it inſtantly grows turbid *; whereas, when the like addition is made to the natural ſulphureous waters, their brightneſs is improved; which ſhews that the ſolution of ſulphur, in the natural waters, is brought about in ſome manner not analogous to that in the artificial; for it ſeems pretty obvious, that the ſulphur is here rendered ſoluble in water, from being deprived of its *cementing principle* by that ſhare of the quick-lime which remains undiſſolved in the boiling.

This preſented a new theory concerning the ſolubility of oil, when combined with

* On mixing the fixed alcali with the ſulphureous water, the peculiar ſulphureous ſmell is inſtantly changed to one which is rather more diſagreeable, and though the mixture becomes turbid, yet no precipitation enſues; the ſulphur and the alcali, joining into a body, ſeparate themſelves from the water, and remain ſuſpended in the glaſs.

the

the caustic alcali, and made into soap; which, I conjectured, might, as well as the sulphur, be rendered miscible with water, when the cohesion of the oily particles is destroyed, by the loss of their fixed air.

EXPERIMENT 5.

THIS conjecture was found to be right, by transferring air, from an effervescent mixture, into a solution of common soap; for the moment the air mixed with the solution, the oily part began to separate, and, in a few minutes, all rose to the surface, the cementing principle now being restored to the disunited particles of the oil.

I REPEATED this experiment on a solution of soap, which was filtered, and kept above a week after it was made; so that there could be nothing of a spontaneous separation in either case.

THESE experiments opened the way to some improvements in *pharmacy*; since it followed plainly, that if oil was thus rendered miscible with water, *camphor*, and all kinds of *resinous bodies*, might, in like manner, be dissolved.

EXPE-

EXPERIMENT 6.

I BEGAN with the camphor, and having rubbed a drachm of it with an equal portion of quick-lime, and then poured on ſix ounces of lime-water, I allowed the mixture to ſtand for half-an-hour, that the groſs and inſoluble part might ſubſide; the clear was then paſſed through a filter, and found to be a ſtrong ſolution, containing at leaſt one half of the camphor.

ON another occaſion, I made uſe of heat, boiling the camphor and quick-lime with water in a cloſe veſſel, and thus obtained an entire ſolution.

THESE ſolutions, when filtered, are perfectly limpid, and never part with the camphor; for though the lime may be precipitated in ſeveral ways, yet I have not hitherto hit upon any method of ſeparating the camphor from the water.

COMMON ſalt, if added in a large proportion to the ſolution, throws up a cream to the ſurface, which, upon examination, is found to conſiſt of little more than mere calcareous earth.

AND ardent ſpirits, though they cauſe a milkineſs when added to the ſolution, do not

not entirely part the *camphor* from the water.

EXPERIMENT 7.

MYRRH, *gum guaicum*, *aſa fœtida*, *aloes*, *caſtor*, *balſam* of *Tolu*, with *maſtich*, *jalap*, and the *cortex*, were all tried in the ſame manner as the *camphor*, and were found to yield ſtrong ſolutions and tinctures, the lime [redacted] enabling the Water to take up the ſame part of theſe ſubſtances that is diſſolved by the means of ardent ſpirit. But theſe aqueous tinctures muſt be much more elegant medicines, and perhaps may be found more efficacious than the ſpirituous ones, on account of the extremely minute diviſion of their more active part, as well as their convenient exhibition, ſince they will never become turbid, or ſeparate, on being mixed in any watery vehicle.

THERE is as much lime in all theſe tinctures and ſolutions, as there would be in the like quantity of lime-water, which bids fair to improve the virtues of ſome of them, and can do no great injury that I know of to any; but if it ſhould ever be thought ſo, the lime may be precipitated from them, by throwing in air from ſome

effervescent

effervescent mixture, as hath been already explained.

THE air, when thus thrown in, renders the solution, or tincture, quite turbid, and appears plainly to the eye, at first, to re-unite the dissolved particles of the resin, as well as the lime; but the former are very soon re-dissolved, and the lime only falls to the bottom.

As the fixed air, when thrown off by putrefaction, or during the first stage of fermentation, equally produced the effect, of rendering *mild* the *caustic* alcali, with that which was set free by effervescence, it might have been fairly concluded, that it would also precipitate the lime from lime-water; but as I had laid it down for a rule to depart as little as possible from actual experiment, and to be very sparing in drawing conclusions from any thing but evident facts, I determined to make the trial.

EXPERIMENT 8.

ACCORDINGLY, having joined two phials together, by means of the bended glass tube, (as in the 17th experiment of the second essay), and filled one with fresh mutton,

mutton, and a little water to make it putrefy the ſooner, and the other with lime-water, I laid them by in order to let the putrefaction proceed.

BEFORE twenty-four hours were elapſed, the precipitation of the lime was evident, and it increaſed every day, for ſix days that the phials remained in this ſituation; but ſhaking the phials one day, in order to make the putrid liquor ſubſide (for it roſe in the tube in the ſame way that it did in the experiment before-mentioned, when I was transferring air from putrid fleſh into the cauſtic alcali), the tube happened to break, and an end was thereby put to the experiment; but I had ſeen enough to prove that *fixed air*, when thrown off by *putrefaction*, would produce the very ſame effect on lime-water with that which was ſet free by *efferveſcence*.

AND here we have an additional proof of the *fixed air*'s being the *cementing principle* in *animal ſubſtances*; ſince we *ſee*, that while the fleſh is reſolved, and falls in pieces, from the loſs of this principle, the lime is rendered ſolid by having it reſtored.

WHILE this experiment, and the following, were going on, I filled two phials with filtered lime-water (that ufed in the experiments was always filtered), and left one of them without a cork, while the other was clofely ftopped, and laid them by as ftandards; to fee if any, and in what proportion, the lime would precipitate when left to itfelf: But neither the one, nor the other, in a fortnight's time, depofited the fmalleft particle of lime.

EXPERIMENT 9.

IN order to try the effects of the *gas*, or vapour, difcharged during the firft ftage of fermentation, I made up fix ounces of a fermentative mixture, of flefh meat, bread, cabbage, and turneps, with the requifite quantity of water, and put it into one phial; which being joined, by means of the tube, to another filled with lime-water, the two were placed in a temperate degree of heat, that the mixture might ferment the fooner.

THE fermentation began in the ufual time, and went on with the common appearances: And as it did proceed, the lime became every day more and more vifible;

ſible; and forming, firſt, light flakes of a feathered reſemblance, near the ſurface, theſe gradually fell to the bottom, until, at the end of five days (the period that the phials remained in conjunction) when I poured out the water, and allowed the precipitate all to ſubſide, I collected three grains of calcareous earth from ſix ounces of lime-water, which was the quantity contained in the phial.

THIS action of the vapour (which, on a former occaſion, was termed antiſeptic) in re-uniting the diſſolved and ſcattered particles of lime, may ſerve to give ſome idea of the manner of its operation on diſſolved blood, when the texture of that fluid is deſtroyed and broken, by a putrefactive acrimony.

AND this experiment likewiſe ſhews, that lime-water, when given as a *lithontriptic*, ought not to be drank at meals, leſt it loſe part of its virtue, from the fixed air of the alimentary ſubſtances ſaturating and rendering inert, the diſſolved and active particles of the quick-lime.

THE activity of lime-water muſt alſo be impaired by infuſing vegetable ſubſtances therein, which contain much fixed air;

ſuch as the *guaicum*, or *ſaſafras*; for theſe woods abounding in reſin, give out their cementing principle, which, uniting with the diſſolved quick-lime, reſtores it to its original ſtate of an inactive calcareous earth: Therefore, when it is intended that theſe woods, or any other ſubſtance of the like nature, ſhould give out their virtue to lime-water, and that the water ſhould, at the ſame time, contain its due proportion of diſſolved lime, ſome quick-lime ought to be added, during the time of maceration.

WE have ſeen, then, in *three* different inſtances, that the lime is precipitated from lime-water by reſtoring to it the fixed air: May not lime-water, therefore, upon this principle, be uſed as a *teſt* to try whether or not bodies contain *fixed air*? If any body, upon mixture with lime-water, occaſions a precipitation, and if the precipitate ſo cauſed effervеſceth with acids, may we not conclude that the body ſo added contains fixed air; and that, in a greater or ſmaller proportion, as the precipitation of the lime from the water is more or leſs immediate?

EXPE-

EXPERIMENT 10.

SPIRITUS *cornu cervi per ſe*, *ſalt of hartſhorn*, and *ſalt of tartar*, being ſeverally mixed with lime-water, immediately threw down a precipitate, which, upon examination, was found to be true calcareous earth.

EXPERIMENT 11.

SPIRIT of *ſal ammoniac, made with quick-lime*, and the *cauſtic alcaline ley*, made of pot-aſh and quick-lime, when mixed with the lime-water, did, neither of them, in the leaſt deſtroy its tranſparency, nor did any precipitation ever enſue.

EXPERIMENT 12.

BUT air being transferred into the ſame cauſtic alcalies, and lime-water then mixed with them, the ſame appearances followed which happened upon mixing the mild alcalies in the 10th experiment.

EXPERIMENT 13.

BROWN ſugar *, when mixed with lime-water, preſently threw down a precipitate, which effervefced violently on the addition of ſpirit of vitriol; but refined ſugar (which is deprived of great ſhare of its fixed air, by the quick-lime that is uſed in refining it), when diſſolved in lime-water, did not at all deſtroy its tranſparency, and, after ſtanding twenty-four hours, threw down ſcarce any precipitate.

EXPERIMENT 14.

RECENT juices of fruits, or other vegetable ſubſtances, when mixed with lime-water, deſtroyed its brightneſs immediately, and ſoon after threw down a precipitate, which effervefced violently on the addition of ſpirit of vitriol. But fermented liquors occaſioned no immediate change, nor did any precipitation enſue until after ſeveral hours ſtanding, and this different

* Dr. *Hales* found the proportion of air, in the coarſeſt ſugar, to be a little more than one-tenth of the whole. See his 65th experiment of the 1ſt vol.

in

in different liquors*: Then, alſo, the quantity of precipitate was but ſmall, the whole of the lime not being ſaturated, as the taſte plainly teſtified was done by the recent, unfermented juices.

EXPERIMENT 15.

ARDENT ſpirits † produced ſtill leſs alteration on lime-water, than the fermented liquors; but they abſorbed the air from an efferveſcent mixture very greedily, and, when thus charged, threw down the lime from the lime-water inſtantly on being mixed therewith.

THESE experiments all concurring to eſtabliſh lime-water as a *teſt* of the preſence, or abſence, of fixed air, I reſolved to examine ſome of the animal fluids, in this manner.

IN Dr. *Whytt*'s very ingenious eſſay on the virtues of lime-watar, we find a number of experiments, made with a view of determining what things impair or deſtroy its diſſolvent power, with regard to the

* Cyder and bottled beer threw down the precipitate much ſooner than claret or port-wine.

† It was rectified ſpirit that was tried.

calculus; one of which plainly ſhews, that the urine contains fixed air; for when this celebrated profeſſor mixed "an ounce and "a half of lime-water, and an ounce of "freſh-made urine, it immediately loſt its "yellow colour, and became whitiſh and "turbid, and, in a little time, a light, "white ſediment fell to the bottom, and "left the liquor above perfectly pellucid, "of a fine light lemon colour, without "any ſcum or cruſt on the ſides of the "glaſs *."

EXPERIMENT 16.

I REPEATED this experiment with preciſely the ſame appearances; and found, that on pouring off the clear, and dropping in ſpirit of vitriol, a violent efferveſcence enſued; plainly ſhewing, that the particles of the quick-lime, now ſaturated with the fixed air, which they had abſorbed from the urine, were returned to their original ſtate of a calcareous earth.

WE have already hinted, that there is ſome danger of lime-water's being deprived of part of its virtue, from the vapour ariſ-

* See the Eſſay, ſect. 2. No. 8.

ing from the alimentary ſubſtances, during their fermentation in the firſt paſſages; and here we have another circumſtance which is diſcouraging, with regard to the diſſolution of the *calculus*. By the experiments hitherto made, the *calculus* appears capable of diſſolution in *two* ways; either by means of a ſtrong acid, ſuch as ſpirit of nitre, which probably acts immediately on the earthy part of the ſtone, or by lime-water, or cauſtic alcali, abſorbing the fixed air; whence the earthy parts, deprived of what bound them together, muſt preſently fall to pieces *.

WITH regard to internal exhibition, the *acid* is entirely out of the queſtion, and the only hope of a ſafe diſſolvent muſt reſt on the *cauſtic alcali*, or on the *lime-water*.

THIS alcali, when combined with oil, and made into *ſoap*, is not only ſo greatly obtunded thereby as to loſe much of its power, but the ſoap itſelf is ſo nauſeous, that few patients can bring themſelves to

* Of all the various ſubſtances examined by Dr. *Hales*, with a view of determining their reſpective quantities of air, the human *calculus* was found to contain the largeſt proportion; above one half of this maſs conſiſting of *fixed air*.

take it in a quantity ſo large as to prove of much effect; it would therefore be a happy diſcovery if any vehicle could be found out, that would ſufficiently ſheath the acrimony of the cauſtic alcali, ſo as to allow it to be taken in large and continued doſes: Poſſibly, veal broth, or a decoction of marſh-mallow roots, might be found to anſwer this purpoſe; and lime-water might be taken at the ſame time, which would not at all interfere with the operation of the alcali, but rather add to its activity.

LIME-WATER, when taken alone, muſt often fail in producing any conſiderable effects as a *lithontriptic*, becauſe it muſt loſe much of its power, not only from the vapour it meets with in the firſt paſſages, but likewiſe from the fixed air of the urine itſelf, which muſt ſaturate great ſhare of the quick-lime, even when it hath reached the bladder.

THAT this actually happens, may be inferred from the great quantity of earthy matter diſcharged in the urine of perſons who are under a courſe of lime-water; this ſediment ſeeming to conſiſt moſtly of lime, parted from the water in which it

was

was diſſolved, being precipitated by the fixed air of the urine.

IT ſhould ſeem, then, as if the cauſtic alcali bade the faireſt for ſucceſs in theſe caſes; and therefore its effects ſhould be tried in hoſpitals, and, as hath been already mentioned, it ſhould be given in ſome gelatinous, or mucilaginous vehicle, that would ſheath the ſharpneſs of the ſalt, in ſuch manner as to allow of a conſiderable quantity being taken; which certainly might be accompliſhed, ſince we find that Dr. *Jurin* brought himſelf, by degrees, to take an ounce and a half of capital ſoap lees, in the courſe of a day, though diluted by liquors that had little or nothing of the mucilaginous nature*.

* There is a paper in the Gentleman's Magazine for October 1763, which proves very plainly, that a noſtrum, exhibited by one Dr. *Chittick*, and which is found, after a perſeverance of ſome months, actually to diſſolve the ſtone, is nothing more than the cauſtic alcali, given in veal-broth. The patients prepare the broth themſelves, and ſend it to the doctor every day, who returns it with the medicine mixed therein.

EXPE-

EXPERIMENT 17.

THE *perſpirable matter* alſo contains fixed air: Three ounces of filtered lime-water being put into a phial, and a funnel fixed cloſe into the neck of it, I blew in my breath through the funnel, and by the time I had continued ſo doing for ten or twelve minutes, I found the water growing turbid, and the lime becoming viſible.

THIS being a tireſome kind of operation, I deſiſted, when I had thoroughly ſatisfied myſelf that the perſpirable matter, if thrown in in a ſufficient quantity, would ſaturate all the lime, ſince even what I had done was found, upon collecting the precipitate, to have thrown down more than a grain.

I FOUND alſo that *ſweat* contains fixed air, and uſed the following method of collecting ſome drachms of this fluid.

EXPERIMENT 18.

HAVING often obſerved hackney-chairmen ſweat ſo profuſely after ſetting down their fare, that they ſweep it off from their bare heads in a full ſtream with their leathern ſtraps, I took an opportunity one day

day of collecting about a couple of drachms of ſweat, that had been raiſed in this manner, and having mixed it with ſix drachms of lime-water, found that the mixture immediately became turbid, and, in a ſhort time, depoſited a light ſediment, ſuch as was thrown down from the urine, and which efferveſced as violently when ſpirit of vitriol was added.

I HAD formerly ventured to aſſert, that air is thrown off from the fluids by perſpiration, and theſe experiments, I apprehend, will readily be allowed as proofs of the truth of that aſſertion.

BUT the *ſaliva* ſeems as if it contained little or no fixed air; for when Dr. *Whytt* infuſed a piece of *human calculus*, weighing three grains, in a mixture of *ſaliva* and lime-water, in the proportion of one of the former, to two and a half of the latter, in two days warm digeſtion, the bit of *calculus* was reduced to one grain and a half *.

THAT is to ſay, the lime-water having loſt ſcarce any thing of its power, the *calculus* diſſolved as readily, in a mixture of

* Sect. 4. No. 21.

saliva and lime-water, as it would have done in lime-water alone, equally dilute; for had the *saliva* abounded in fixed air, which would have saturated the quick-lime of the water, its dissolvent power would have been proportionably weakened, as we find it was by mixing fresh vegetable juices, or honey, with lime-water *.

EXPERIMENT 19.

Two drachms of *saliva* being mixed with six drachms of lime-water, the mixture did not grow turbid; but in two hours I found a sediment, which, on pouring off the clear, and dropping in spirit of vitriol, shewed little or no sign of ebullition. Hence I concluded, that this sediment was scarce any thing more than the gross part of the *saliva*, which, when left to itself, in a little time deposites a considerable portion of thick and viscid matter.

* See Dr. *Whytt's* Essay, sect. 6 & 7, No. 34, 36, 37, & 38.

EXPERIMENT 20.

I THEREFORE refolved to repeat the experiment, and having collected near an ounce of *faliva*, and fuffered it to ftand long enough for the thick part to fubfide, I then mixed two drachms of the clear with fix drachms of lime-water, and found it produce no immediate alteration.

BUT two drachms of the fame clear *faliva* being put into a fmall phial, and air transferred into it from an effervefcent mixture, and then mixed with fix drachms of lime-water, inftantly the mixture became turbid, and a large quantity of precipitate, in the form of flakes, fell to the bottom, and effervefced violently when fpirit of vitriol was poured on it.

THE firft mixture of lime-water and *faliva*, after ftanding twenty-four hours, was covered with a cruft, and found to have depofited but a fmall quantity of whitifh vifcid matter, which effervefced but flightly with the acid fpirit.

So that the *ſaliva* naturally contains very little fixed air, but, nevertheleſs, is a powerful abſorbent thereof *.

FROM another experiment of Dr. Whytt's, the bile appears to contain as little fixed air as the *ſaliva*; for when he immerſed a fragment of *calculus*, weighing three grains, in an ounce of cyſtic bile, and three ounces of oyſter-ſhell lime-water, and kept it in a moderate heat for forty-two hours, he found that near a grain and a half of the ſubſtance of the *calculus* was diſſolved in the form of thin whitiſh ſcales †.

* We had a former proof of the affinity between ſaliva and fixed air, in the 14th experiment of the ſecond eſſay; wherein it was found that the ſaliva, when intimately mixed with an animal ſubſtance, has ſome degree of antiſeptic power; which agrees with the general theory concerning this power, as laid down in the third eſſay: For *ſaliva*, being an attracter of fixed air, when mixed with an animal ſubſtance, unites itſelf with the fixed air of that ſubſtance, and in this manner reſtrains, for ſome little time, the flight of the cementing principle.

† Sect. 4. No. 22.

EXPE-

EXPERIMENT 21.

As I could not, at this time, procure any fresh human bile, and excepting it were fresh, and taken from a healthy subject, the experiment would not have been fairly made, I was obliged to try that of a dog: One of these animals being therefore killed, and its gall-bladder taken out, about a drachm and a half of bile was found in the cyst.

ONE half of this quantity being mixed with three drachms of lime-water, the mixture remained transparent, and equable, for an hour; it then lost its pellucidity, and gradually deposited a light sediment, of dark yellow, or rather orange colour. When it had stood twenty-four hours, I passed the mixture through a filter, in order to separate the sediment; which being done, spirit of vitriol was poured on, and found to raise a slight degree of effervescence.

THE other half of the bile was put into a small phial, and air transferred into it from an effervescent mixture, as had been done in regard to the saliva, and then it was mixed with three or four drachms of lime-water.

THERE was very little difference between the appearances of this mixture, and thoſe of the former ones: It remained tranſparent for about the ſame ſpace of time, and then, like the other, loſt its brightneſs by degrees, and depoſited a ſediment, which only differed in regard to the colour, being of a more light yellow. When this ſediment was examined, after ſtanding twenty-four hours, it was found to efferveſce violently with the acid, whereas the ebullition of the other ſediment was but obſcure.

FROM theſe experiments (if the lime-water be a true teſt) we ſee, that *bile* contains ſomewhat more fixed air than *ſaliva*, and does not abſorb this element ſo powerfully *.

AND here we plainly ſee in what ſenſe theſe fluids are to be called ſaponaceous;

* As the *bile*, in a *ſound ſtate*, contains ſo little *fixed air*, we immediately ſee the reaſon why *putrid bile*, or the ſpirit diſtilled from it, raiſe little or no ebullition with *acids*, notwithſtanding the other marks of the *alcali* in that fluid.

and

and may likewiſe comprehend in what manner they perform their action of diſ-ſolving fat, or oily matters: They *abſorb* the *fixed air* from the oils expoſed to their action, and thus deſtroying the bond of union between the oleoſe particles, render theſe bodies miſcible with water.

AND hence the obvious reaſon, why the *ſaliva* ſhould be the more powerful abſor-bent of the two; for had not the oily part of our food, from its admixture with the *ſaliva* in maſtication, been rendered miſci-ble with the watery part, the alimentary mixture could not have fermented properly when received into the ſtomach; the con-ſequence of which would been ſickneſs, nauſea, and heartburning *, from the ſharpneſs of the oil, now become rancid by the mere heat of the place.

BUT when all the diſcordant parts of the alimentary mixture are blended toge-ther, by the diſſolvent power of the *ſaliva*, and further united by the ſame quality in *the ſuccus gaſtricus*, *bile*, and *pancreatic*

* Not the heart-burning attended with acid, but that accompanied with nidoroſe, eructations.

juice *, then no ſeparation of oil enſues, but the fermenting motion goes on, kindly and regularly, until new combinations take place, and that every particle of the food is broken and changed.

BUT in ſome conſtitutions this abſorbent power of the digeſtive fluids is ſo greatly weakened (or, in other words, they contain much fixed air, when, in a natural and healthy ſtate, they ought to contain very little), that the oily part of the food is never thoroughly mixed, or ſubdued; and hence the immediate cauſe of indigeſtion, cardialgia, rancidity in the ſtomach, and extraordinary flatulence.

AND poſſibly this might appear, upon examining the *ſaliva* of the patient, by mixing it with lime-water: If the mixture ſhould immediately become turbid, and depoſite a ſediment that ſhould effervefce on the addition of an acid ſpirit, it would ſhew the morbid ſtate of the *ſaliva*, as

* Though neither the *ſuccus gaſtricus*, nor *pancreaticus*, were tried, with relation to their containing fixed air, yet I apprehend that their ſimilitude to the *ſaliva* will make it no unfair inference to ſay, that theſe fluids contain very little of this element.

containing too great a proportion of fixed air, which muſt neceſſarily hinder the abſorbent power of this fluid, and conſequently diſenable it from diſſolving the oily part of the food.

I AM inclined to think, that this is actually the caſe in gouty ſubjects, where the complaints above-recited are conſtant forerunners, or attendants; and that the juices in theſe people are too much loaded with fixed air, which not only impairs the abſorbent power of the digeſtive fluids, but alſo diſpoſeth the earthy and ſaline particles of the blood, to run into concretions, which obſtruct and tear the ſmall veſſels wherein they happen to be impacted.

IF this be the real condition of the fluids in gouty conſtitutions, lime-water, or the cauſtic alcali, would promiſe fair to be excellent *antarthritics*; and perhaps the benefits which accrue to patients, from the uſe of certain waters, may ariſe, in great meaſure, from theſe waters containing an earthy matter diſſolved therein, *void* of *fixed air*, and which have an abſorbent power, like what is obſervable in lime-water; which enables them not only to help digeſtion, but alſo to diſſolve, in ſome meaſure, the concretions that conſtitute the diſeaſe *.

THESE

* The Bath-water, which is found to give ſo much relief in gouty and nephritic caſes, and in complaints of the ſtomach, ariſing from a weakneſs of the abſorbent power in the digeſtive fluids, though perfectly limpid as it flows from the ſpring, yet preſently depoſits a large proportion of earthy matter, and is alſo ſaid to grow turbid, and let fall a precipitate, on being mixed with an alcali.

If any perſon on the ſpot be deſirous of knowing whether this earthy matter, which is diſſolved in the water, be *void* of *fixed air* (like quick-lime diſſolved in lime-water), or whether it be held in a ſtate of diſſolution, by the intervention of an acid, let him make the following trials.

1. Drop either *lixivium tartari*, or *ſpiritus cornu cervi per ſe*, into the Bath-water.

2. Drop either the *cauſtic alcaline ley*, made of *pot-aſh* and *quick-lime*, or *ſpiritus ſalis ammoniaci cum calce viva*, into the ſame water; and obſerve whether it becomes equally turbid with the latter as with the former.

If it ſhall be found to do ſo, the experiments will ſhew that the earthy matter is diſſolved in the water by the means of an *acid*; but if the precipitation ſhall be found to follow only from the mixture of the *mild alcalies*, and that the brightneſs of the water is not at all impaired by the addition of the *cauſtic*, then we may be aſſured, THESE waters may be conſidered as a kind of natural lime-waters, containing a conſiderable portion of earthy matter, *void of fixed air* (like the particles of quick-lime diſſolved in lime-water) which, as ſoon as the water comes into contact with bodies containing much of the cementing principle, this laſt is attracted by the earthy particles which thus acquire ſolidity, and form a ſucceſſion of cruſts, or layers; and it is in this manner that, I think, we may form a plauſible theory for petrification *, and for the cruſts that are found

aſſured, that the earthy matter is diſſolved in *Bath water* from being, ſome way or other, deprived of its *cementing principle.*

N. B. It will be neceſſary to try the *cauſtic* alcali with an *acid*, previous to the making of the experiments, in order to be certain that it is perfectly *non-efferveſcent*; that is, *void* of *fixed air*.

* A petrifaction that I have met with, ſince writing the above, ſeems to confirm this *hypotheſis.*

It is a petrified moſs, wherein may be obſerved, very diſtinctly, the ſeveral gradations from abſolute ſtone to the living vegetable; the courſe of the fibres being every where plain, and eaſy to be traced. The part of the petrifaction that lay conſtantly under water found in the pipes and veſſels containing certain kinds of waters.

THESE

is abſolute ſtone, and is of the calcareous kind, effervеſcing ſtrongly with acids; in the middle part, which was not ſo continually expoſed to the action of the water, the petrifaction is incomplete; and at the top, which was always above water, the vegetable is ſtill alive, and in its natural ſtate.

The well from whence this petrifaction was brought being in the neighbourhood of *Dublin*, I ſent for ſome bottles of the water, in order to examine it.

On dropping a little of the filtered ſolution of *pot-aſh* into a glaſs of the petrifying water, it immediately loſt its brightneſs, turned milky, and, in a few hours, depoſited a white ſediment, which effervеſced ſtrongly with ſpirit of vitriol.

The very ſame appearances happened when *Lixivium Tartari* was dropt into the petrifying water.

On air being transferred into ſome ounces of the petrifying water, it loſt its brightneſs, and, in twelve hours, let fall a ſmall quantity of white ſediment.

Hence it appeared, that the petrifying water did contain an earthy matter diſſolved therein, *void* of *fixed air*, which was capable of reſuming the ſolid form, as ſoon as the cementing principle was reſtored.

Vegetable bodies, therefore, by remaining long expoſed to the action of ſuch kinds of waters, will have their ſubſtance gradually diſſolved; becauſe the earthy particles in the water attract the fixed air from the ve-

THESE petrifying waters were formerly condemned, as being apt to create the ſtone, but later experience has ſhewn, that the waters which abound moſt in this earthy matter, and which form the greateſt abundance of the cruſts above-mentioned, are the moſt effectual diſſolvents of the ſtone, as is every day experienced with regard to the *Carlſbadt* water in *Bohemia*.

THE abſorbent quality of the *ſaliva* moreover ſhews, how apt it muſt be to lay hold of infectious *miaſmata*, which oftentimes are in reality putrid vapours, or fixed

getable ſubſtance, and the moment they are ſaturated they acquire ſolidity, become inſoluble, and remain in the places of the vegetable particles, which are melted away.

This change of a vegetable into a foſſil ſubſtance, ſeems analogous to the change of iron into copper, which is brought about in no very long ſpace of time, by leaving iron plates in a water that is ſtrongly impregnated with a ſolution of copper in the vitriolic acid; the ſuperior attraction of the acid to iron cauſing it to ſeize this metal, and let go the particles of copper. So, in the caſe of petrification, fixed air having a ſtronger affinity with calcareous earth than it has with the vegetable ſubſtance, lets go the latter, and ſeizeth on the former.

air,

air, detached from bodies during putrefaction; and confirms what hath been frequently recommended, namely, to ſhake off infection *, and prevent the *miaſmata* from getting into the maſs of fluids by immediate vomiting; and we may likewiſe ſee, that the cautions given by authors concerning the ſwallowing of the *ſaliva*, while in the places abounding with infectious vapours are founded in reaſon.

IT will not appear ſtrange that ſome of the animal fluids ſhould contain ſo little fixed air, when we find that the *ſerum* of human blood ſeems almoſt void of this element.

EXPERIMENT 22.

HAVING ordered ſome ounces of human blood, drawn from a healthy perſon,

* By the precautions taken by Dr. *Lind*, and by immediate vomiting, "only *five* perſons died, from "among more than an hundred, who were ſeverally, "and ſome of them conſtantly employed, during eighteen months, in various offices about the ſick, in "*Haſlar* hoſpital;" where there conſtantly was a great number of people ill of fevers that were highly infectious. See his *Diſcourſe on Fevers and Infection*, paper 2d, p. 74.

to

to be kept until the *ſerum* and *craſſamentum* had fairly parted, I mixed two drachms of the ſerum with an ounce of lime-water: No change enſued; the mixture continued tranſparent, and, after forty-eight hours ſtanding, no precipitate could be perceived, while the liquor remained in the glaſs; but, upon pouring it out, a very ſmall quantity of white earthy matter was found at the bottom, which, however, would not efferveſce with vinegar.

EXPERIMENT 23.

ABOUT two drachms of the *craſſamentum* of the ſame blood being put into a cup with an ounce of lime-water, and left for five days, did neither totally diſſolve, nor turn putrid; a piece of it being then taken out, and ſpirit of vitriol poured on, an efferveſcence enſued, the lime which had penetrated, and joined itſelf to the fixed air of the *craſſamentum*, now burſting forth from every part of it, the moment the acid was applied.

So that the fixed air appears to be connected chiefly with the red globules, and with that part of the blood called by *Senac* the

the *lympha coagulabilis*; ſince theſe two are found to compoſe the *craſſamentum* *.

EXPERIMENT 24.

Two ounces of lime-water being put into a tall drinking-glaſs, about half an ounce of blood was allowed to flow from the vein of a perſon in health, into the glaſs with the water: when it had ſtood ſix hours, the mixture was all poured out, to about a drachm, which was ſuffered to remain in the bottom of the glaſs; on this ſediment ſome ſpirit of vitriol was dropped, and raiſed a ſmart ebullition, the calcareous matter turning white, as it boiled up on the addition of the acid; ſo that the fixed air, is eaſily detached from freſh blood.

* There was a very ingenious theſis publiſhed in 1762, by Dr. *Butt*, when he took his degree at *Edinburgh*; which contains a number of very ſatisfactory experiments and obſervations, concerning the component parts of the human blood. The title is *De Sanguinis Spontanea Separatione*.

EXPE-

EXPERIMENT 25.

NEW breaſt milk, when mixed with lime-water, in the proportion of one to three, in great meaſure deſtroyed the acrid taſte of the lime, yet did not cauſe any ſeparation that was immediately perceivable; but after ſtanding twelve hours, the precipitation was viſible, and, on pouring out the mixture, the ſides of the glaſs were found incruſted with a calcareous matter, which, as well as what fell to the bottom, effervеſced violently on the addition of ſpirit of vitriol.

So that milk contains a large proportion of fixed air, and conſequently ought not to be mixed with lime-water, ſince it muſt neceſſarily take off from its activity.

DR. *Alſton* obſerved very well, that there is ſcarce any thing that is uſually mixed and given along with lime-water, that does not, more or leſs, deſtroy its efficacy; for which reaſon he recommended it always to be taken alone *.

* Diſſertation on Quicklime, p. 41. ſect. 11.

LIME-

LIME-WATER, when mixed with milk of any kind, prevents it from turning four; the reafon of which is obvious, becaufe, by abforbing and retaining the fixed air, the inteftine motion is prevented, whence there can be no change of combination.

I HAVE now finifhed what was originally propofed; and, I hope, have fatisfactorily fhewn, that *fixed air* is the *cementing principle*, and *immediate caufe*, of *perfect* cohefion, at leaft in animal and vegetable bodies *; and though the experiments which I have made are very far from exhaufting the fubject, yet they certainly are fufficient to raife curiofity, and to prompt men of leifure to a further inveftigation of this important element;

* I have faid *perfect* cohefion, for, as Dr. *Hales* obferves, "Doubtlefs all the particles of matter what-"ever do in actual contact cohere; yet fince it is found "by experiment, that the moft folid parts of animals "and vegetables yield a vaftly greater quantity of air, "and lefs water, than the more lax and fluid parts, it "feems therefore hence reafonable to conclude, that "their folidity is principally owing, not to the watery, "but to the air and fulphureous particles." Vol. ii. p. 280.

which ought not, by any means, to be confounded with the *atmoſpheric air:* for, excepting its being for a time capable of elaſticity, the *fixed dir* does not appear to agree, in any other property, with the *common air* which we breathe.

WE know for certain, that the *atmoſpheric* air could not immediately penetrate the body of the lime-water, or other fluids, in the manner that the *fixed air* plainly appeared to do: This laſt, though perfectly elaſtic when firſt ſet free, yet, in a very little time, loſeth its ſpring, mixeth with the liquid, penetrates every where, and ruſheth into union with the diſunited and ſcattered particles of the ſubſtances diſſolved *.

BUT

* The *air* which flies off from bodies, whether ſolid or fluid, in the exhauſted receiver of an air-pump, is *not* the *fixed air*; for this never departs but when the body to which it belongs either ſuffers a decompoſition, or is diſſolving into minute parts.

Thus, if the *mild* volatile alcali, and the *cauſtic* volatile alcali (*viz.* Sp. cornu cervi per ſe, *and* Sp. Sal. Ammon. cum calce viva), be both incloſed in the ſame exhauſted receiver, the one will throw off as many air-bubbles

BUT a ſtill more ſtriking diſtinction between the *fixed* and the *common atmoſpheric air*, may be remarked in the very different and oppoſite effects which the two produce in the bodies of living animals.

THE *fixed air*, when ſet free, and in a ſtate of perfect elaſticity, whether it be during the firſt ſtage of fermentation, by fire †, by efferveſcence, or by putrefacttion, if it be received into the lungs of any living animal, cauſeth inſtant death.

BUT the ſame elaſtic matter, when received into the ſtomach, whether thrown off from efferveſcent mixtures, given in the way of medicine, or extricated from the food in the natural proceſs of alimentary fermentation, is ſo far from producing any ill effect, that, in the firſt inſtance, it often operates like a charm in reſtraining vomitings, and, in the ſecond, is

bubbles as the other; though we certainly know that the firſt contains a large proportion of fixed air, while the ſecond is entirely void of this principle.

† Dr. *Hales* ſuffocated a ſparrow, by putting it into air that had been obtained by diſtillation from heart of oak. Vol. i. p. 176.

abſolutely

abſolutely neceſſary for the ſupport of life and health.

WITH regard to the *atmoſpheric air*, it is univerſally known that *no* animal can live long without freſh ſupplies of it, and thoſe who have lungs cannot exiſt many minutes without taking in large quantities of this element. But if a very ſmall portion of the ſame be forced into the veſſels of any living animal, death preſently enſues.

So that theſe two elements ſeem to be different in their natures, and to have quite diſtinct provinces with regard to animal life: It is required of the firſt, that it mix *wholly with* the blood; it ſeems ſufficient that the ſecond only communicate ſome ſubtile matter, or make *ſome impreſſion upon* that fluid.

IT muſt be confeſſed, however, that notwithſtanding what hath been juſt now ſaid, we have not, as yet, a ſufficient number of facts to determine *poſitively*, whether theſe be *originally diſtinct elements* in nature; or whether the *fixed air* is nothing more than a portion of the *univerſal aerial fluid*, which is altered, and modified, from its having been united with ſome other principle *.

IT appears, however, from a circumſtance peculiar to lime-water, that there is great ſtore of the *cementing principle* always floating in the atmoſphere, which is ready to be abſorbed by ſuch bodies as have an affinity therewith; for we ſee that the particles of the diſſolved quick-lime, which are neareſt the ſurface of the water,

* This ſeems to have been the opinion of Dr. *Hales*, who looked on fixed air as a portion of common, repellent, elaſtic air, deprived of its ſpring, and reduced to a ſtate of fixity and attraction, by the power of the *ſulphur* in bodies.

Dr. *Cullen*, if I am rightly informed, teacheth, that *phlogiſton* is a compound, and holds fixed air to be one of its conſtituents.

Boerhaave was in ſome doubt what to think concerning the fixed air. "Dubitatum quandoque, an omne "illud quod ita gigneretur foret quidem ejuſdem ita "naturæ ut eodem nomine aeris elaſtici appellari de- "bet? an vero, corpora certa lege reſoluta in partes "minimas, omiſſa natura ſua prima, forte vera tranſ- "mutatione permutarentur in aerem hunc elaſticum, "quidein rurſum concretus aliis iterum firma redderet "nova corpora? an adeoque præter aerem commu- "nem elaſticum, aliud illi ſimile, non idem, in rerum "natura obtineret?" *Element. Chem.* tom. i. p. 532.

attract

attract the fixed air from the atmoſphere, and form cruſts, which are nothing more than the pure calcareous earth, ſuch as the quick-lime was before calcination, and which, by the action of fire, may be again reduced to quick-lime.

AND the abundance of fixed air in the atmoſphere may be ſtill further proved, by its deſtroying the cauſticity and ſolubility of quick-lime, and by its rendering mild, and effervеſcent, the cauſtic alcalies, when theſe bodies are long expoſed to the open air; and alſo by its action on living vegetables.

IT is univerſally known, that vegetables do not grow, or enjoy health, but in a free air; for as they are perpetually taking in ſome nouriſhing principle from the atmoſphere, they require that this ſhould be preſented to them in a continual ſucceſſion.

IT ſeems pretty evident, that this is the *cementing principle*, as theſe bodies are found, upon analyſation, to contain a larger proportion thereof than can well be ſuppoſed is ſupplied by the roots, notwithſtanding that there is found a good deal of fixed air in ſome kinds of ſoil.

THE fixed air resides principally, if not altogether, in the most elaborate part of the vegetable juice, the gum and the resin; and all bodies of the resinous kind, we have already seen, become soluble in water, when the cohesion of their particles is destroyed by withdrawing the fixed air: but as this method of solution * may be applied to many useful purposes in medicine, and perhaps in mechanics, it will not be amiss to lay down the several processes with a greater degree of accuracy and precision.

* Until within a few days before these papers were sent to the press, I looked on this method of dissolving resinous bodies as a discovery, not having observed, when I first read Dr. *Lewis*'s *Materia Medica*, that the dissolvent power of quick-lime, with respect to these substances, is known to that ingenious and useful writer. The passage relating to this matter is under the head of *calx viva*, and runs in the following words.

" Lime-water dissolves, by the assistance of heat,
" mineral sulphur, vegetable oils and resins, and ani-
" mal fats; it extracts in the cold the virtues of sun-
" dry resinous and oily vegetables, and dissolves thick
" phlegm, or mucous matters, and the curd of milk,
" with which last it forms a white liquid, nearly simi-
" lar to milk in its natural state."

IT has been already mentioned, that the ſolutions made by the means of quick-lime, do all of them contain a certain proportion of the ſame; but as this may ſometimes be reckoned injurious to the virtue of the medicine, *camphor, and* the ſeveral reſinous bodies, may be diſſolved in ſuch manner as not to contain a ſingle particle of quick-lime; as for example,

Take of camphor one drachm;
——— double-refined ſugar one drachm;
——— ſimple lime-water one pint;

RUB the camphor and the ſugar together into a fine powder, and then gradually pour on the lime-water; let the whole ſtand for two hours, and then paſs the liquor through a filter. And thus will be produced, not indeed an intire ſolution, but a much ſtronger one than that in the common *julepum camphoratum*.

IN the common way of making the *julepum e moſcho* (as directed in the London Diſpenſatory) ſcarce any of the *muſk* is diſſolved; but if it be made in lime-water, a perfect ſolution of the finer and more active part of the medicine will immediately take place.

Take of muſk one ſcruple;
——— double-refined ſugar one drachm;
——— lime-water ſix ounces;

Rub the muſk and the ſugar together, then add the lime-water and filter, as before directed.

To this, as well as to the foregoing, the preſcriber may add any ſpirituous water, or the volatile alcaline ſpirits, without deſtroying the tranſparency of the ſolution.

IN like manner may *ſcammony*, or *reſin* of *jalap*, be diſſolved; and if ſome grains of *Jamaica pepper* be added, and rubbed up along with the ſugar and other ingredients, it will communicate a moſt agreeable *cinnamon* flavour, that entirely covers the taſte of the *jalap*, or *ſcammony*.

THESE ſolutions make very elegant and pleaſant purging draughts; only it muſt be remembered to order near triple the quantity of either the *reſin* or the *ſcammony*, that would anſwer if given in ſubſtance; for the reſinous particles are ſo minutely divided in this ſort of ſolution, that they give but a very gentle degree of irritation to the bowels.

IF

IF an acid ſpirit be poured upon what is left on the filter, after any one of the foregoing ſolutions, it will be found to raiſe a ſmart ebullition; which plainly ſhews that the quick-lime that was diſſolved in the water is now ſaturated, and rendered ſolid, by the *cementing principle*, and has changed places with part of the reſinous body, which remains diſſolved in the water, while the lime is precipitated.

BUT there are caſes wherein the lime will bid fair to improve the virtues of the reſinous ſolutions; as, for inſtance, when the *cortex* is preſcribed merely with a view to its aſtrictive quality, as in ſcrophulous and relaxed habits, in order to check or dry up ulcers, gleets, or uterine diſcharges; and here it may be ordered in the following manner:

Take of Peruvian bark, in powder, two ounces;
——— quick-lime one ounce;
——— lime-water thirty ounces;

RUB the bark and the lime together, until they be thoroughly mixed; then gradually pour on the lime-water; let the whole ſtand for twelve hours, and then paſs the liquor through a filter.

AND thus will be obtained a moſt elegant, and not unpalatable tincture, which may be taken, either quite alone, or in any convenient vehicle, and in what quantity the preſcriber ſhall judge proper.

I CAN venture to aſſure the reader, from experience, that the bark, given in this manner, and in the caſes above-mentioned, produceth excellent effects. And where a yet ſtronger aſtringent is required, oak-bark, managed in like manner, has been found to anſwer exceedingly well.

RHUBARB, prepared in the ſame manner, yields a beautiful tincture, which promiſeth to be of great ſervice in all caſes where ſmall quantities of this root are given with a view to ſtrengthen the bowels, and to preſerve them free from a load of viſcid ſlime, as in weak and ricketty children.

ALOES, when joined with the lime, is not near ſo nauſeous as when diſſolved in the common way; and therefore independent of the lime, whoſe virtues, as an anthelminthic, are conſiderable, bids fair to be of great uſe; for children, who generally are the patients in theſe caſes, will

probably

probably be induced to take the medicine better when thus made up, than when it is prepared in the uſual manner.

MYRRH and *ſaffron* may be occaſionally joined with *aloes*; and being all diſſolved by the means of quick-lime, will make an efficacious *elixir proprietatis*, as the lime will certainly improve the virtues of the other ingredients, in moſt caſes where a compoſition of this ſort may be ordered to advantage.

GUM GUAICUM diſſolves very completely, in the manner we are now ſpeaking of, being rubbed up with an equal quantity of quick-lime, and afterwards mixed with the requiſite quantity of lime-water; and perhaps may be found a more powerful medicine, in cold rheumatic complaints, than the common tinctures: I have not, indeed, made trial of it; but I find that *caſtor* anſwers exceedingly well, given in this manner, and may be taken in large doſes, without offending the ſtomach.

Two drachms of *caſtor*, rubbed up with a drachm of quick-lime, and mixed with ſix ounces of lime-water, give a ſtrong and elegant tincture, which may be flavoured by by adding nutmeg-water, or any other of the like ſort, and then given in doſes of two or three ſpoonfuls, as often as ſhall be thought convenient.

It will, no doubt, be reckoned ſuperfluous, that *lime-water* is ordered to be added to theſe ſeveral ſubſtances, when they are alſo to be rubbed along with *quick-lime*; but the reaſon is this: If the lime were ſo quick and freſh as to raiſe heat when common water is poured on it, the ſolution might then be made without the aid of lime-water; but as it will, for the moſt part, happen that the lime kept in the ſhops will not be perfectly freſh, it will be beſt that the preſcriber ſhould direct lime-water to be uſed, in order to be ſecure of the ſolution, which would not be ſo completely made, nor ſo much of the reſinous ſubſtance be diſſolved, if *ſlacked lime* and *common water* only were made uſe of.

And it is much the ſame thing in the end, with regard to the proportion of lime in the ſolution; for although lime-water may receive ſome additional ſtrength, from being poured repeatedly on freſh quick-

lime

lime (as Dr *Whytt* and Dr. *Home* * insist, in opposition to Dr. *Alston*), yet here the quantity acquired must be so very inconsiderable as not to be worthy of notice.

* See Dr. *Whytt*'s paper on this subject, in the first volume of the Edinburgh Physical and Literary Essays, and Dr. *Home*'s experiments on bleaching. In the last-mentioned book (which I had not read when I made my experiments), I have the pleasure to find many things perfectly coincide with, and confirm, as well the general theory laid down in the foregoing essays, as what relates particularly to the antiseptic power, and to the nature of petrifying waters.

FINIS.

POSTSCRIPT.

AS I had neglected looking into the third edition of Dr. Pringle's book, until the foregoing ſheets were all printed off, I have not now an opportunity of correcting myſelf with regard to a paſſage in the ſecond eſſay; where I have introduced the doctor as ſaying, that putrid animal ſubſtances are not to be regarded as alcaline. This I had taken from the ſecond edition; but I ſhould certainly have expreſſed myſelf in other terms, had I then known that Dr. Pringle has, with that candour which is inſeparable from the ſcholar and the gentleman, altered his opinion concerning this matter, in conſequence of ſome experiments made by M. Gaber at Turin,

ERRATA.

Page	line	
27	4	inſtead of *from* read *by*.
72	4	for *arrive* read *ariſe*.
94	12	for *nor* read *on*.
144	19	dele *as*.
146	14	read (figure) 2 inſtead of 11.
176	3	read *in* inſtead of *of*.
219	12	for *yellowing* read *yellowiſh*.
256	10	read *putrefaction*.

Page—Line		
94	12	for *nor* read *on*.
171	(in the note)	for *blood's fibres*, r. *blood and fibres*.
172	5	for *theſe*, r. *there*.
174	20	for *any*, r. *every*.
220	4	for *latter*, r. *natural*.
223	9	for *appearing*, r. *enabling the water*.
249	5	for *from*, r. *form*.

Beſide the following, which do not ſo much affect the ſenſe.

Page 1, line 3, read *tranſmutations*. p. 160, l. 8, r. *perſpiration*. p. 176, l. 3, for *of*, r. *in*. p. 227, l. 21, for *drank*, r. *drunk*. p. 138, in the note, r. *kinds*. p. 142, l. 5, for *ones*, r. *one*.

And in the firſt figure, the engraver has committed a very great miſtake, by *not* repreſenting the *Cylindrical Glaſs* C, as *inverted*.