Engraved by J. Caldwell

GALENUS CONVERSIO.

MEDICAL EXTRACTS:

ON THE

NATURE OF HEALTH,

WITH

PRACTICAL OBSERVATIONS:

AND

THE LAWS

OF THE

NERVOUS AND FIBROUS SYSTEMS,

BY

A FRIEND TO IMPROVEMENTS.

[R. J. Thornton]

VOL. I.

A NEW EDITION.

There are three things which almost every person gives himself credit for understanding, whether he has taken any pains to make himself master of them or not. These are, 1. *The art of mending a dull fire:* 2. *Politics:* and 3. PHYSIC.

From Dr. BEDDOES's *Guide to Parental Affection.*

LONDON,
Printed for J. JOHNSON, St. Paul's Church-yard; and ROBINSONS, Paternoster-Row:
And sold by them, and DILLY in the Poultry; MURRAY, Fleet-street; MANSON, Pall Mall; OWEN, Piccadilly, opposite Bond-street; and COX, St. Thomas's-street, Borough.

1796.

THERE is a late publication, called MEDICAL EXTRACTS, a Work which would do credit to the *knowledge* of the firſt medical man in England, but to which the ingenious Author, with a ſingular ſhare of ſelf-diffidence, has not affixed his name.

From CRUIKSHANK *on the Nature of Perſpiration.*

THE taſk of an author is either to teach what is unknown, or to recommend *known truths* by his manner of adorning them; either to let new light upon the mind, and open new ſcenes to the proſpect, or vary the dreſs and ſituation of common objects, ſo as to give them freſh grace and more powerful attractions. To ſpread ſuch flowers over the regions through which the intellect has already made its progreſs, as may tempt it to return, and take a ſecond view of things haſtily paſſed over, or negligently regarded.

DR. JOHNSON.

TO

SIR JOSEPH BANKS, BART.

Prefident of the Royal Society, &c. &c.

SIR,

As a Patron of the Liberal Sciences, and more efpecially, from the native benevolence of your difpofition, as the favourer of every attempt that may tend to alleviate the afflictions of mankind, this work is humbly offered to your notice.

It exhibits in a concentrated point of view the late improvements in Chemiftry, and thofe important difcoveries refpecting the animal œconomy, which thefe have fuggefted.

It places man in the center, and explains the relation he ftands in with regard to the bodies which furround him.

The office of the lungs being known, and the alteration of the blood from the *Air* we breathe, and the influence of *oxygenated blood* on the nerves and animal œconomy, the ſtudy of phyſic is NOW become a pleaſing and intereſting purſuit. Nature appears ſublime and ſimple in her operations. The great myſtery of life is laid open to our view, and we are enabled clearly to comprehend, how this wonderful machine of ours depends every moment for its exiſtence on the due ſupply of *air* to our lungs, diſplaying at once the wiſdom and benevolence of THE ALMIGHTY. Having learnt this intimate connection, we ſee the grounds for the *pneumatic practice* lately inſtituted; and, from the exertions of phyſicians in this line, we are led to entertain ſome hopes of ſeeing even thoſe reſtored, who have already been deſpaired of by their friends. We are taught here, alſo, how to avoid many common and afflicting diſorders incident to the human frame; and, thanks to Dr. BEDDOES, and Dr. DARWIN, and the Rev. Mr. TOWNSEND, who ſtand confeſſedly

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the foremoſt among the modern improvers of medicine, the way to a prolongation of life and health, comparatively ſpeaking, is made eaſy:—and if the execution of this work has at all correſponded with the intention of the author, perſons of both ſexes, who have the power of fixing their minds for a few hours, and feel themſelves intereſted in the important enquiry, will ſoon be initiated into the new diſcoveries of chemiſtry, and the new theory and practice of phyſic, thereby introduced.

The labours of many enlightened phyſicians are here preſented in one body, and by notes, and ſome alterations in the text, and a methodical arrangement, it is hoped, they are rendered intelligible even to ſuch as have not been accuſtomed to ſtudies of this kind. As a juſt tribut of reſpect and eſteem,

I have the honour to ſubſcribe myſelf,

SIR,

Yours, &c. &c.

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SECT. III. THE MODERN ANALYSIS OF ATMOSPHERIC AIR,

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Or its *Separation* into its *two elaſtic Fluids*,
1. VITAL AIR,
2. AZOTIC AIR.

LAVOISIER'S 1ST EXPERIMENT.

He put 83 *Grains* of crude MERCURY into a Veſſel which contained 100 *cubical Inches* of COMMON AIR, - - - - - - - - - 7

After five Days Application of a moderate Heat, there remained in the Veſſel only 86 *cubical Inches* of AIR, - - - - - - - ib.

14 *Cubical Inches* of AIR had therefore *diſappeared*, - - - - - - - - - - - ib.

Now 14 *cubical Inches* of AIR weighs 7 *Grains*, - - - - - - - - - - - 8

The crude MERCURY was become a *Calx*, and inſtead of 83, it weighed *now* 90 *Grains*, - - - - - - - - - - ib.

The 7 *Grains acquired Weight* in the MERCURY in its *calcined State* muſt *therefore* have ariſen from the Abſorption of the 14 *cubical Inches* of AIR which had diſappeared, - - - - - - - - - - ib.

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LAVOISIER then examined the 86 *cubical Inches* of AIR remaining in the Glafs after the *Calcination* was ended, and

1. It *deftroyed an Animal* which was put into it, - - - - - - - - - 8

2. It *extinguifhed,* like Water, *the Flame* of a Candle, - - - - - - - ib.

Being found *adverfe* to *Life,* it was called AZOTIC GAS, from *α, privitive*; and *ζωη, life,* - - - - - - - - - - - - - ib.

Of its *other Appellations,* - - - - - - ib.

1. *Phlogifticated Air,*
2. *Non-refpirable Air,*
3. *Noxious Air,*
4. *Mephitic Air,*
5. *Impure Air.*

LAVOISIER'S 2D EXPERIMENT.

He took the 90 *Grains* of the RED CALX of MERCURY, and put it into a Veffel *void* of AIR, - - - - - - - - - - - 9

A *greater Heat* than in the laft Experiment being applied, the MERCURY was *reduced back* to *its metallic State,* - - - - - ib.

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The Calx in this Procefs loft 7 *Grains* (only 83 *Grains* of RUNNING QUICKSILVER being procured), - - - - - - - - - - 9

Now 14 *cubical Inches* of Air was found in the Veffel, which weighed exactly 7 *Grains*, ib.

He then examined this Air, produced from the *Reduction* of THE CALX, and

1. An *Animal* being placed in it, became remarkably *lively*.

2. A *lighted Body* being put into it, burnt with *uncommon Splendour*, - 10

This Air being found fo *very favourable* to *Life* was called therefore VITAL AIR, - ib.

Of its *other Appellations*, - - - - - - ib.

1. *Dephlogifticated Air*.

2. *Pure Air*.

3. *Empyreal Air*.

4. *Highly refpirable Air*.

5. *Oxygen Gas* (Acid making Air), from the Greek Words οξυς, *four*; and γεινομαι, to *beget*.

The *Reafons* for this laft Term OXYGEN GAS, - - - 11

1. *Sulphur* combining with *Vital Air* forms an *Acid Air*, which being abforbed by *Water*, is denominated VITRIOLIC ACID.

2. *Charcoal*,

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2. *Charcoal*, by Combuftion, alfo combines with *Vital Air*, forming an *Acid Air*, which being abforbed by *Water*, is denominated SELTZAR, or THE AERIAL ACID WATER.

3. The OXYD or CALX of ARSENIC is a perfect *acid Calx*.

Of the Difcovery of the VITAL, or OXYGEN, GAS, - - - - - - - - - - - 11

Dr. PRIESTLEY, Mr. SCHEELE, and LAVOISIER, each laid claim to *this great Difcovery*, - - - - - - - - - - - ib.

Dr. PRIESTLEY is believed to have been the *Firft* who difcovered *this aerial Gas*, which is juftly denominated the *Pride* of MODERN PHILOSOPHY, - - - - - 10

LAVOISIER however is undoubtedly the *Firft* who proved, by direct and exact Experiments, that the *Weight* which *Metals* gain by *Calcination* correfponds with *that* of the AIR which they *abforb*, - - - - - - - - - ib.

And HE was undoubtedly the *Firft* who proved, that ATMOSPHERIC AIR confifts of *two diftinct aerial Fluids*, viz.

1. *Azotic Air*, and

2. *Vital Air*, - - - - - - - - - - ib.

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SECT. IV. THE SYNTHESIS, OR COMBINATION, OF

1. AZOTIC AIR, and
2. VITAL AIR.

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Having repeated *theſe* 2 *Experiments* with the *ſame Reſult*, he took

1. The 84 *Cubical Inches* of AZOTIC AIR, remaining after the *Calcination* of the 83 Grains of *Mercury*; and

2. The 14 *Cubical Inches* of VITAL AIR, given out by the *Reduction* of the 90 Grains of the *red Calx* of Mercury; and

3. *Combining them*, he produced 100 *cubical Inches* of ATMOSPHERIC AIR, 12

Hence he concludes that ATMOSPHERIC AIR is actually compoſed of *two heavy* and *ſolid Subſtances*,

1. AZOT, and
2. OXYGEN.

Which Bodies are rendered *aeriform* by their Combination with CALORIC, or MATTER OF HEAT, - - - - - - - - - - - 14

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That OXYGEN is a *ſolid Body* was proved by its forming part of a *metallic Calx*, - - - - - - - - - - 14

That AZOT is a *ſolid Body* is proved (page 39) by its entering into the Compoſition of *Ammoniac* or *Alkali*, - ib.

That CALORIC, or Matter of Heat, ſhould render OXYGEN and AZOT *gaſeous*, is not more extraordinary than that it renders ICE *fluid*, and heated to 212 it becomes *gaſeous* or *aeriform*, - - - - - - - - - - ib.

Even a DIAMOND has been converted by CALORIC into an *aeriform* Body, - - - - - - - - - - - ib.

Although theſe two Experiments of LAVOISIER furniſh us with a very ſimple Means of obtaining *ſeparate* from each other the *two elaſtic Fluids* which compoſe our *Atmoſphere*, yet do they not give us an exact Idea of THE PROPORTION in which *theſe two* enter *its Compoſition*, - - - - ib.

For the *Azotic Air* remaining after the *Calcination* of the MERCURY ſtill retains a ſmall Part of the *Vital Air*, which the MERCURY could not *ſeparate*,

1ſt. From the mutual adheſion of the *Oxygen* and *Azotic Airs*, and

2d. From the ſtrong Affinity which unites *Oxygen* with *Caloric*, - - - 15

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In conſequence of *theſe Affinities*, though the OXYGEN is torn from the *Caloric* and *Azot* by the ſuperior attraction of the *Mercury*, yet towards the Cloſe of the Proceſs there remains with the *Azotic Gas* ſome ſmall Portion of the VITAL AIR, - - - - - 18

The true *Proportion* of

1. AZOTIC AIR, and
2. VITAL AIR,

is uſually,

In a Gallon of ATMOSPHERIC AIR, - { 3 *Quarts* of AZOTIC AIR, and 1 *Quart* of VITAL AIR, - ib.

A more *philoſophic*, though to the generality of Readers a leſs intelligible, Explanation of theſe Experiments, - - - - - - 12

LAVOISIER'S 1ST. EXPERIMENT.

MERCURY at a certain Temperature, overcoming the Affinities of *Caloric* and *Azotic Air* for *Oxygen*, attracts and fixes within itſelf *that Principle*, - - - - - - - ib.

An experimental Philoſopher might illuſtrate *this* by placing,

A NEEDLE in contact with *two Magnets* of different Powers,

which would repreſent,

the OXYGEN in union with the *Azotic Gas* and its own *Caloric*.

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As a LOADSTONE would draw
the NEEDLE from the *two Magnets*;
so the MERCURY draws to itself
the OXYGEN from the *Azot* and *Caloric*:

Hence 1. Its Conversion into a *Calx* or *Oxyd.*
2. Its *Increase* of *Weight.*
3. The *Azotic Gas* remaining when the Calcination is complete, - - - 13

The Term *Affinity* may be illustrated by a Bullet which is cut into two Parts;

If the Sides are brought into contact, they adhere by the Law natural to Bodies, called the *Attraction* of *Cohesion*, - 12

If a Grain of *Sand* interpose, or any roughness exist, the Particles being beyond the *Sphere of mutual Attraction*, they are no longer actuated by this law, - - - - - 13

The Attraction of Cohesion in MERCURY at the *common Temperature*, hinders the Admission of *Oxygen* for which it has an *elective Attraction*, - - - - - - - - ib.

But when exposed to a *strong Heat*, the *Caloric* expands this Fluid; that is, insinuates itself through the Body, and *separates* its Particles, and, like the Pieces in the Bullet where *Sand* interposed, the divided Particles are no longer subject to the *Law of Cohesion*; then it is they obey the *Law of Attraction*, and each Atom of MERCURY *attracts to itself* a Particle of *Oxygen*, just as a Loadstone would draw to itself a Particle of Iron, - - ib.

The LOADSTONE only attracts *Iron*. This represents the Term *Affinity*. As the LOADSTONE does not attract *Tin*, so the MERCURY did not attract the *Azot*, because, as Chemists would say, it had *no Affinity* for it, - ib.

The

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The Temperature being increafed,
The Affinity of CALORIC for *Oxygen*
is rendered fuperior to
The Affinity of MERCURY for *Oxygen*:

Hence the *Oxygen is withdrawn* from the MERCURY, and hence,
1. Its *Decreafe* in Weight.
2. Its *Reftoration* from a Calx to a *Metallic Body*, and
3. The *Vital Air* (Oxygen and Caloric) obtained by this Procefs, - - - 14

SECT. IV. THE ANALYSIS OF OXYGEN AIR,

Or its *Separation* into its *three Conftituent Parts*,

1. OXYGEN,
2. HEAT, and
3. LIGHT.

Dr. INGENHOUSZ's *elegant Experiment*, - - 16

He took the *Steel-chain* of a Watch, and heated one Extremity *red hot*;

He then thruft the *heated End* into a Phial containing OXYGEN AIR, - - - - - ib.

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It *burnt away* like a Match, exhibiting the *brightest light*, - - - - - - - - - - - 16

As it burnt, it cast off brilliant Sparks, like a Firework, which fell to the Bottom in *Globules*, - - - - - - - - - - - - ib.

Soon a *rapid diminution* of the OXYGEN AIR took place, - - - - - - - - - - - 17

If the OXYGEN AIR be *pure*, and the IRON *sufficient*, the *whole* of the AIR will be *absorbed* by the *Iron*, - - - - - - - ib.

And if the Qnantity of the *Iron* be *insufficient*, the *remaining* AIR *unabsorbed* will be found *perfectly pure*, - - - - - - - ib.

That is, if 100 *Grains* of *Iron* be consumed in 70 *cubic Inches* of OXYGEN AIR, the *whole Volume* of *Air* will *disappear*, - - - - - - - - - - - - - ib.

Now 70 *cubic Inches* of OXYGEN AIR weighs 35 *Grains*, and 100 *Grains* of *Iron* will, *when converted* into A CALX, weigh 135 *Grains*, - - - - - - - - - - ib.

Since, where the *Iron* is *not sufficient* to *absorb* all the OXYGEN AIR employed, the *remaining* OXYGEN AIR is nevertheless found *pure*, the AZOTIC AIR left us, after the *Calcination* of the *Mercury* in the first Experiment, page 8, *could arise* from *no other Cause* than its *Separation* from the OXYGEN AIR.

This Experiment also shews that AZOTIC AIR *retards* the *Union* of OXYGEN with *Bodies attracting it*, and in some Cases *altogether prevents it*, - - - - - - - - - 16

How

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How much *slower* is the *Calcination* or *Rusting* of IRON under *other Circumstances!* - - - 16

The ROUND GLOBULES thrown off, as the *Iron* was *burning*, being collected, was found to be *martial Æthiops*, and *equalled* the *Weights* of IRON and of the OXYGEN AIR *employed* and *consumed*, - - - - - - - ib.

A *more philosophic Account* of THIS EXPERIMENT.

At a *certain Temperature* IRON has a *stronger Affinity* for the OXYGEN than CALORIC and LIGHT have, - - - - - - - - - 17

The IRON *therefore attracts to itself* the OXYGEN, with which it *combines*, - - - - ib.

And the CALORIC and LIGHT becoming *disengaged* are rendered *active*, and *evident to* the *Senses*, - - - - - - - - - - - ib.

As the *Calcination* of MERCURY in LAVOISIER's Experiment lasted *several Days*, the *Disengagement* of CALORIC and LIGHT was *extremely small* for each particular Moment of Time, and *therefore* not *perceptible* to the Sight, - - - - - - - - - - - - - - 17

The HEAT also of the Furnace was confounded with it, which made it necessary to relate the above Experiment, where the *Combustion* of the METAL was *more rapid*, or, more justly speaking, the *Decomposition* of the OXYGEN AIR, - - - - - - - - - - - - - - - ib.

When

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When we are failing on the Water in a ftill Day, diftant Objects appear to meet us, but *our Reafon* corrects the Delufion, - - - - - - - - - - - - - - ib.

When we behold the Sun, moving from Eaft to Weft, *Philofophy* again affumes its Empire, and we are convinced it is ftationary, - - - - - - - - - - - - - ib.

If we take a Prifm, it difplays to us a Variety of Colours; *our Reafon* tells us here alfo, that thefe colours arife from the Rays of Light, and are not in the Prifm, - - - 13

So of the Combuftion of Bodies, the CALORIC and LIGHT are not from *the Wax* of our *Candles*, but from the *Oxygen Air*, which, as we faw in the laft Experiment, *becomes*, under certain Circumftances, *decompofed*, - - - - - - - - - - - - - - ib.

SECT. V. THE SYNTHESIS OF WATER,

Or *its Compofition* from its *two Principles*,

1. HYDROGEN, and

2. OXYGEN.

WATER is neither that *compound* or *fimple Element* formerly fuppofed, - - - - - - 18

DR. PRIESTLEY'S CELEBRATED EXPERIMENT.

In the Middle of a Glafs Tube he put fome *calcined Lead*, - - - - - - - - - - ib.

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To the two Ends, he affixed Bladders filled with *inflammable Air*, - - - - - - 18

Having applied a ſtrong Heat to the Middle of the Tube, he preſſed the Bladders, - - ib.

The INFLAMMABLE AIR ſoon *diſappeared*, - 19

The RED LEAD re-aſſumed its *original metallic Splendour*, - - - - - - - - - - ib.

No OXYGEN GAS was *evolved*, - - - - - ib.

A *Queſtion* then aroſe, whence *this Property* in INFLAMMABLE AIR, which the *Anti-phlogiſtians* would aſcribe to the Evolution of OXYGEN GAS? - - - - - - - - ib.

The INFLAMMABLE AIR which had appeared was ſaid to have been *abſorbed*, and was now called *Phlogiſton*, - - - - - - - 19

But *this* muſt have occaſioned an *Increaſe* of *Weight*, if INFLAMMABLE AIR or PHLOGISTON be Matter, whereas on the contrary the *metallic Lead* weighed *lighter* than in its State of *Calx*, - - - - - - - ib.

Fortunately for the *new Doctrines* of *Chemiſtry*, the Honourable Mr. CAVENDISH reſolved this Difficulty, - - - - - - ib.

He

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He paſſed the *electric Shock* through OXYGEN AIR blended with INFLAMMABLE AIR and formed WATER, - - - - - - - - 19

The INFLAMMABLE AIR in Dr. PRIESTLEY's Experiment had united with the OXYGEN AIR evolved from the metallic Calx, and WATER was produced, - - - - - - ib.

This was afterwards proved by the *French Chemiſts* to have been *the Fact*, - - - - ib.

85 *Grains* weight of OXYGEN AIR, and 15 *Grains* of INFLAMMABLE AIR, produce exactly 100 *Grains* weight of WATER, - - - - - - - - - - - - - ib.

The Properties of INFLAMMABLE AIR, - - - - - 19

1. It *deſtroys Life*.
2. It is 15 Times *lighter* than *common Air*.
3. It *explodes* with *common Air*, provided any Body in actual Inflammation be preſent.

DR. PRIESTLEY's EXPERIMENT.

Of the *Production* of INFLAMMABLE AIR from *Iron* and *diluted vitriolic Acid*, - - - - - - - - - ib.

This ariſes from the *Decompoſition* of the WATER, and not from the Iron or vitriolic Acid, - - - - - - - ib.

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SECT. VI. THE ANALYSIS OF WATER;

Or its *Separation* into its *two Principles,*

1. HYDROGEN, and
2. OXYGEN.

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MEUSNIER'S FAMOUS EXPERIMENT.

He put ſome IRON WIRE into a Gun-barrel, 21

He carefully noted down the Weight, - - ib.

He ſo contrived it, that WATER glided down the Barrel, - - - - - - - - - - ib.

At the other Extremity he had an Apparatus adapted to receive any aerial Product, - ib.

Having applied Heat to the Middle of the Tube, where the IRON WIRE was, as ſoon as this became red hot, as the WATER paſſed along it, - - - - - - - - 22

1. HYDROGEN AIR, or Inflammable Air, entered into the Recipient adapted to the Gun-barrel for receiving any aerial Body, and - - ib.

2. The *Oxygen* of the WATER being united to the IRON WIRE converted it into a *Calx,* - - - - - ib.

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3. The Gun barrel weighed *heavier* than before,—which *Weight* being *added* to *the Weight* of INFLAMMABLE AIR obtained, anſwered *exactly* to the Weight of the WATER, which had *diſappeared,* - - - - - - - - 22

The HYDROGEN AIR here proceeded from the Combination of the *Hydrogen* of the WATER to the *Caloric* of the Furnace, - - - - - - - - - - - - ib.

INFLAMMABLE AIR the *French Chemiſts* call HYDROGEN GAS, from the Greek Words *ὕδωρ, water*; and *γείνομαι to produce,* - - - - - - - - - - ib.

SECT. VII. THE ANALYSIS OF CARBONIC ACID AIR, OR FIXED AIR;

Or *its Separation* into its *two Conſtituent Parts,*

1. CHARCOAL, and

2. OXYGEN AIR.

MR. TENANT'S INGENIOUS EXPERIMENT.

He took a Glaſs Tube, into which he put ſome PHOSPHORUS and powdered MARBLE, - - - - - - - - - - - 23

Now

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Now PHOSPHORUS is a *ſimple Body*; that is, one with whoſe Compoſition we are as yet unacquainted, - - 23

But MARBLE is compoſed of,

1. *Carbon* or Charcoal combined with

2. *Oxygen*, i. e. Carbonic Acid, and

3. *Calcareous Earth*, - - - - - - - - - - 24

For if *diluted* VITRIOLIC ACID be poured on MARBLE, this Acid having a ſuperior Attraction for the *calcareous Earth* than the *carbonic Acid* has, it unites with the *calcareous Earth*, - - - - - - - - - - - ib.

And the *carbonic Acid* becoming diſengaged attracts to itſelf *Caloric*, and eſcapes in the Form of *Gas*, - - - - ib.

Hence MARBLE is ſaid to contain *Carbonic Acid Air*, or *Fixed Air*, - - - - - - - - - - - - ib.

Mr. TENANT having applied a quick Heat to the PHOSPHORUS and MARBLE in the Tube, the *Reſult* was

1. *Phoſphoric Acid* and *calcareous Earth*.

2. *Phoſphorus* and *calcareous Earth*, and

3. *Carbon* or Charcoal, - - - - - 23

Or, in other Words, at a certain Temperature PHOSPHORUS overcoming the Attraction of the *Carbon* for *Oxygen*, divorces it of *that Principle*, and becomes in conſequence,

1ſt. *Phoſphoric Acid*, which unites with the *calcareous Earth* of the MARBLE.

The

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The PHOSPHORUS having then no more *Oxygen* to convert it to an Acid, we have,

2dly. *Phosphorus* combined with the *same Earth*, and

3dly. The *Carbon* or Charcoal left in its simple State, - - - - - - - - 24

We owe our first Knowledge of *Fixed Air* to Dr. BLACK, - ib.

But that *Water* absorbed *this Air*, and was made SELTZER or PYRMONT WATER; and that if *Iron Filings* be put into this *acidulated Water*, it becomes a *Chalybeate*, the same nearly as the TUNBRIDGE WATER, we are indebted to the happy industry of Dr. PRIESTLEY, ib.

It is still however a Question, whether *Water* actually absorbs *Fixed Air*, and *Marble* contains *the same*, or whether they possess only THE PRINCIPLES of THIS AERIFORM BODY, viz. *Carbon* and *Oxygen*? - - - - ib.

SECT. VIII. THE SYNTHESIS OF FIXED AIR;

Or *the Combination* of its *two Principles*,

1. CARBON or Charcoal, and

2. OYYGEN AIR.

The CHARCOAL obtained in the last Experiment was burnt in OXYGEN AIR, - - - 26

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The Carbonic Acid Air, or Fixed Air, *obtained, equalled* the *Weights* of the Charcoal and the Oxygen Air employed, - 26

Fixed Air is compofed of 28 *Parts* of Charcoal to 72 of Oxygen Air, - - - - ib.

Or in other Words, 144 *cubic Inches* of that Air will faturate or take up 28 *Grains* of Charcoal, - - - - - - - - - ib.

The Properties of Fixed Air are,

1. It is fpecifically *heavier* than common Air.

2. It is adverfe to both *Flame* and *Life*, - ib.

Sect. IX. The Analysis of Adeps, or Animal Fat;

Or its *Separation* into its *two Conftituent Parts*,

1. HYDROGEN, and

2. CHARCOAL.

Of the *Diftillation* of *animal* and *vegetable Subftances*, - - - - - - - - - - 27

Vegetable Oil is proved to be compofed of *Hydrogen* and *Carbon* or Charcoal, - - - 28

That

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That animal OIL, or Adeps, is compofed of *Hydrogen* and *Carbon* we have the following proof,

In the firft *Rectification* of ANIMAL OIL a fmall quantity of WATER is formed by the Union of the *Oxygen* contained in the AIR of the diftilling Veffel, and the *Hydrogen* of the OIL, - - - - - - - - - - - 29

We at length, by frequent Diftillations, can decompofe the whole OIL, and convert it into *Water* and *Charcoal,* and the *Weights* of the *Charcoal* and *Water* will be found *exactly correfponding* with *thofe* of the OIL and the OXYGEN AIR confumed, - - - ib.

Of the Burying-ground called the *Innocents,* at PARIS, the common Receptacle of the Dead of that City, - - - - - - - - 30

The Bodies were converted into a Subftance refembling *Fat* or *Spermaceti,* - - - - ib.

The Rev. Mr. TOWNSEND'S CELEBRATED EXPERIMENT, - - - - - - - - - - - 35

The Converfion of *animal Subftances* into *Spermaceti* muft arife, fays Monf. LAVOISIER, from the Difengagement of *Azot,* leaving behind the *Hydrogen* and *Carbon* which are the true Elements of *Fat,* - - - - - 34

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SECT. X. ON PUTREFACTION;

Or the *Resolution* of *Organized Matter* into its *Constituent Principles.*

1. HYDROGEN,
2. OXYGEN,
3. CARBON, and
4. AZOT.

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NATURE acts in a *Circle*, - - - - - - 37

The *Changes* of *corporeal Things* are to be placed only in the *various Separations*, and *new Associations*, of PERMANENT PARTICLES, - - - - - - - - - - - - 36

VEGETABLE SUBSTANCES which consist of *Hydrogen*, *Oxygen*, and *Carbon*, maintain for a long while their organized Structure and putrefy with difficulty, - - - - - - 37

The *first Effect* produced on VEGETABLE SUBSTANCES which have lost their vital Principle is the Destruction of the Equilibrium, or just Union of their constituent Principles, - - - - - - - - - ib.

The *Oxygen* unites with the *Carbon*, and the fermenting Juice is covered on its Surface with CARBONIC ACID GAS, or Fixed Air, ib.

 The

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The *ſpecific Gravity* of the Liquor is now conſiderably *diminiſhed*, and the other Principle, or HYDROGEN, is predominant, - 37

For from Diſtillation, *Alcohol*, or Spirit of Wine, is obtained, - - - - - - - - ib.

That *Alcohol* is chiefly *Hydrogen*, may be proved by its combining with *Oxygen*, and forming WATER, - - - - - - - - 38

Thus 8 *Ounces* of *Alcohol* will produce by combuſtion 9 Ounces of WATER, - - - ib.

We have next the *acetous Fermentation*, - - ib.

This is no other than the abſorption or imbibing of *Oxygen* from the AIR, - - - ib.

The laſt Proceſs of the Fermentation is the *Putrefactive*, - - - - - - - - - ib.

In this the ſmall Reſidue of *Oxygen* and *Carbon* evaporates in the Form of CARBONIC ACID GAS, or Fixed Air, - - - - - ib.

The *Hydrogen* eſcapes in the Form of HYDROGEN GAS, or Inflammable Air, - - ib.

And nothing remains but a ſmall Reſiduum of CARBON and VEGETABLE EARTH, - · ib.

The

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The Progreſs is different with Subſtances containing *Azot*, - - - - - - - - 38

Thus *animal Bodies* putrify immediately; or if the Putrefaction be preceded by either of the other Stages, their Duration is too ſhort to be perceived, - - - - - - - - ib.

Hence it is that *animal Excrements*, which contain a Quantity of *Azot*, are added to the Elements capable of Putrefaction, to form Compoſts on Dunghills, - - - ib.

The Addition of *Azot* not only accelerates the putrefactive Proceſs, but combining with the *Hydrogen*, a new Product is formed, viz. AMMONIAC, or Volatile Alkali, - - 39

That AMMONIAC is compoſed of *Azot* and *Hydrogen* we have the following Proof,

If AMMONIAC be applied to a *metallic Oxyd*,

1. The *Metal* is *revived*,
2. *Water* is formed,
3. *Azotic Gas* is obtained pure, - - - ib.

Here the *Oxygen* of the METALLIC OXYD unites with the *Hydrogen* of the AMMONIAC, and *Water* is formed, and the *Azot*, the other Principle of Ammoniac, is in conſequence diſengaged, - - - - - - - ib.

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He invefts *Calcutta*, - - - - - - - - - - ib.

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He is obliged at length to furrender to the Soubah; after being promifed, upon the Honour of a Soldier, "*That no Injury* "*fhould be offered him or his Garrifon*," - ib.

He is conducted with 146 other Prifoners to a Place called the BLACK-HOLE Prifon, - ib.

The Symptoms that arofe in confequence of this confined Place, were

1. *A profufe Sweat*,
2. *An infatiable Thirft*,
3. *Difficulty of breathing*, - - - - - ib.

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Mr. HOLWELL promifes the Serjeant of the Guard a thoufand Rupees, provided he could find Means to remove fome of his People into another Place of Confinement, ib.

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The Offer was accepted: But *the Tyrant*, by whofe Order alone fuch a Step could be taken, *was afleep, and no One durft difturb his Repofe!* - - - - - - - - - - - 48

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Mr. HOLWELL's peculiar Situation, - - - 50

The *extraordinary Refpect* which was paid HIM, ib.

He is feized with ftrong Palpitations of the Heart, and calls aloud for Water, - - - ib.

"*Give him Water*," his People cried, nor would one of them attempt to touch it until *he* had drank! - - - - - - - - - - - 51

Mr. HOLWELL finding himfelf ftill more thirfty after drinking, he abftained from Water, and moiftened his Mouth from Time to Time by fucking the PERSPIRATION from his Shirt-fleeves, which tafted *foft, pleafant*, and *refrefhing*, - - - - ib.

Here the OXYGEN of the Animal Oil might perhaps fupply in fome Degree the want of *that Principle*, which was held here in a lefs clofe Bond of Union than in Water, ib.

They drop faft now on all Sides, and a *pungent Steam* like HARTSHORN (Hydrogen and Azot) arofe from the Bodies of the Dead, ib.

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Out of 146, who entered this Prifon, only 23 were found *alive* in the Morning, - - - 52

All thefe were feized with a *putrid Fever*, - ib.

Mr. HOLWELL fuffers *further Hardfhips*, - 53

At length the Soubah's Mother interpofed, and with unexpected Generofity he replied, "*their Sufferings have been great, and they fhall have their Liberty*;" and they were accordingly releafed, - - - - - - - ib.

Another melancholy Proof of THE NECESSITY OF A DUE SUPPLY OF AIR may be drawn from the Evidence of Dr. TROTTER delivered before the Houfe of Commons, - ib.

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A Defcription of the *Places* in the Ship where the Slaves are ftowed, - - - - ib.

The *Temperature* of thefe Rooms is generally *above* 96 of Fahrenheit's Scale, - - - - ib.

I have often, fays Dr. TROTTER, obferved the Slaves drawing their Breath with all the laborious and anxious Efforts for Life, which are obferved in expiring Animals, fubjected by Experiment to *foul Air*, or in the exhaufted Receiver of an *Air-pump*, - ib.

I have

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I have often ſeen them, when the Tarpawlings have been inadvertently thrown over the Gratings, attempting to heave them up, crying out in their own Language, "*We are ſuffocated,*" - - - - 56

Many have I ſeen DEAD, who the Night before have ſhewn no Signs of the ſmalleſt Indiſpoſition; *ſome* alſo in a DYING STATE, and if not brought up quickly upon the Deck, irrecoverably loſt, - - - - - ib.

Hence out of 650 *young, ſtout,* and *healthy Slaves,* before the Veſſel arrived at Antigua more than 50 had *died;* and about 300 were tainted with the *Sea Scurvy,* - - - ib.

Mr. WILSON declares upon Evidence that ſome Ships employed in the Slave Trade bury a *Quarter,* ſome a *Third,* and others even *Half* their Cargo, - - - - - - ib.

A fine poetic Addreſs on the Subject of the *Slave Trade* to the Britiſh Commons and Lords by Dr. DARWIN, - - - - - - ib.

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{That is nearly *one Child* out of *every Six*, - 57

{These Children, many of them, foamed at their Mouths, and the Face looked *blue*, as though they were *choaked*, - - - - - ib.

{This last Circumstance led the Physicians to conclude that the Room in the Hospital was *too close* and *crowded*, and hence that the Infants had not a *sufficient Quantity* of GOOD AIR to breathe, - - - - - - ib.

{The Contrivances that were devised to let in *fresh Air* and remove the *Bad*, - - - ib.

{The CONSEQUENCE was that out of 7650 Children born, there died *only* 279, - - 58

{That is not even *one Child* in *Twenty*, - - ib.

{Mr. HOWARD's Opinion respecting the Cause of *Jail-Fevers*, - - - - - - - - - ib.

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{Dr. PRIESTLEY's *Eudiometer*, - - - - - 59

{His Discovery of NITROUS AIR, - - - - ib.

{The MANNER *this Air* is produced, - - - ib.

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Its Property of *confuming Vital Air*, - - 59

The Union of *Nitrous Air* with *Vital Air* forms Nitrous Acid, - - - - - - - - - - - - - 60

Hence the *Decreafe* of the *Bulk* of the *two mixed Airs*; as Nitrous Acid occupies but a *fmall Space* in comparifon with thefe *two Airs*, - - - - - - - - - ib.

This *Decreafe* marks the Quantity of *Vital Air* in any given Portion of *Common Air*, - ib.

By this Test, Dr. Priestley perceived, that there was lefs *Vital Air* in his Study than on the Outfide of his Houfe, - - - - ib.

And that the Air in the Neighbourhood of *York* was not fo good as the Air near *Leeds*, - - - - - - - - - - - ib.

That is, the Bulk of the Air in the firft Trials was not *diminifhed* equally by the Nitrous Air, as in the latter Trials, - - - - ib.

Lavoisier's *Eudiometer*, - - - - - - 61

He places a cylindrical glafs Tube inverted over Quickfilver, - - - - - - - - ib.

He then paffes into it fome *Phofphorus*, - - ib.

This being fet on fire confumes all the *Vital*, or *Oxygen*, Part of the Air, - - - - - ib.

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PHOSPHORUS, like other combustible Bodies, attracts *Oxygen*, the Particles being once separated by heat beyond their Sphere of mutual Attraction, or the Attraction of Cohesion, - - - - - - - - - - - - - - - 61

The *Phosphorus* becomes, in consequence of this union with *Oxygen*, PHOSPHORIC ACID, - - - - - - - - ib.

The PHOSPHORUS obtains by this Conversion into an *Acid* an *Increase of Weight* exactly corresponding to the Weights of the *Phosphorus* and the *Oxygen Air* consumed, - - 62

That is 100 Parts of PHOSPHORUS will *absorb* 154 Parts of OXYGEN, or VITAL, AIR, - - - - - - - ib.

LAVOISIER'S Experiments to ascertain the PURITY of the AIR *abroad*, in the *General Hospital*, and at the *Theatre*, - - - - ib.

Abroad there was 27 Parts OXYGEN AIR in an Hundred, - - - - - - - - - - ib.

In the *Hospital* there was 25 Parts OXYGEN AIR in an Hundred, and in the *upper Parts* of the *same Room* less, - - - - - - - ib.

And in the Pit of the *Theatre* only 21 Parts in an Hundred, - - - - - - - - - 63

Whence it is evident, that the Quantity of OXYGEN, or VITAL, AIR had been *diminished* in the *Theatre* in the Proportion of 27 to 21, or nearly *one Fourth*, - - - - ib.

That is, it was *one Fourth* less fit for Respiration than before, - - - - - - - - ib.

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The different *ſpecific Gravities* of Fixed, Oxygen, and Azotic Airs, - - - - 63

Of the *Circulation* of the Air, - - - - - - - - 64

The Cure of *ſmoaky Chimneys*, - - - - - - - - ib.

The *Quantity of Air* vitiated by a *Man* in an Hour, - - - - - - - - - - - 65

The Air of a Room 30 Feet long, 25 broad, and 30 Feet high, containing 100 Spectators, would be rendered perfectly *mephitic* in four Hours and a Half, were it not for the *Circulation* of *the Air*, - - - - - 65

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Dr. Thornton's *Propoſal* to *diffuſe* Vital Air in *Mines*, *Churches*, *crowded Rooms*, and *Hoſpitals*, - - - - - - - - - 67

His *Obſervations*, and *Propoſal*, for rendering the *Bathing Rooms* at Bath more *ſalubrious*, ib.

Of the *Production* of Oxygen, or Vital, Air, and the Proſpect, as Chemiſtry advances, of obtaining this at a *very moderate Rate*, - 68

Of Ventilation, - - - - - - - - - - 67

An eaſy and cheap Proceſs for removing the *foul Air* of a Room, and throwing in *good Air*, - - - - - - ib.

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COMMON AIR is compofed of *two Principles*, viz.
1ft. *Oxygen*, or *Vital*, *Air*, and
2d. *Azotic Air*, - - - - - - - - - 69

Soon by Refpiration we have,
3dly. *Fixed Air*, - - - - - - - ib.

At length the *Oxygen Air* is wholly ABSORBED, and the *remaining Air* is compofed of,
1. *Azotic Air*, and
2. *Fixed Air*.
Both which Airs are adverfe to Life, - - ib.

A *Queftion* here naturally arifes, WHAT HAS BECOME OF THE OXYGEN, OR VITAL, AIR, DEPRIVED OF WHICH AN ANIMAL DIES? - - - - - - - - - - - - ib.

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Experiments to prove that *arterial Blood* contains Oxygen Air, - - - - - - - 71

The Reaſon why *Lime-water* detects the preſence of Fixed Air, - - - - - - - - - - - - ib.

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The *Oppoſition* that this great Diſcovery at firſt met with, - - - - - - - - - 73

It was obſerved,

1ſt. That no Phyſician paſt the Age of Forty *believed* in it,

2d. That the *Practice* of this great and good Man *declined* from the Moment he publiſhed to the World his ever memorable Diſcovery, - ib.

The Conduct of the *ſenior Phyſicians* at Bononia, - - - - - - - - - - - ib.

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3. The *right Auricle of the Heart*, - - ib.
4. The *right Ventricle*, - - - - - ib.
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6, 7. The *right* and *left Lobes* of the *Lungs*, - - - - - - - ib.
8, 9, 10, 11. The *four Pulmonary Veins*, - 76
12. The *left Auricle*, - - - - - - ib.
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Of the Circulation,

1ft. From the *right Cavities* of the *Heart* THROUGH THE LUNGS to the *left Cavity* of the *Heart*, - - ib.
2d. From the *left Cavities* of the *Heart* THROUGH THE VARIOUS PARTS OF THE BODY to the *right Cavities* of the *Heart*, - - ib.

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The Office of *Refpiration* was unknown to the late Dr. HUNTER, - - - - - - - 77

A valuable *Quotation* from that learned Teacher, - - - - - - - - - - - ib.

IF EVER we fhould be happy enough, fays he, to difcover clearly the Object of *Refpiration,* we fhall doubtlefs, as clearly fee, that *this* *Organ* is as wifely contrived for an *important Office,* as we now fee the Purpofe and Importance of the Heart, and vafcular Syftem; which, till the Circulation of the Blood was difcovered, was wholly concealed from us, - - - - - ib.

The *Blood,* as it comes in contact with the AIR, expanding the Lungs, works many *chemical Alterations* in it, - - - - - - 78

1ft. The *Charcoal* of the Blood forms with the *Vital Air,* FIXED AIR, - - - ib.

This is proved by making an Expiration through a Tube containing *Lime-water,* which will become inftantly TURBID, - - - - - - - - - - - - - - ib.

Or if *Venal Blood* be confined in a Phial containing *Vital Air,* the whole of *that Air* will be converted into FIXED AIR, - - - - - - - - - - - - - - - ib.

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2d. The *Hydrogen* of the Blood forms with the *Vital Air* the HUMID VAPOUR, that iſſues from the Mouth, - - - 78

This you may prove by placing *venal Blood* in *Vital Air* in a warm Temperature, when preſently the Sides of the Veſſel will be covered with large Drops of WATER, - ib.

Or if black Blood be received in a Phial containing *Azotic Air*, AMMONIAC will be formed (which was proved Page 39 to be *Hydrogen* combined with *Azot*), - - - ib.

3d. The *Blood* alſo *abſorbs* within itſelf the *Vital Air*, which changes its *dark Colour* to a *brilliant Red*, - - - - ib.

Thus *changed*, it becomes

1. The SPUR TO ACTION of the *Heart* and *Arteries*,
2. The *Source* of ANIMAL HEAT,
3. The Cauſe of SENSIBILITY,
4. IRRITABILITY, and
3. MOTION, - - - - - - - - - - ib.

A *Quotation* from Dr. HARVEY, - - - - 79

Dr. GOODWIN's celebrated *Experiment*, which proves the Dependance of the CIRCULATION on RESPIRATION,—or rather on the Condenſation, or Fixation, of OXYGEN AIR in the Blood, - - - - - - - - - - ib.

A valuable Quotation from Dr. SMITH, - - ib.

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Sect. VII. On Animal Heat.

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Dr. Crawford was the firſt who aſcertained by direct Experiments that *Animal Heat* was derived from the *Air*; but he knew not that *Vital Air* was *imbibed* by the *Blood* in the *Lungs*, - - - - - - - - - 81

Dr. Thornton next *improved* upon *this important Diſcovery*, - - - - - - - - 83

This laſt Phyſician firſt publicly taught, at *Cambridge*, that the Oxygen Air imbibed by the *Blood* in the *Lungs* underwent a *Decompoſition* by the other Principles in the animal Body, - - - - - - - - ib.

Animal Heat is therefore a Species of *gentle Combuſtion*, - - - - - - - - - 84

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2d. A Supply of *Principles* attractive of *Oxygen*, diſengages *Caloric*, - - ib.

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MR. SPADDING'S CELEBRATED EXPERIMENT, - 89

He obferved that when he had eaten *animal Food* or drank *fermented Liquors*, he confumed the *Air* in the Diving-bell much *fafter* than when he lived upon *vegetable Food* and drank only *Water*, - - - - ib.

In my putrid fever, fays the Rev. Mr. TOWNSEND, whenever I breathed *fuperoxygenated Air*, as my Phyfician Dr. THORNTON often witneffed,

1. My *Refpiration* was *pleafant*,
2. My *Oppreffion* at my Cheft *relieved*,
3. My *Appetite* was greatly *increafed*, and
4. My *Digeftion* was confiderably *quickened*, - - - - - - - - - ib.

The *Reafon* why people who are *oppreffed* with *Food* PANT, - - - - - - - - 90

The *Caufe* of SNORING, - - - - - - - ib.

Miners, when recovering from Afphyxia arifing from breathing *impure Air*, are conftantly feized with *Naufea*, and the *Stomach* rejects its *Contents* quite *crude*, - - ib.

JOHN

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John Hunter conveyed Worms, &c. down the Throats of Lizards, which were *torpid*, and always upon examination found the *Subſtances* which he had introduced *entire*, and without having undergone any the leaſt Alteration, - - - - - - - - - - 91

But when the *Heat* was raiſed to 93 *Degrees*, the *digeſtive Proceſs* was eſtabliſhed, - - ib.

For the *Heat* rouſed up the *Actions* of the *Animal Œconomy*; the *Breathing* became *quickened*; and the *Blood*, having imbibed a greater quantity of Oxygen Air, containing *latent Fire*, to be *extricated* by *Principles* ſeparated by the Stomach, hence the *immediate Call* on the *digeſtive Powers* of *that Organ*, - - - - - - - - - ib.

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The Agency of *Heat* firſt produces the Life of the Chick, - - - - - - - - - - 93

When it is extricated from the ſhell, it imbibes in the Lungs *Vital Air*, and generates its own *Heat*, which at *firſt* being *inſufficient*, it is cheriſhed by the *Heat* of its Mother, - - - - - - - - - - - 94

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The *Heat* of the *Body* is always *greater* than that of the *external Air*, - - - - - - - 96

This is proved,

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2. By the *Coldneſs* occaſioned by a *briſk Wind*, - - - - - - - - - - 97

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The *cooling Effect* of EVAPORATION is ſhewn,
1. From the *Fall* of the *Thermometer* by putting on it a *few Drops* of *Æther* or *Volatile Alkali*,
2. By the *Manufacture* of *Ice* in *warm Climates*, - - - - - - - - ib.

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APOLOGY.

Nos qui ſequimur *probabilia,* nec ultra id quod veri ſimile occurrerit progredi poſſumus, et refellere ſine pertinacia, et refelli ſine iracundia parati ſumus.

CICERO.

THE reader will ſoon perceive that the Author of MEDICAL EXTRACTS intended at firſt only to have preſented to the Public a conciſe view of "THE RELATION WE STAND IN WITH REGARD TO THE AIR WE BREATHE;" and as the *pneumatic chemiſtry* had been ſucceſsfully introduced into the practice of phyſic, this Volume would have been ſucceeded with "PATHOLOGICAL EXTRACTS RELATIVE TO THE EXHIBITION OF DIFFERENT AIRS:" but the progreſs of *this new ſcience* has been ſo ſlow, from the oppoſition which naturally awaits every great undertaking, that though the infant ſcion ſoon bloſſomed, and bore fruit, yet was the product ſcanty, and the tedious interval was therefore filled up at the deſire of ſeveral ſcientific friends, in giving " THE RELATION WE STAND IN WITH REGARD TO HEAT,—LIGHT,—CLOTHING,—FOOD,—EXERCISE,—and laſtly, THE OBJECTS WHICH EXCITE THE MIND THROUGH THE MEDIUM OF THE SENSES."

Firſt, it is explained " HOW THESE STIMULI IN A PROPER PROPORTION CONDUCE TO HEALTH." This occupies the two firſt volumes: and at the commencement of the third it is ſhewn " HOW THESE STIMULI TEND TO DESTROY HEALTH WHEN IN EXCESS."—and in this volume it is alſo ſhewn " HOW THE ANIMAL FRAME IS AFFECTED, WHEN THESE STIMULI ARE IN AN UNDER PROPORTION." —The fourth volume relates chiefly to the *nervous ſyſtem*, " BEING THE HISTORY AND EFFECTS OF THE EMOTIONS AND PASSIONS OF THE MIND AND THE LAWS TO WHICH THESE ARE SUBSERVIENT."

Thus,

Thus, amidſt numerous avocations, I have attempted to explain, more extenſively than has hitherto been done, part of the SYSTEM, which was firſt eſtabliſhed by Dr. JOHN BROWN, and upon which the *pneumatic practice* is engrafted; a ſyſtem not in *itſelf* at any time *complete*, but to be conſidered as a FOUNDATION and a SCAFFOLDING, which will enable *future induſtry* to erect a SOLID and a BEAUTIFUL EDIFICE, eminent both for its *ſimplicity* and *utility*, as well as for the *permanency* of its *materials*—which may not moulder, like the ſtructures already erected, into the ſand of which they were compoſed: but which may ſtand unimpaired, like the NEWTONIAN PHILOSOPHY, a rock amid the waſte of ages!

Desine quapropter *novitate* exterritus *ipsa*
expuere ex animo *rationem:* sed magis acri
judicio perpende, et, si tibi vera videtur
dede manus.———

LUCRET.

THE

PROGRESS

OF

CHEMISTRY.

WE will not tire the reader with tracing the progrefs of chemiftry from the earlieft antiquity: but commence at that time when alchemifts gave up their golden dreams, and turned their attention to improve by this art the fcience of medicine.

The doctrines of Galen, which were fpread over Europe, had taken fuch firm root in the 16th century, that they feemed to defy all oppofition. The remedies invented by chemical operations were at that time only adminiftered by men in the loweft condition of life, men without fcience, without induftry, and without honour. At length, however, PARACELSUS appeared. He does not feem to have ftudied phyfic in any of the eftablifhed fchools; but while he travelled in different countries he picked up remedies from all forts of people, and particularly from the chemifts of thofe

Paracelfus.

thofe days. From thefe he learned the ufe of mercury and antimony, and from fome hardy empirics the ufe of opium. When returning home from his travels he determined upon following his father's profeffion, which was that of phyfic, and by thefe remedies he was able to cure many difeafes that baffled the inert remedies of the Galenifts; and being of a bold and boaftful difpofition, he made the moft of thefe cures; while, at the fame time, the partiality of mankind to novelty foon contributed to give him fame. He was fo far more fortunate than other chemical practitioners, that he obtained the profeffor's chair at the univerfity of Bafil. In this new fituation he attempted a fyftem of phyfic, blended with the moft extravagant and vifionary doctrines, fupported and covered by a great deal of new and unmeaning jargon of his own. His lectures were chiefly employed in recommending his own chemical remedies, and declaiming in the moft outrageous manner againft the regular practitioners. He went even fo far as publicly to burn the works of the Greek phyficians; and he infolently told the phyficians of Bafil, that the very down of his bald pate had more knowledge than all their writers, the buckles of his ſhoes more learning than Galen or Avicenna, and his beard more ſenſe than all the univerſities together.

It ſeldom happens, that a man of but common abilities, and in the moſt retired ſcenes of life, obſerves ſuch a ſtrict uniformity of conduct, as not to afford prejudice and partiality ſufficient materials for drawing his character in different colours; but ſuch a great and irregular genius as PARACELSUS could not fail of becoming alike the ſubject of extremes of panegyric and ſatire. He has accordingly been eſteemed by ſome a ſecond Æſculapius; and others have thought that he was poſſeſſed of more impudence than merit, and that his being ſpoken of was more owing to the brutal ſingularity of his conduct, than to the cures he performed.

But in whatever eſtimation the merit of PARACELSUS as a chemiſt or phyſician be held, certain it is that he formed a ſect of practitioners, who appeared in oppoſition to the eſtabliſhed ſchools, which were then entirely followers of Galen, and theſe two adverſe parties agitated Europe for more than five hundred years. Nothing but ſucceſs could ſhake off the torpor or vanquiſh the bigotry of the Galeniſt.

Theſe

Thefe at laft finding their throne totter, called in the aid of the fecular power, and employed it to crufh their adverfaries. In France antimony was prohibited: but in Germany the chemifts prevailed, and the Galenifts were obliged fometimes to have recourfe to the remedies of the chemifts, when SENNERTUS, one of the moft eminent of the Galenifts in Germany, endeavoured to reconcile the two oppofing parties.

Sennertus.

Sir Theodore Mayerne.

Very early in the feventeenth century, Sir THEODORE MAYERNE, who as a chemical phyfician had been much oppofed and oppreffed by the Galenifts of France, was called over into England, where he was appointed firft phyfician to the king, and continued to hold that office for more than thirty years after. His theory and his prefcriptions were like thofe of the Galenifts; but he was at the fame time a great favourer of chemical medicines, and particularly of antimony; the medicine, with regard to which the two fects were moft efpecially divided. It does not however appear, that he met with any violent oppofition from the phyficians in England: but, on the contrary, we find him becoming a member of, and acquiring

acquiring great authority in, the London college. It is probable that his great credit put an end in England to all diſtinction between the Galenic and chemical practitioners; and, as in the year 1666, the faculty of Paris reſcinded their arret forbidding the uſe of antimony, the odious diſtinction between the Galeniſts and chemiſts gradually diminiſhed.

VAN HELMONT was the diſciple of PARACELSUS. *Van Helmont.* He firſt gave the name of *gas* to thoſe vapours, which reſemble the air we breathe. He obſerved, that ſome bodies reſolve themſelves almoſt entirely into this aeriform ſubſtance. Not, adds he, that they are contained in this ſhape in thoſe bodies from which they are ſeparated; but exiſt in them in a concrete form, as if fixed or coagulated. He aſſerts, that 62 pounds of charcoal contain 61 pounds of gas, and only one pound of earth. The gas which flies off from calcareous earths and metallic bodies while they efferveſce in acids, did not eſcape his notice: the quantity contained in tartar is ſo great, that it breaks and burſts into ſhivers the veſſels in which it is diſtilled, if a free egreſs be not given to it. He applied this theory to the explanation of ſome phænomena of the animal œconomy. It is to this effluvium that VAN HELMONT attributes the fatal effects of the Grotto Del Cani; — the suffocation of workmen in mines;— the accidents occasioned by the vapour of charcoal;— and that deleterious atmosphere which is breathed in cellars, where spirituous liquors are in fermentation. He accounts for several diseases upon this principle, and ascribes the propagation of epidemical disorders to noxious vapours with which the air is sometimes infected. We are astonished, says LAVOISIER, in reading his treatise *de Flatibus*, to find an infinite number of facts, which we are accustomed to consider as *more modern*, and we cannot forbear to acknowledge, that VAN HELMONT has related, at that period, almost every thing, which we are now better acquainted with, on this subject.

His skill was so great, and the phænomena his chemistry presented so marvellous, that he was accounted a magician, and thrown into the inquisition: and having with difficulty extricated himself from this abominable charge, he was released, and retired to Holland, where he died in the year 1644.

I shall not presume to decide which of the two great branches of natural philosophy contributes most

to

to the ufe and the ornament of life; but I think it natural that the mechanical department, where palpable maffes of matter are brought into action, and motion is vifible in its progrefs, fhould fooner advance towards perfection than the chemical, where effects are produced by the infenfible movements of imperceptible particles. It feems therefore to have its foundation in the order of things, that the philofophers of the preceding age fhould have been employed chiefly by aftronomifts and mechanics, and thofe of the prefent by chemiftry. Yet if the rule be at all juft, what a violent exception,—fuffer me to repeat it, have we in the inftance of JOHN BAPTIST VAN HELMONT, who filently, and unperceived, difcovered, if not the whole fum and fubftance, yet certainly many of thofe fplendid facts which adorn the writings of PRIESTLEY, CAVENDISH, SCHEELE, LAVOISIER, and other philofophers of the prefent day.

Not long after, the illuftrious BACON formed plans for promoting the fciences in general, and particularly the ftudy of nature. In his comprehenfive view of things, he felt that chemiftry might turn out one of the moft curious and ufeful branches of na- *Bacon.*

tional philofophy. He advifed the collecting of facts, and to compare thefe very maturely and cautioufly, in order to difcover, if poffible, the caufes and circumftances upon which they depend, and declares that in this way only could any fatisfactory fyftem be produced. Theories, he thought, were only ufeful fo far as they arofe from experiments already made, or as they might lead to new ones: for reafoning may be confidered as the eye of the philofopher; but experience is his feeling; and this latter fenfe ought conftantly to rectify the too frequent errors of the former. If experiments, undirected by theory, are only a blind feeling; theory, without experiments, is a deceitful and uncertain vifion.—It was thus that this fagacious philofopher directed men in the true path of fcience, and banifhed that dark and abftrufe philofophy, which was built upon the abfurdeft conjectures.

Boyle. On the day in which this great promoter of the fciences died, BOYLE was born. He was in opulent circumftances, and by the agreeablenefs of his manners, and goodnefs of his heart, he was peculiarly turned to the ftudy of nature, which pleafed him moft, moſt, and the knowledge of which he cultivated in the way recommended by Lord BACON. He was poſſeſſed of that penetration and ingenuity of mind, which in experimental philoſophy ſerves to point out the ſhorteſt, ſimpleſt, and moſt uſeful, experiments, and which enabled him to deduce the moſt important truths from the moſt ſimple and inſignificant facts. Theſe are the talents we diſtinguiſh in an eminent degree in this philoſopher, and for which Sir ISAAC NEWTON was afterwards ſo remarkable. He examined the prevailing philoſophy of the chemiſts, and expoſes its weakneſs; but he does it with a temper, candour, and modeſty, which is truly admirable. What VAN HELMONT called *gas*, BOYLE denominated *artificial air*. Furniſhed with the new inſtruments with which he has enriched natural philoſophy, he repeated all VAN HELMONT's experiments in vacuo, in condenſed air, and in the open air. It is eaſy to ſee that nearly all the diſcoveries of this kind, which are uſually attributed to BOYLE, really belong to VAN HELMONT, and that the latter even carried his ideas much further. But one obſervation, which is particularly BOYLE's, does not ſeem to have been even ſuſpected by VAN HELMONT, viz. that

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there are bodies ſuch as ſulphur, camphor, &c. which *diminiſh* the volume of air in which they burn.

As I am about to draw the firſt line of the next ſketch, my hand is ſuſpended by the intruſion of a wiſh, that has often before mixed with my thoughts. It may, perhaps, be not a very inviting taſk, but methinks in the ſuperfluity of literary men, one at leaſt might be ſpared from other ſervices, to explore the dark volumes of ancient chemiſtry. Should any one, however, be able, ſo far to ſubdue his diſguſt, as to define, by careful enquiry, what degree of knowledge had been acquired from ſyntheſis and analyſis concerning the conſtitution of bodies, before the middle of the laſt century, I am ready to believe, *Mayow.* that he would find more credit due to MAYOW than I dare venture at preſent to aſcribe to him. "*He* "*was acquainted with the compoſition of the atmoſphere,* "*—and perceived the action of oxygen, or vital, air in* "*almoſt all the wide extent of its influence. He was* "*well aware of the cauſe of the increaſe of weight in* "*metallic calces; and diſtinctly aſſerted, that certain* "*baſes are rendered acid by the acceſſion of the vital*

"*air,*

" *air, or what has been ſince called oxygen, or the aci-*
" *difying principle. The doctrine of reſpiration is all*
" *his own. He has carried on his inveſtigation of this*
" *function from the diminution of the air by the breath-*
" *ing of animals to the change it produces in the blood*
" *during its paſſage through the lungs. The office of the*
" *lungs,*" ſays he, " *is to ſeparate from the air and*
" *convey to the blood one of its conſtituent parts.*" He alſo adds, " *that on expiration ſomething noxious is*
" *thrown out* *." At the age of twenty-ſix he formed the peculiar ſyſtem which pervades all his works: his mind indeed diſcovers perpetual reſtleſſneſs, and an habitual tendency to advance; for having conveyed the *vital particles* of the air into the blood, here was now a very inviting reſting place;—but he could not be content without proceeding to inveſtigate what part they *afterwards* perform in the animal œconomy; a queſtion which ſtill occupies the patient induſtry of philoſophers of the preſent age. He ſuppoſes " *theſe particles are neceſſary to form the vital*
" *heat, and to ſupport muſcular action.*" The tranſlator of his works into Dutch (an honour which they did not obtain from any other people), in the

* Vide Dr. BEDDOES's analyſis of Dr. MAYOW's works.

preface

preface to them, affirms, *that his philoſophy found very little approbation in his own age**. So much does the fortune, both of truth itſelf, and of thoſe who ſpeak it, depend upon the diſpoſition of the times in which it is ſpoken. None indeed ſmiled upon the fair features of this new-born offspring of ſcience His name, therefore, as it never was echoed by popular applauſe, was ſoon forgotten among men, and his memory obliterated. In the *Biographia Britannica* there is no article appropriated to him. But henceforth, I hope, he will ſhare the glory of BACON and of NEWTON, and be named with due reſpect by all; and that when the enthuſiaſm of an Engliſhman ſalutes his country, as

Magna parens frugum !——
Magna virum !

MAYOW will be ranked amongſt the foremoſt in her liſt of *illuſtrious men*.

The united experiments of VAN HELMONT, of BOYLE, and of MAYOW, had made it evident that a great quantity of elaſtic fluid analogous to air was ſeparated from bodies in many operations;—that alſo

* How much this doctrine was received by the learned of that time, conſult Vol. III. page 610, Note *.

in

in ſome other operations a portion of atmoſpheric air was abſorbed; but no one had any idea of the *exact quantities* either produced or abſorbed.

Dr. HALES was the firſt perſon who accompliſhed this uſeful purpoſe. Hence it did not eſcape this benevolent and indefatigable philoſopher, that the quantity of air *abſorbed* either by the burning of ſulphur or of candles, or by the reſpiration of animals, preſented different appearances, according to the quantity of air employed. He diſcovered that this abſorption of air is limited, and that it never proceeded beyond a certain point. *Dr. Hales.*

Dr. HALES, in the courſe of his experiments, has obſerved alſo the alternate *production* and *abſorption* of air, of which he, however, does not ſeem to have underſtood the true cauſe: the burning of charcoal, and other ſubſtances, furniſhed him with a great increaſe of air, but that air diminiſhed daily. This phænomenon depended upon the water which the Doctor uſed in theſe experiments: and it will be ſhewn hereafter, that moſt of theſe vapours, and particularly thoſe which we are accuſtomed to denominate *fixed air*, have a great affinity for water, which is capable of abſorbing more than its own bulk of *this air*.

The great number of experiments made by Doctor HALES, which may be found in chap. vi. of his *Vegetable Statics*, comprehends vegetable, animal, and mineral ſubſtances. He has examined into the effects of fermentation, chemical diſſolutions and combinations, the combuſtion of bodies, and reſpiration. Too much cannot be ſaid to induce the reader to peruſe his ineſtimable work. He will find in it a moſt inexhauſtible fund of meditation.

It is in this work, that we perceive the firſt traces of the exiſtence of air in thoſe waters, which are called *acidulous*. Dr. HALES has not only remarked that theſe waters contain four or five times more air than common water, but he alſo ſuſpected that they owed their remarkable ſparkling and briſkneſs to this air.

All the philoſophers of his time believed, that fire became fixed, and combined itſelf with metals, and that to this addition they owed their reduction to a ſtate of calx. Dr. HALES has not only diſcarded this error, but he has moreover advanced that air contributed to produce that effect, and that to it alone muſt be attributed the augmentation in the weight of metallic calces. He grounded his opinion chiefly in having obtained from 1922 grains of lead, only ſeven cubic inches of air ;—whereas an equal quantity of minium afforded him 34 cubic inches.

Dr. HALES, in ſumming up his knowledge on this ſubject, compares the air to a true Proteus, now fixed, now volatile, entering into the compoſition of bodies, where it exiſts in a ſolid form, deprived of elaſticity, and of thoſe properties which formerly diſtinguiſhed it, adding gravity to theſe bodies, and under certain circumſtances alone capable of recovering its elaſticity, and becoming again an elaſtic and thin fluid, and therefore deſerving to be adopted among chemical principles, and to poſſeſs a rank which has hitherto been denied it.

The immortal BOERHAAVE, the honour of his country, of his profeſſion, and of his age, next improved upon the experiments of Dr. HALES, by not permitting the factitious airs to have any communication with *water*. It muſt be acknowledged, ſays he, that by chemiſtry we ſeparate from bodies an *elaſtic vapour*, and conſequently that this aerial mat- *Boerhaave.*

 ter

ter refides in them, but in fuch a manner as not to have the properties of air, as long as it is combined and united;—but that whenever it is detached, it refumes its former nature, and becomes *true air*, difpofed to reunite with other fubftances again, and remain quiet, but without lofing its real nature; for whenever it is freed from the bonds which retain it, it fhews itfelf to be the fame body. Nothing can be more certain than this *refolution* and *compofition*; and I would have given many examples of it, had I not lately read Dr. HALES' celebrated treatife on Vegetable Statics; in the fixth chapter of which book, the author has collected with fo much labour and juftnefs, and has related in the beft poffible order, the experiments which have been made on this fubject, fo that he has exhaufted the fubject. To thefe I refer my readers, and they will fee how ART has arrived at the power of *unveiling* NATURE.

Hitherto chemiftry, though it was much advanced, had been treated in a defultory manner. A great number of facts were difcovered; but none had attempted to generalize them, and form a fyftem; and though many particulars were known, yet the fcience itfelf was not in exiftence.

The illuſtrious BECHER firſt began to collate, examine, and compare, the immenſe ſtore of chemical facts, and obſerve their relations. This man, whoſe genius equalled his knowledge, ſaw with a ſingle glance, the immenſe multitude of chemical phænomena. He invented a theory that ſoon obtained credit all over Europe. He was invited to Vienna, where he contributed to the eſtabliſhment of ſeveral manufactures, a chamber of commerce, and an India company; but the jealouſy of the miniſtry finally accompliſhed both his diſgrace and his ruin. He was not leſs unfortunate at Mentz, Munich, and Wurtzburg; which determined him to go to Haerlem, where he invented a machine for working a great quantity of ſilk in a little time and with few hands; but new diſgraces and misfortunes made him retire to England, and he died in London in 1682, at the age of 57, of a broken heart. *Becher.*

The theory invented by BECHER was adopted and commented upon by STAHL, principal phyſician to the king of Pruſſia. Born, as BECHER was, with a ſtrong paſſion for chemiſtry, which ſhewed itſelf in *Stahl.*

its

its early youth, he inherited a genius equal to that of BECHER. His imagination was as lively, as brilliant, and as active, as that of his predeceſſor, and he had the advantage of being heard with attention. In the opinion of theſe two philoſophers *fire* enters into the compoſition of all inflammable bodies, and into metals and moſt minerals, and in that condenſed, compacted, fixed ſtate, it was called PHLOGISTON * (latent fire), to diſtinguiſh it from its condition when in a free ſtate.

The Doctrine of Phlogiſton.

We behold flame, we ſee bodies conſumed, we feel a pleaſing, and ſometimes a painful ſenſation, when we approach within the ſphere of theſe phænomena. Now is this fire as much a material body, as a piece of wood, or glaſs, or ſtone, or any other ſubſtance? If it be, whence does it ariſe? and what becomes of it?—We neither ſaw or felt it before the body was kindled; and when the fuel is conſumed, it no longer appears. In anſwer to theſe queſtions BECHER and STAHL tell us,—that *fire*, or PHLOGISTON, is actually a material body, and liable to be modified by the in-

* A word derived from the Greek word φλὸξ, γος, flame, or fire.

fluence

fluence of circumftances. In bodies liable to burn, it exifts in a latent ftate:—place them in circumftances in which combuftion is produced—you then will behold it, perceive it operate, and feel its influence.—In bodies, as metals, though you do not perceive the flame, yet will you difcover this principle by the alteration of their properties. Hence it is*,

If you take a piece of SULPHUR, and fet it on fire, it will burn entirely away, without leaving any afhes, or yielding any foot. During the burning of the fulphur, a copious vapour, powerfully affecting the organs of fight and fmell, and the action of the lungs, is difperfed. Means have been invented for collecting this vapour, and it is found to be a very ftrong acid. The acid thus procured from the burning of the fulphur, is incapable of being either burnt by itfelf, or of contributing towards the fupport of fire in other bodies; the fulphur from which it was procured was capable of both: there is a remarkable difference then, between the acid procured from the fulphur, and the fulphur itfelf. The acid is not the

* The following examples are taken from Dr. WATSON's *Chemical Effays.*

only

only conſtituent part of the ſulphur:—is it not evident then that it muſt have contained *ſomething* elſe, by which it was rendered capable of combuſtion. This *ſomething* is, from its remarkable property of rendering a body combuſtible, denominated therefore PHLOGISTON, or the *inflammable principle.*

If you burn CHARCOAL in the open air, and hold a glaſs over its flame, you will perceive that it burns without emitting either any watery vapour or ſooty impurity; and nothing will remain, from a large portion of charcoal, but a ſmall quantity of white aſhes, which are incapable of any further combuſtion. The principle effecting the combuſtion of the charcoal, and diſperſed by the act of combuſtion, is the PHLOGISTON.

If you ſet SPIRITS OF WINE on fire, they will, if pure, burn entirely away; they differ from charcoal in this, that they emit a vapour: but they leave no reſiduum. You may, by proper veſſels, collect the vapour of burning ſpirits, and you will find it to be an inſipid water, incapable of combuſtion. The principle effecting the combuſtion of the ſpirits of wine, and diſperſed by the act of combuſtion, is the PHLOGISTON.

Some

Some METALLIC SUBSTANCES burn, when fufficiently heated, with a flame more bright than that of fpirits of wine or charcoal; others burn or fmother away like rotten wood; and moft of them, when they have been kept in the open air in a proper degree of heat, lofe their metallic appearance, and are converted into earth. Thus red lead or minium is the earth procured from the burning of lead; and putty, fuch as the polifhers of glafs and marble ufe, is the earth procured from tin. The principle effecting the combuftion of metallic fubftances, and difperfed in the act of combuftion, is PHLOGISTON.

The *acid* of *fulphur*;—the *afhes* of *charcoal*;—the *water* of the *fpirit* of *wine*;—the *earths* of *metallic fubftances*, are utterly incapable of combuftion: their refpective differences from SULPHUR, CHARCOAL, SPIRITS OF WINE, and METALLIC SUBSTANCES, with refpect not only to *inflammability*, but to *fmell*, *colour*, and *other properties*, are attributed to the PHLOGISTON which is difperfed during the combuftion of each of them.

From the ANALYSIS or decompofition of SULPHUR, we conclude that the conftituent parts of fulphur are two—an *acid* which may be collected; and an INFLAMMABLE PRINCIPLE which is difperfed. The reader will wifh to fee this ANALYSIS confirmed by fynthefis, that is, in common language, he will wifh to fee fulphur actually made by combining its *acid* with the *inflammable principle.*

As this *inflammable principle* cannot be obtained in a palpable form feparate from all other bodies, the only method by which we can attempt to unite it with the acid of fulphur, muft be by prefenting to that acid fome fubftance in which it is contained.—Charcoal is fuch a fubftance, and by diftilling powdered charcoal and the acid of fulphur together, we can produce undoubted fulphur. This fulphur is formed from the union of the acid with the PHLOGISTON; and the charcoal may be by this means fo entirely robbed of its PHLOGISTON, that it be reduced to the ftate it is found after complete combuftion in the open air.

Spirits of wine, we have faid, confifts of PHLOGISTON united with *water*:—and if we diftil fpirits of wine and the acid of fulphur mixed together we fhall obtain a pure yellow fulphur, in no way to be diftinguifhed from common fulphur.

But

But one of the ſhorteſt and moſt obvious ways of illuſtrating both the compoſition of ſulphur and PHLOGISTON of metallic ſubſtances is the following.—Upon melted lead pour the acid of ſulphur; collect the vapour which will ariſe, by holding a very large glaſs or other veſſel over the melted lead, and you will, as ſoon as the vapour is condenſed, obſerve ſeveral filaments of ſulphur ſticking to the ſides of the glaſs. Here, when the lead is in a ſtate of ſtrong fuſion, its PHLOGISTON is in a ſtate of diſperſion; and the acid of ſulphur inſtantaneouſly unites itſelf with this *phlogiſton*, and forms ſulphur.

I will in this place, by way of further illuſtration of the doctrine of PHLOGISTON, add a word or two concerning the neceſſity of its union with a metallic earth, in order to conſtitute a metal.

Lead, it has been obſerved, when melted in a ſtrong fire, burns away like rotten wood; all its properties as a metal are deſtroyed, and it is reduced to aſhes.—If you expoſe the aſhes of lead to a ſtrong fire, they will melt; but the melted ſubſtance will not be a metal, it will be a yellow or orange-coloured glaſs.—If you pound this glaſs, and mix it with charcoal duſt, or if you mix the aſhes of the lead with charcoal duſt, and expoſe either mixture to a melting heat, you will obtain, not a glaſs, but a *metal*, in weight, colour, conſiſtency, and every other property, the ſame as lead.

This operation, by which a metallic earth is reſtored to its metallic form, is called reduction. The aſhes of lead melted without charcoal is *glaſs*;—the aſhes of lead melted with charcoal becomes a *metal*; the charcoal muſt then have communicated SOMETHING to the aſhes of lead, by which they are changed from a glaſs to a metal.

Charcoal conſiſts of two things, of aſhes, and of PHLOGISTON; the aſhes of charcoal, though united with the aſhes of lead, would only produce *glaſs*; it muſt therefore be the other conſtituent part of charcoal, or PHLOGISTON, which is communicated to the aſhes of lead, and by an union with which the aſhes are reſtored to their metallic form.

The aſhes of lead we ſee then can never be reduced to their metallic form, without their being united with ſome matter containing PHLOGISTON; and they may be reduced to their metallic form, by being united with *any* ſubſtance containing

7 PHLO-

PHLOGISTON in a proper ftate, whether that fubftance be derived from the animal, vegetable, or mineral kingdom (for tallow, or iron filings, may be fubftituted with fuccefs in the room of charcoal, in the experiment of reducing the lead); and thence we conclude, not only that PHLOGISTON is a neceffary part of a metal, but that it has *an identity* belonging to it, from *whatever fubftance* it be extracted.

The doctrines of pneumatic chemiftry.

It had long been obferved, that certain fubftances, fuch as *marble*, *chalk*, and *limeftone*, effervefced with acids;—that thefe fubftances were infoluble in water; they were foft to the touch and inoffenfive:—But when treated with fire they affumed directly contrary properties, not effervefcing with acids;—being eafily diffolved by water fo as to form a tranfparent liquor;—and laftly, they were rendered fo cauftic as to corrode all animal and vegetable fubftances. Thefe curious phænomena had not efcaped the notice of attentive obfervers of former times; but the honour of firft fatisfactorily explaining the true caufe of thefe events feemed referved for the illuftrious profeffor of chemiftry at Edinburgh, Dr. Black. He difcovered, *Dr. Black.*

vered, that by the procefs of fire, thefe fubftances loft half their former weight, and when treated with acids the compound weighed lighter than before. *Something* therefore was loft. In a treatife, which indeed is a fine fpecimen of the beft method of inveftigating and demonftrating chemical truths, he afcertained, "*what this SOMETHING was*," and proved it to be a permanently elaftic fluid, which he therefore denominated FIXED AIR, deprived of which, the refidue was cauftic or *quick-lime*—having thofe properties firft enumerated.

Macbride. Hitherto the exiftence of FIXED AIR, and its combination with bodies was a phyfical opinion, and no phyfiologift fince VAN HELMONT had adopted it, when the amiable and learned MACBRIDE, profeffor of phyfic at Dublin, examined into the medicinal properties of THIS AIR, and eftablifhed by the moft decifive experiments its *antifeptic properties.* He afcertained, that flefh, which is half putrid, having loft a portion of the FIXED AIR which enters into its compofition, may recover its former fweetnefs, by reftoring to it its FIXED AIR; to produce which effect, it will be fufficient to expofe it to the vapours of of any fermenting fubftance, or rather to a current of FIXED AIR from an effervefcing mixture.

The honourable Mr. Cavendifh.

Soon after the publication of Dr. MACBRIDE's treatife, the Hon. Mr. CAVENDISH communicated to the Royal Society fome new experiments confirming the doctrines of thefe two eminent profeffors. He further fhewed that water is capable of abforbing a volume of FIXED AIR more than equal to itfelf; that this quantity is proportionably greater as the water is colder, and is compreffed by a heavier atmofphere; that water thus impregnated with fixed air has all the acidulous and fpirituous tafte of Seltzar water. Mr. CAVENDISH added to BOYLE's and HALES' method of obtaining the permanently elaftic fluids, the modes of confining and transfufing them from one veffel to another, fo that they might be examined and managed with pleafure, and thus he gave "*to airy nothing a local habitation and a name:*" he determined the quantities of fixed and inflammable gafes obtained from different fubftances: he afcertained their fpecific gravities: and introduced, or at leaft fet the example, by his accurate mode of experiment-

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ing, of eftablifhing a complete fyftem of *pneumatic chemiftry.*

Mr. Lane. Mr. LANE difcovered* that water impregnated with *fixed air* has the property of diffolving almoft all metals, and efpecially iron and zinc; a very fmall quantity of thefe metals being fufficient to communicate to water their tafte and virtues.

Dr. Prieftley. Soon after Dr. PRIESTLEY entered upon his career, and proceeded with fuch rapidity of fuccefs, that he attracted the attention of philofophers of all nations to thefe and fimilar objects, and excited their emulation in the fame purfuit; and thereby he has given rife to fuch aufpicious confequences in chemiftry, that his entry into this branch of experimental philofophy will be ever confidered as an æra in the annals of chemiftry.

It is impoffible to comprefs his numerous difcoveries in the limits of a few pages. They fill up fix volumes; and as the knowledge of the *permanently elaftic fluids* is the moft important part of chemiftry, and has

* This honour is ufually attributed to Dr. PRIESTLEY, as he took the moft active part in diffufing this knowledge.

in

in a manner given to this ſcience an entirely *new appearance*, I would therefore recommend the reader to a careful ſtudy of the whole of this incomparable and entertaining work. I ſhall therefore here confine myſelf ſolely to the account he gives us of his diſcovery of VITAL AIR, which he denominates DEPHLOGISTICATED AIR.

Of the diſcovery of vital air.

On the 1ſt of Auguſt, 1774, I endeavoured, ſays this illuſtrious philoſopher, to extract air from MERCURIUS CALCINATUS PER SE; and I preſently found that, by means of a very large burning-glaſs, an *aerial fluid* was expelled very readily. Having got three or four times as much as the bulk of the materials, I admitted water to it, and found it was not fixed air, becauſe water did not abſorb it. But what ſurpriſed me exceedingly was, " *that when a candle* " *was put into this newly acquired air, the flame,* " *beſides being larger, burnt with conſiderable more* " *ſplendour, and heat, than in common air; and a* " *piece of burnt wood that had any redneſs in it, was* " *rekindled, and burnt away very faſt, reſembling by* " *its crackling noiſe paper that had been dipped in a ſo-* " *lution of nitre.*"

I extracted, he adds, in the ſame way, a quantity

 of

of *air*, with the very *ſame property*, from the common RED PRECIPITATE, which had been produced by a ſolution of mercury in ſpirit of nitre, and hence I concluded that this peculiar property was derived in both inſtances from *nitrous particles*. I even thought that what was uſually ſold as the MERCURIUS CALCINATUS PER SE was contaminated with *nitrous acid*. However, upon mentioning this ſuſpicion to Mr. Waltire, he furniſhed me with ſome, which he aſſured me was genuine. This being treated in the ſame manner as the former, only by a longer continuance of heat, I extracted much more air from it than from the other. This experiment might have ſatisfied any other; but, being at Paris in the October following, and knowing that there were ſeveral very eminent chemiſts in that place, I did not omit the opportunity, to get an ounce of MERCURIUS CALCINATUS prepared by Monſ. Cadet; of the genuineneſs of which there could not poſſibly be any ſuſpicion; and at the ſame time I frequently mentioned my ſurpriſe at *the kind* of *air* I had got from this preparation to Monſ. LAVOISIER, and ſeveral other philoſophers who honoured me with their notice in that city.

At

At the ſame time that I had obtained the air above deſcribed from the MERCURIUS CALCINATUS and the RED PRECIPITATE, I alſo procured ſome of the ſame kind from MINIUM, or RED LEAD. As I never made the leaſt ſecret of any thing that I obſerved, I mentioned this experiment *alſo*, to all my philoſophic acquaintance at Paris, and elſewhere; having no idea at that time to what theſe remarkable facts would lead.

The French chemiſts, who had been inattentive to the admirable diſcoveries of Dr. BLACK and Mr. CAVENDISH, were rouſed by the ſtriking phænomena which Dr. PRIESTLEY's diſcoveries preſented. Their minds being prepared by the active and enlightened genius of the age, the ſpark was no ſooner ſtruck, than the moſt brilliant effects began to ſhew themſelves along the French meridian. Never was the paſſion for novelty, now concurring with philoſophical ardour, more happily exerted among the philoſophers of that lively nation, than in the cultivation of this ample field of knowledge, which had been firſt explored, and the richneſs of the ſoil demonſtrated principally by our illuſtrious countrymen, MAYOW, BOYLE, HALES, BLACK, CAVEN-

DISH, and PRIESTLEY ; of the three laſt of whom I ſhall be joined, by every lover of ſcience, in the wiſh,

Sero in cœlum redeant.

But the efforts of Dr. PRIESTLEY'S diſcoveries were not confined to France. They paſſed to every country in Europe, and acroſs the Atlantic. More extenſive in their influence than the commotions of Calabria, they ſpread their better agitations, particularly into Germany, Italy, and Sweden ; in which laſt kingdom they met the congenial ſpirit of two illuſtrious chemiſts, BERGMAN and SCHEELE ; the *former* diſtinguiſhed by the order, preciſion, and various abilities with which he improved chemiſtry ; and the *other* by ſo numerous a train of diſcoveries as could only occur to a man who, like SCHEELE, joined to a profound knowledge of chemiſtry, an intuitive genius, and a laborious zeal. The diſcovery of VITAL AIR, the pride, as it is called, of modern philoſophy, had ſlumbered for more than a century, when this illuſtrious philoſopher drew it forth from nitre, and a variety of other ſubſtances, and called it EMPYREAL AIR, a word which implies, "*formed of the element of fire,*" or "*an air pure in the extreme.*"

Bergman.

Scheele.

It

It is fingularly curious, that two philofophers of the prefent day fhould both, and at the fame time, and by different proceffes, difcover this WONDERFUL GAS, which has thrown light on the whole œconomy of nature, and both of them ignorant of the prior claim of MAYOW, of whofe book they certainly knew nothing. Dr. PRIESTLEY and Mr. SCHEELE however paid the debt to humanity, being biaffed by the prevailing opinion of *phlogifton*, in which they were feconded by the ingenious and laborious KIRWAN, who wrote a book exprefsly to fupport the *old theory*, as it is called. *Kirwan.*

At this time the *new*, or *antiphlogiftic theory* fprang up in France. It derived its chief origin from LAVOISIER, who had foon the felicity of being joined by BERTHOLLET, MORVEAU, ADET, HAZENFRATZ, DE LA PLACE, MONGE, CHAPTAL, FOURCROY, and others, who have united their labours in eftablifhing this *new fyftem*; which, from fuch a combination of talents, could not fail of being exhibited with every advantage, and of fixing the attention of the philofophic world. *Lavoifier.*

I. They contend, that although the atmofphere is a vaft laboratory, in which nature operates im- *Atmofpheric air fupports refpiration*

 menfe

and combuſ-tion. menſe analyſes, ſolutions, precipitations, and combinations, although it is the grand receiver, in which all the attenuated and volatilized productions of terreſtrial bodies are received, mingled, agitated, combined, and ſeparated, nevertheleſs the ATMOSPHERIC AIR is the ſame with regard to its *qualities*, being decidedly marked by its *two properties* of ſupporting reſpiration and combuſtion.

The proof of this. II. A combuſtible body cannot burn without the contact of atmoſpheric air. Thus combuſtion cannot take place in vacuum.

Combuſtion is limited by the quantity of air. III. A combuſtible body cannot burn in a given quantity of atmoſpheric air, beyond a certain period. An hundred pints of this air contain only 27 pints capable of ſupporting combuſtion; when theſe 27 pints have been *united to* the combuſtible body, the combuſtion ceaſes, as the other 73 pints cannot in any way contribute to its ſupport.

Combuſtion gives the analyſis of common air. IV. Hence it appears, that ATMOSPHERIC AIR i a compound of *two different airs*;—of theſe two ſubſtances, *one* ſupports reſpiration and combuſtion; this

this is termed VITAL AIR: the *other* is the reverſe of it, and is called AZOTIC AIR.

V. Thus a burning body in the air effects a real analyſis of this fluid. It ſeparates from it and abſorbs the VITAL AIR, which augments the weight, and changes the nature of the burning body. *Vital air unites with the combuſtible body.*

VI. The AZOTIC AIR which remains is lighter than the atmoſpheric air, extinguiſhes bodies in combuſtion, and kills animals. *The qualities of the reſiduary air.*

VII. Combuſtion then conſiſts in the *fixation* and *abſorption* of VITAL AIR by the combuſtible body, by a true decompoſition of the atmoſpheric air. *The true definition of combuſtion.*

VIII. A combuſtible body which has burnt in atmoſpheric air, and *abſorbed* all the VITAL AIR to which it is capable of uniting, can burn no longer even in a freſh quantity of air: it has become incombuſtible, and frequently *acid.* *The qualities of the combuſtible body, when burnt.*

IX. As many bodies by abſorbing the VITAL AIR are rendered *acid*, hence the term which it has alſo received of OXYGEN AIR, or the ACIDIFYING PRINCIPLE. *The origin of the term oxygen air.*

X. There

Of the difengagement of heat and light.

X. There is another interefting phænomenon in combuftion, which modern chemiftry is able to explain; namely, that of the difengagement of *heat* and *light*.

Combuftion alfo decompofes the vital air.

XI. Combuftion is not confined to the decompofition of atmofpheric air by abforbing one of its principles; for it alfo *decompofes* the VITAL AIR, by abforbing, fixing, and rendering more or lefs folid, in the combuftible body, the *oxygen*, or bafe of the vital air, and difengaging the folvent of this bafe, *caloric*, or *heat*, in greater or lefs quantity.

Light and heat component parts of vital air.

XII. It is demonftrated, that the light which conftitutes *flame* is contained in the VITAL AIR, of which it is one of the principles; for combuftible bodies afford much more flame when they burn in vital air, than in atmofpheric air.

A corollary.

XIII. Hence it follows, that when we burn a combuftible body, in order to procure *heat* or *light*, as we do to mitigate the rigours of winter, or to chace away the darknefs of the evening, we obtain thefe from the AIR itfelf in which they enter as principles.

XIV. Now

XIV. Now as VITAL AIR only ſerves to ſupport combuſtion, it is eaſy to conceive, that a very combuſtible body, capable of abſorbing the whole of the VITAL AIR, may be employed to determine the proportion of the vital and azotic airs in common air: thus phoſphorus and nitrous air are now uſed for the purpoſe of *eudiometry*, or to diſcover the purity of the air; that is to ſay, the proportion of the VITAL AIR which it contains.

How the goodneſs of common air may be aſcertained.

XV. Combuſtible bodies are too various, numerous, and important in the phænomena they exhibit, and the combinations they are inceſſantly entering into with each other and with the air, not to excite us to examine them with care, and endeavour accurately to aſcertain their properties and ſpecific characters.

Why we ſhould appreciate different combuſtible bodies.

XVI. The diamond is the hardeſt of all the bodies we know. It is very remarkable for the power with which it refracts and decompoſes light, from which the immortal NEWTON rightly conjectured it was combuſtible, and this is found actually to be the caſe *.

The diamond is a combuſtible body.

* Vide p. 14.

Metals unite with oxygen the baſe of vital air.

XVII. Though there are various circumſtances under which metals may be united with OXYGEN, they may be reduced to three.

1. The firſt is the contact of *air*,
2. The ſecond is owing to the decompoſition of *water*, which we ſhall preſently ſhew is compoſed principally of oxygen,
3. The third depends on *acids*.

In this triple view the oxydation and diſſolution of metals are here to be conſidered.

Metals are to be eſteemed combuſtible bodies.

XVIII. All metals heated in the air, and raiſed to a temperature more or leſs high, are ſuſceptible of burning with a vivid flame, great heat, and a true deflagration, in which proceſs they abſorb OXYGEN. Thoſe that oxydate ſlowly, and without perceptible inflammation, equally diſengage *light* and *caloric* from the vital air, but in ſo ſmall a quantity at a time, that they are not rendered ſenſible to our organs.

Metals during combuſtion in-

XIX. All metals increaſe their weight during this operation, which does not take place without the contact

contact of air, and consequently they absorb a principle, the OXYGEN of the atmosphere, without losing any one.

crease in weight by absorbing oxygen.

Neither the name of calcination which was given to this phænomenon, nor that of metallic calces, can be retained; but instead of these have been substituted the terms of combustion and oxydation for the operation, and of metallic oxyds to denote the metals thus burnt or oxydated.

XX. Elevation of temperature favours the absorption of the OXYGEN of the atmosphere by metals, and renders the combination of this principle with these combustible bodies more considerable.

Heat increases this absorption.

XXI. While there are some metals which never burn in the air, except at a high temperature, as gold, silver, and platina, there are others which burn at all temperatures, even the lowest, and with great promptitude, as manganese. Some, as iron, copper, lead, burn slowly, and in the course of some months, in the air, even though cold.

Metals differ in this respect.

XXII. Not only do all metals compared with each other absorb different quantities of OXYGEN to

Metals absorb different quantities of vital air.

 saturate

faturate them in their combuftion by the contact of air, but each metal confidered feparately abforbs different proportions, and ftops at various points of *oxydation*, according to the degree of temperature to which it is raifed. Thus tin, lead, copper, iron, change colour and affume the tints of the rainbow, at the firft degree of fire to which they are expofed in contact with the air: lead firft becomes a grey oxyd, next yellow, and laftly red; mercury paffes from black to white, from white to yellow, and from yellow to red; iron, at firft a black oxyd, becomes next green, then brown, and ultimately white: copper is at firft a brown oxyd, from which it changes to blue, and its laft degree of oxydation imparts to it a green colour.

The reafon why metals exhibit different coloured flames.

XXIII. The colour which metals difplay in burning, or with which their flame is tinged, appears to be owing to the diffolution of the metallic molecules in the light that is evolved. Thus copper yields a green flame, &c.

Before we confider the oxydation of metals in *water* and *acids*, it may be proper firft to notice the compofition of thefe bodies.

XXIV. WATER

XXIV. WATER is not a fimple element, as was formerly fuppofed. By burning with rapidity a number of combuftible bodies, more or lefs heated, as charcoal, red-hot iron, oil, &c. water is decompofed, yielding to thefe combuftible bodies the OXYGEN it contained.

Combuftible bodies decompofe water, depriving it of its oxygen.

XXV. In proportion as the OXYGEN of the water becomes fixed in the combuftible bodies which it burns, its other principle which is diffolved in the caloric forms the INFLAMMABLE AIR which is evolved.

Hence the evolution of its other principle hydrogen.

As this fecond principle is one of the elements of water, it has been called HYDROGEN, and when it is an elaftic fluid from its folution in light and caloric, HYDROGEN or INFLAMMABLE AIR.

XXVI. Reiterated experiments have proved, that water contains 85 parts in a hundred of OXYGEN, and 15 of HYDROGEN. The recompofition of water, one of the moft brilliant difcoveries of modern chemiftry, which was made by the Honourable Mr. CAVENDISH, confirms the analyfis of this body; for on uniting by combuftion 85 parts of OXYGEN with 15 of HYDROGEN, 100 parts of pure water are obtained.

The compofition of water proved by fynthefis.

XXVII. The

Hydrogen air ariſes always from the decompoſition of water.

XXVII. The HYDROGEN AIR produced in various experiments always originates from water, either in conſequence of a preceding decompoſition, in which it had been combined in the ſtate of *fixed hydrogen*, with one of the ſubſtances employed, or from the decompoſition of the water actually taking place in the experiments themſelves.

All HYDROGEN therefore proceeds from water, and when it is in the form of *air* it has combined with caloric: and it is eaſy to conceive how hydrogen, one of the elements of water, acquires levity by participating of the elaſtic property of caloric: and, in fact, while a cubic foot of water weighs ſeventy pounds, a cubic foot of pure hydrogen air weighs only ſixty-one grains.

Heat aſſiſts the decompoſition of water.

XXVIII. The combuſtible bodies which decompoſe water, generally ſpeaking, are thoſe which have a greater affinity, or ſtronger attraction, for oxygen, than hydrogen has: but this attraction is greatly aſſiſted by the preſence of caloric, which, as we obſerved, united with the hydrogen, holding it in ſolution in the form of gas or air.

XXIX. HYDRO-

XXIX. HYDROGEN GAS carries along with it various ſubſtances, either ſuſpended or diſſolved in it, according as the bodies are applied to the water from whence it is extricated. From the difference of theſe adventitious ſubſtances which it contains, it *varies* in ſmell, weight, and inflammability, the colour of the flame it yields, its action on different bodies, and alſo in the product which it affords in burning. Hence are derived the ſeveral ſpecies and denominations of inflammable air admitted by authors, of which hydrogen always conſtitutes the general baſis.

The different ſpecies of inflammable air.

XXX. To recapitulate. HYDROGEN is one of the principles of water. With caloric and light it forms hydrogen air, thirteen times as light as common air, capable of diſſolving ſulphur, phoſphorus, charcoal, oil, &c. and then forming the different ſpecies of hydrogen air, formerly called ſulphurated, phoſphorated, carbonated, oleagenous, inflammable air. It imparts to all the compounds into which it enters, whether they be combuſtible or not, a conſiderable refringent power, which property led the ſagacious NEWTON to conjecture, that a combuſtible ſubſtance was contained in water.

The properties of hydrogen.

XXXI. The

The cause of the aurora borealis.

XXXI. The hydrogen air being thirteen times lighter than common air, it rifes above the common air, and to the combuftion of this air, by means of the electric fluid, arifes moft probably the phænomenon of the aurora borealis.

The cause of detonations.

XXXII. The difengagement of this principle in the form of gas, which takes place wherever water is decompofed by a combuftible body, is the caufe of a great number of detonations and fulminations, which occur in chemical proceffes.

Of thunder and rain.

XXXIII. It is alfo probable that atmofpheric detonations, claps of thunder, proceed from the hydrogen air inflaming in common air; and accordingly they are often fucceeded by a torrent of rain.

Sudden appearance of ftorm.

XXXIV. When in a clear day a ftorm on a fudden takes place, and the heavens are overcaft, it is probable that this fudden formation of water in the atmofphere, arifes from the rapid union of the hydrogen gas and vital air, occafioned by the neceffary re-eftablifhment of an equilibrium of electricity between different clouds, or between the clouds and the earth.

XXXV. As

XXXIV. As every acid contains OXYGEN, and loſes its acidity exactly in proportion as it is deprived of this principle, we ought to conſider acids as burnt or oxydated ſubſtances, which are akin to each other from the preſence of this acidifying principle. *The origin of acids.*

XXXV. Since all acids reſemble each other in their taſte, their manner of giving a red colour to vegetable ſubſtances, their tendency to combine with alkalies, and metallic oxyds, and their property of attracting and being attracted powerfully, it was natural to preſume, as Sir Iſaac NEWTON obſerved, that they likewiſe reſembled each other in their intimate nature, and poſſeſſed ſome homogeneal principle: and chemical analyſis has eſtabliſhed this as a truth beyond the poſſibility of a doubt. *Why acids have common properties.*

XXXVI. The beſt method of acquiring a knowledge of the nature of acids is by forming them, by compoſing them, from their conſtituent parts, in uniting with OXYGEN ſuch ſubſtances as are capable of becoming acid by an union with it. *Method of inveſtigation.*

The advance made in this branch of ſcience.

XXXVII. Out of thirty known ſpecies of acids, there are but three, ſtrictly ſpeaking, which we can either compoſe or decompoſe, ſo that we are neceſſarily ignorant of their nature; but there is no reaſon why we ſhould not regard ſubſtances of this kind as accurately diſcriminated, and contemplate their general properties and compoſitions.

Why acids are differently characteriſed.

XXXVIII. All acids being compounds of OXYGEN with DIFFERENT SUBSTANCES, the *former principle* is the cauſe of their reſemblance and common properties; the *latter*, being different in each, may ſerve to characterize each in particular. For this reaſon, thoſe matters which are variable in acids are termed their baſes, or acidifiable principles.

Of the common principle and baſe.

XXXIX. Thus all acids are combinations of baſes, or acidifiable ſubſtances, different in each ſpecies, with oxygen, which is the ſame in all: whence it follows, that their common properties, their characters as acids, depend on OXYGEN; their particular properties, their ſpecific characters, ariſe from their baſes.

XL. The

XL. The word acid, indicating the general and identical nature of thefe fubftances, forms their generical name, while the particular name of the bafes of each may with propriety defignate each particular acid. Thus fulphur is the bafis of the acid we call fulphurous, carbon that of the carbonic, and fo on. *The new nomenclature.*

XLI. Various metals decompofe WATER, and this the more rapidly the higher the temperature is raifed. Thus iron decompofes water with the greateft rapidity when much heated, though it requires a confiderable time to effect its decompofition at the higheft temperature our atmofphere ever attains. *Metals decompofe water.*

LXII. Sulphurous acid, diluted with water, greatly facilitates the decompofition of the aqueous fluid by means of metals, and evolves in this procefs hydrogen gas; this is eminently the cafe in the diffolution of iron or zinc by the diluted fulphurous acid. *Sulphurous acid promotes the decompofition of water.*

XLIII. There are fome cafes in which the WATER and the ACID are at the fame time *decompofed* by the metal, as in the folution of tin in the nitrous acid. Tin is fo greedy of OXYGEN, and requires fo large *Sometimes acids are alfo decompofed.*

a quantity for its ſaturation, that after having abſorbed that of the nitrous acid, and reduced it to the ſtate of azote, it decompoſes likewiſe the water, and diſengages hydrogen. Theſe two principles being ſeparated from their firſt compounds, unite together, and immediately form ammoniac.

The different affinities which metals have for oxygen.

XLIV. Metallic oxyds have different degrees of affinity with acids; hence ſome may be employed to decompoſe combinations of others. Thus ſeveral metals, by taking OXYGEN from the others which are diſſolved by means of acids, occaſion the re-appearance of the diſſolved metal. Thus mercury will occaſion the re-appearance of ſilver, copper of mercury, iron of copper, zinc of iron, &c.

The reduction of metals.

XLV. The reduction of metals ariſes from ſubſtances which have a greater affinity for OXYGEN than the metallic baſe, and theſe combine and form with this principle different compounds. Thus carbon or charcoal added to a metallic oxyd, at a certain temperature, unites with the OXYGEN of the calx, and forms carbonic acid air, or fixed air, and hydrogen air, by uniting with the OXYGEN of a metallic

metallic oxyd, or calx, forms water, while the metal is reftored to its metallic fplendour and its other characteriftic properties*.

The progrefs of the new chemiftry.

One may here paufe a moment to confider the caufes that pervert the underftandings of men, and the difficulty there is to root up error when once eftablifhed.—It is natural in the rudeft ftate of fcience to confider the changes of property in chemical bodies as refulting from the lofs or acquifition of *fomething*, and, if this could not be demonftrated, to give it fome general appellation. Hence the term PHLOGISTON. It was this principle, which efcaping from a metal during calcination converted it into a calx, or earthy fubftance; and it was the union of this principle which rendered the air mephitic. Here the PHLOGISTIANS appealed to the fenfes.—But when thefe altered bodies came to be accurately weighed, it was found that 100 pounds of lead converted into minium, or calx of lead, weighed 112 pounds; and when the experiment was performed in clofe veffels, the volume of air was diminifhed during the procefs; and the air, after the calcination was complete, weighed exactly 12 pounds lefs than before.—This

* Many of thefe pofitions are proved by *analyfis* and *fynthefis* in PART I. of this work.

argument,

argument, which ſhook the very foundation of the *phlogiſtic doctrine*, the ſophiſtry of men, who wiſhed to indulge their deluſion, endeavoured to anſwer by ſaying, that gravity was relative; thus a cork which falls to the ground riſes in water, and PHLOGISTON having a tendency upwards, buoyed as it were each body in which it entered, and hence, when removed from the metal, its increaſe of weight, and hence the decreaſe of weight in the atmoſpheric air employed in calcination.—When it was obſerved, that this explanation would not hold in other inſtances, for when charcoal was burnt there was but a ſmall reſiduum, and this weighed *lighter* than when it had its phlogiſton, and the mephitic air on the contrary *heavier*, "Ah," ſay they, "there are dif-"ficulties in every ſcience, and we do not preſume "to explain every thing;" generally at this ſame time, knitting the forehead, and walking off.—But the ANTIPHLOGISTIANS kept on exulting at every interview, and they examined the *mephitic air* from each proceſs, and obſerved it was ſometimes *azotic air*, ſometimes when charcoal was uſed *fixed air*, and ſometimes *water*; and when the MERCURIUS PRECIPTATUS PER SE was diſcovered by Monſ. LAVOI-

SIER

SIER to give out VITAL AIR which calcined other metals, giving them weight, and that when any refidue of this air remained it was not *mephitic*, and when combined with mephitic air in the proportion of one to four it made common atmofpheric air, it was then that the ANTIPHLOGISTIANS truly triumphed, and the VITAL AIR, which forms a fourth part of our atmofphere, became the univerfal ŒDIPUS that unlocks all the myfteries of chemiftry; the *caufa fine qua non* of the antiphlogiftic fchool.

The *new doctrine* was combated by Dr. BLACK for ten years, who finally became a convert to it. Writing to LAVOISIER, he fays, " fuch is the force " of PREJUDICE that it requires ten years to over- " come this hydra, but now I feel the force of truth, " and affent to it."—The celebrated KIRWAN next writes to LAVOISIER, " that he has renounced his " work in favour of the *phlogiftic doctrine*, and means " himfelf to refute it." Even Dr. PRIESTLEY declares, " that he has been more than once upon the point of " abandoning the doctrine of *phlogifton*;" and in his fixth volume he actually declares " in favour of " the decompofition of water," and adds, " nor fhall " I feel much reluctance to adopt the *new doctrine*,

" although

"although I think the chemical phænomena admit "of the easiest explanation on the old system."

Respecting the nature of the composition of the *air* Dr. PRIESTLEY says, "for my own part I will frankly "acknowledge, that, at the commencement of the "experiments recited *, I was so far from having "formed any hypothesis that led me to the discoveries "these produced, that they appeared to me improbable "when I heard of them; and when the decisive facts "did at length obtrude themselves upon my notice, it "was very slowly, and with great hesitation, that I "yielded to the evidence of my senses. And yet, "when I reconsider the matter, and compare my "last discoveries relating to the constitution of the "atmosphere with the first, I see the closest and "easiest connection between them, so as to wonder "that I should not have been led immediately from "the one to the other. That this was not the case, "I attribute to the force of PREJUDICE, which, "unknown to ourselves, biasses not only our judg-"ments, properly so called, but even the percep-"tions of our senses; for we may take a maxim so "strongly for granted, that the plainest evidence of

* Vide page xxix.

" ſenſe will not entirely change, and often hardly
" modify, our perſuaſions; and the more ingenious
" a man is, the more effectually he is entangled in
" his errors; his ingenuity only helping him to de-
" ceive himſelf by evading the force of truth."

We will not fatigue the reader by entering more deeply into the *new* or *antiphlogiſtic doctrine* reſpecting thoſe bodies which have no vital principle, and which are therefore diſtinguiſhed as belonging to the mineral kingdom.

XLVI. In the *mineral kingdom*, we are juſtified in referring all the phænomena to the action of external bodies, and the ſimple law of affinity affords deductions ſufficient to account for all its changes. In the *vegetable kingdom*, on the contrary, we are compelled to acknowledge a vital principle which preſides over every thing, and performs many chemical proceſſes which we poor mortals attempt in vain to imitate.

The difference between the mineral and vegetable kingdoms.

XLVII. That plants have a *living principle* is evident by the motion of the ſenſitive plant, which we may excite at pleaſure; by the ſpontaneous motion of

Plants are diſtinguiſhed by poſſeſſing a living principle.

of the hedyfarum gyrans; the retraction of the ftamina of the ceftus; the advance of the ftamina to the piftillum in other flowers; by the leaves turning to the light; and fome plants following the fun; by their clofing againft rain; by the roots turning out of their direction to plunge themfelves into water, or a more favourite foil, &c.

They reproduce their fpecies.

XLVIII. The reproduction of *vegetables* is effected in the fame manner as that of *animals*; and modern botanifts have fupported the comparifon between thefe two functions in the moft conclufive manner.

Their relation to air.

XLIX. *Vegetables* require the fame kind of air as *animals*.

They have no locomotive power.

L. The *great difference* which exifts between *vegetables* and *animals* is, that the latter *in general** are capable of conveying themfelves in fearch of nourifhment; whereas vegetables, being fixed in the fame place, are obliged to take up in their own vicinity all fuch materials as are capable of nourifhing them:

* Oyfters, mufcles, polypi, &c. connect this chain, and feem as it were intermediate links, having no locomotive power.

and

and nature has therefore provided them with leaves, to extract from the atmofphere the air and water, while the roots extend to a diftance in the earth to take firm hold, as well as to imbibe water and the fixed air contained within the bowels of the earth.

LI. Dr. PRIESTLEY difcovered, in the year 1772, that plants emitted VITAL AIR and abforbed FIXED AIR; for which difcovery he received the thanks of the *Royal Society*, in an eloquent fpeech delivered by the prefident, " From your difcoveries," fays Sir JOHN PRINGLE, " we are " affured, that no vegetable grows in vain, but " that, from the oak of the foreft, to the grafs in the " field, every individual plant is ferviceable to man- " kind; if not always diftinguifhed by fome medi- " cinal virtue, yet making a part of the whole, " which cleanfes and purifies our atmofphere. In " this the fragrant rofe-tree and deadly night-fhade " co-operate: nor is the herbage, nor woods that " flourifh in the moft remote and unpeopled regions, " unprofitable to us, nor we to them, confidering " how conftantly the winds convey to them the " FIXED AIR iffuing from our lungs, while they " fend out VITAL AIR for us." Mr. SCHEELE *Dr. Prieftley's and Dr. Ingenhouz's difcoveries refpecting plants.*

having

having made ſome experiments diametrically oppoſite to this poſition, Dr. PRIESTLEY employed a whole ſummer to repeat his former experiments, and perceived that upon many occaſions AZOTIC AIR was given out, but he confeſſes, "he could not "diſcover the cauſes of this circumſtance." This laurel was reſerved to decorate the brow of the laborious and ingenious Dr INGENHOUZ, phyſician to her Imperial Majeſty. He firſt ſhewed, that the trunk and foliage of plants gave out VITAL AIR only in the preſence of *light*. Hence if you put a plant under water in an inverted tumbler, and expoſe it to the rays of the ſun, in a few minutes air will be given out, and upon examining this, it will be found to be the pureſt VITAL AIR: or if ſucceſſive plants be put into *azotic air*, it will be ſo ameliorated, that combuſtion will be ſupported in it, and it will poſſeſs the nature, and moſt probably the ſame identity, as common air: or if a plant be expoſed under theſe circumſtances to *inflammable air*, it will form a truly exploſive air*. This philoſopher, all

Dr. Ingenhouz's diſcoveries.

* That inflammable air and vital air when mixed are exploſive, is a very valuable diſcovery, which enabled this philoſopher firſt to give a diſtinct theory of gunpowder, and the wonderful phænomena of earthquakes. Vide his *Nouvelles Experiences et Obſervations ſur divers Objets de Phyſique*, in four volumes octavo.

whoſe

whoſe experiments are exceedingly elegant, and whoſe apparatus is the ſimpleſt imaginable, and his narrative the eaſy flowing of a ſagacious mind intent upon the truth, at the ſame time diſcovered that in *the abſence* of *light*, not VITAL, but AZOTIC and FIXED, AIRS* were given out; and that even

* If we caſt our regards with aſtoniſhment on the vaſt ſcene of that perpetual rotation of organized beings; when we conſider that all living animals, by their reſpiration, perſpiration, digeſtion of food, by the putrid fermentation of their bodies after death; that all vegetables as long as they live, as well as when they are in a ſtate of decompoſition after death; that in combuſtion, and, in ſhort, in an infinite variety of operations, every where obvious on the ſurface of the earth, they have one general effect, that of producing carbonic acid, or FIXED AIR; if we conſider, I ſay, that all theſe conſpire, as it were, in forming this compound ſubſtance (carbon and oxygen), is it poſſible to doubt that this fluid, the carbonic acid or fixed air, has an utility as extenſive as its almoſt univerſal production?

But it may be aſked, why is not *this air* to be found in the atmoſphere? The ſolution is given us by this admirable philoſopher himſelf. "This union of CARBON and OXYGEN in the ſtate of air, having a greater *ſpecific gravity* than atmoſpheric air, quits, almoſt as ſoon as it is generated, the common ſtock, ſinks to the ground, and being eaſily miſcible with water, percolates through the ground to become the food of plants, and in the rays of the ſun is decompoſed, ſupplying them with their *carbon*, or wood. Thus 3 cubic inches of a *triplex laciniata* in common water produced in ſix hours in bright ſunſhine 3 meaſures of VITAL AIR, quality 228; whereas in ſtrongly aerated water it produced $9\frac{1}{2}$, and whoſe quality above atmoſpheric air was 286." Dr. INGENHOUZ alſo diſcovered that common air was abſorbed by plants as well as water, which in the ſunſhine were decompoſed and gave out their common principle, viz. VITAL AIR. See his ingenious Diſſertation *on the Food of Plants*, preſented to THE BOARD OF AGRICULTURE, and printed by their order; and his *Experiments on Plants*, which were firſt publiſhed in Engliſh, and afterwards in French.

during

during the funfhine flowers, roots, and ripe fruit, always produced thefe deleterious airs. Hence he taught us the true relation we ftand in with regard to the *vegetable race*, and he has alfo extended thefe curious and beautiful refearches by afcertaining the different proportions of VITAL AIR to the AZOTIC AIR in different fituations, and has demonftrated, that in a given quantity of atmofpheric air, " there is more VITAL AIR in the country than " in towns; and more near the fea than inland;" neverthelefs he found by his *eudiometer*, " lefs in the " marfhy lands of *Holland* than at *Vienna*, and he " attributes *the keennefs of appetite, and quicknefs of di-* " *geftion, in the latter place, to this circumftance.*" He formed great expectation of the VITAL AIR in

Dr. Ingenhouz's experience with regard to vital air.

difeafes, and after inhaling it himfelf, " he experi- " enced," he fays, " a remarkable *alacrity* of *mind* " and *body*, and thinks he *flept founder* than *ufual* that " night." He was the firft who adminiftered the VITAL AIR in ASTHMA, and he has had the honour of giving it to the ARCHDUCHESS OF RUSSIA, who alfo experienced the fame benign effects as this philofopher *.

LII. When

* In 1779 Dr. INGENHOUZ difcovered that the animal body threw out AZOTIC, and FIXED, AIRS. In the very fame year Mr. CRUIKSHANK,

LII. When Dr. PRIESTLEY inhaled the VITAL AIR, he felt for ſome time afterwards "his *breaſt* peculiarly *light* and *eaſy*." He conjectures from the greater ſtrength and vivacity of the flame of a candle in VITAL AIR, "that it might be peculiarly ſalutary in all caſes of weakneſs, or a want of energy in the ſyſtem.—Hitherto," he adds, "only two mice and myſelf have had the privilege of breathing it." *Dr. Prieſtley's experience.*

Speaking of *factitious airs* in general, he ſays, "I cannot help flattering myſelf, that, in time, very great medicinal uſe will be made of the application of theſe different kinds of air to the animal ſyſtem. Let INGENIOUS PHYSICIANS attend to this ſubject, and lay hold of the *new handle*, which is now preſented them, before it be ſeized on by RASH EMPIRICS; who, by an indiſcriminate and injudicious application, often ruin the credit

CRUIKSHANK, the celebrated author of a work on the Abſorbent Syſtem, and lecturer on Anatomy in London, publiſhed a ſimilar diſcovery, and in juſtice to both characters, I muſt obſerve, that their reſpective works were in the preſs at the ſame time. This however is not the only inſtance of two perſons, ignorant of each others purſuits, happening to hit upon the ſame thing (vide page l.). Mr. CRUIKSHANK has extended this diſcovery to the phænomena of *reſpiration*, and a more accurate inveſtigation may hereafter perhaps determine for this philoſopher the honour of a ſtill more IMPORTANT DISCOVERY. Vide Vol. II. page 277.

" of things and proceffes, which might otherwife " make an ufeful addition to the materia and ars " medica."

The effects of fixed air.

Dr. Percival's experience.

Dr. Smith's important difcovery.

LIII. It is not in the order of this work to trace here minutely the progrefs of the *pneumatic practice* of phyfic, we fhall therefore pafs over the teftimonies of Dr. PERCIVAL, &c. refpecting the falutary effects of FIXED AIR in confumption, mortification, and ulcers, and haften briefly to record the introduction of the OXYGENATED NITROUS ACID VAPOURS, for arrefting the progrefs of *contagious fever.*

The efficacy of the nitrous acid vapour in arrefting peftilential fever.

In the year 1782 an infectious fever broke out among the prifoners in *Winchefter.* This excited the attention of Parliament, and many eminent phyficians in London were applied to, to take charge of the prifoners there; but they refufed venturing upon fo hazardous an office. The late Dr. FOTHERGILL then waited on Dr. SMITH, and requefted him, in the moft urgent manner, to accompany the commiffioner to Winchefter. Two hundred and forty perfons had already perifhed by this dreadful malady, whofe

whofe violence feemed daily increafing. Moft of the officers and fervants belonging to the hofpital had fallen victims to this fatal diftemper. But fuch was the powerful influence of the NITROUS ACID VAPOUR, the number was reduced to 9, 5, 3, and 2,—and afterwards none died. Dr. CARMICHAEL SMITH himfelf was feized with this diforder, and confined to his bed, yet, like a true hero, he would not yield to his difeafe, but continued to give directions. In a memorial which he afterwards fent to the minifter of ftate, in mentioning thefe circumftances, he fays, "But thefe, my lord, are only "the fufferings of an individual. I readily complied with your lordfhip's wifhes, and as to the "conditions of my attendance I made none: convinced that no pecuniary recompence could be an "adequate compenfation to me, circumftanced as I "then was, for the rifk I ran; and that if I was fortunate enough to furvive, and *fucceed*, I was certain of the firft of all rewards, the *confcioufnefs* of "having *difcharged* a *duty* to which I was *called* by the "*voice* of *my country*, and in the event of which the "national as well as my own honour was involved. "My endeavours have been attended with a fuccefs

" which even my friends could hardly expect, and " which I believe ftands *without example* in the an- " nals of phyfic. I have already received from the " *public* the fulleft approbation of my conduct, and " make no doubt that, in confequence of your lord- " fhip's favourable reprefentation of it to the *king*, I " fhall receive from *his majefty*, ever attentive to re- " ward merit in the loweft of his fubjects, fome " mark of his Majefty's royal favour." In confe-quence of which difcovery, he was appointed phyfi-cian extraordinary to the king.

This *antifeptic vapour* was afterwards applied, in the year 1795, by the order of the lords commiffioners of the Admiralty, on board the Union hofpital fhip, and with the fame happy fuccefs *.

De Morveau.

LIII. Near about the fame time in *France* a very important difcovery was made. Monf. DE MORVEAU, the affociate of LAVOISIER and FOURCROY, employed for the fame purpofe the OXYGENATED MA-RINE ACID in the form of air, or vapour, and

* Vide *An Account of the Experiment made on board the Union Hofpital-Ship, to determine the Effect of the Nitrous Acid Vapour in deftroying Contagion, in a Letter addreffed to the Right Hon. Earl Spencer.* By James Carmichael SMITH, M. D.

1 purified

purified the infected hofpital at Dijon. This method was afterwards extended to the different military hofpitals by a decree of the national affembly.

LIV. Since there is no diforder to which human nature is fubject, more deftructive or alarming than contagious fever, the humane reader will not require an apology for delaying his attention upon fo important a point, more efpecially as it confers the higheft honour on the prefent enlightened age, and holds out a profpect that one of the greateft fcourges to mankind will be at laft banifhed from the earth, never again to rear its truly formidable head.

LV. As Dr. CRAWFORD, brother to the late celebrated Dr. ADAIR CRAWFORD, of whom we may juftly fay, *Dr. Crawford's difcovery.*

——————Par nobile fratrum,

was returning to England from India, in the year 1770, on board the Earl of Middlefex, an epidemic fever broke out among the crew, which feemed to threaten an alarming mortality*. Thirty of the men

* For an account of this fever, vide *An Effay on Fever accompanied with a Difeafe of the Liver, hitherto but little known, though very frequent and fatal in warm Climates.* A new edition of this very interefting work is now printing for Kearfley.

were ſeized with the characteriſtic ſymptoms of this diſeaſe. Three of the unhappy ſufferers early periſhed. On each ſide the eye was now ſaddened with the deſpondence which was viſible in every countenance: and the ear was diſtracted with the groans and difficult reſpiration of thoſe who ſuffered, or by the foreboding of ſuch as had hitherto eſcaped. Nor was the ſituation of this compaſſionate phyſician leſs lamentable than the reſt. The uplifted eye implored for help in vain! He had no clue to conduct him in his preſent difficulty. But the man of ſcience does not ſoon yield up to deſpair. He inveſtigates the hidden cauſes of diſeaſe, and Nature in her bounty not unfrequently bleſſes the laudable endeavour. From the accurate and ingenious experiments of Dr. Adair Crawford, it appears, that when an animal is immerſed in hot water, the veins pour out upon veneſection, not a black, but florid, blood; and other obſervers have alſo noticed, that blood taken from the arm in ſummer is of a brighter hue than in winter. Hence it is reaſonable to ſuppoſe, that as the liver is an organ deſtined by nature to receive black, or venal blood, that this dark blood is intended to be a ſufficient ſtimulus; but when, on the

the contrary, that organ receives florid or arterial blood, that the ſtimulus is then too great, and inflammation of that viſcus enſues. Perhaps under this perſuaſion (for the Earl of Middleſex was now near the tropic), or from its acknowledged utility, Dr. Crawford opened one of the dead bodies, and had a demonſtrative proof that the liver was the chief ſeat of the preſent diſeaſe. It was not only enlarged, but externally ſhewed a *florid* appearance. Upon this diſcovery he had inſtant recourſe to bleeding and mercurial cathartics, and he obſerved, that where the mercury produced *ſalivation* the recovery was more ſtriking, and he therefore exhibited mercury alſo with this intention.

On the 20th of May this fever attacked John Mason, a ſtrong athletic ſailor. I ordered, ſays Dr. Crawford, ſixteen ounces of blood to be taken from him. The pulſe roſe immediately in fulneſs, and his reſpiration became eaſy. Three of the aperient pills (theſe were compoſed of mercury, aloes, ſoap, and jalap) were adminiſtered, and the ſame quantity repeated in the evening, which produced a ſufficient effect. Theſe were continued each day, ſo that he had taken now about half a drachm of calomel. On the 25th, his mouth

mouth was a good deal affected, and all uneafinefs in breathing was inftantly removed. On the 27th the falivation abated confiderably, when his refpiration became proportionably oppreffed, he therefore returned to the ufe of the pills. On the 28th the falivary difcharge was again abundant, and it is not a little remarkable, Dr. CRAWFORD adds, " that as " this increafed, the difficulty of breathing, and all " the other fymptoms of the difeafe, diminifhed." This obfervation led me, he adds, to keep up the fpitting for a few days, at the fame time care was taken to prevent it from being too copious*. On the 29th, 30th, and 31ft, the forenefs of the mouth was the only difeafe, and this decreafing, the failor was foon reftored to found health.

Dr. Wade's and Dr. Chifholm's experience.

LVI. This practice has been fince purfued with equal fuccefs by Dr. WADE, in Bengal, in the year 1791, and by Dr. CHISHOLM in the ifland of Grenada, for the cure of the yellow, or bilious autumnal, fever. Dr. WADE did not lofe one patient, and

* When violent falivation came on, this able practitioner had recourfe to opium. This often occafioned violent torment in the bowels, which was as inftantly removed by juice of limes. Pleafe here to confult Vol. III. page 639.

Dr.

Dr. Chisholm loſt only one out of forty-eight patients in whom the mercury affected the ſalivary glands. The latter gave 150 grains of calomel, and applied the ſtrongeſt mercurial ointment below the groin on each ſide in ſeveral caſes. He declares, that not only the cure was ſpeedy, but that not a ſingle relapſe occurred where the fever was cured by *ſalivation.*

LVII. I preſcribed, ſays Dr. Rush, ſpeaking of the late peſtilential fever in Philadelphia *, bark in large quantities; in one caſe I ordered it to be injected into the bowels every four hours. I directed buckets full of cold water to be thrown frequently upon my patients. The bark was offenſive to the ſtomach, or rejected by it, in every caſe in which I preſcribed it. The cold bath proved grateful, but no otherwiſe ſalutary. Three out of four of my patients died to whom the cold bath was adminiſtered in addition to the tonic remedies before mentioned. Baffled in every attempt to ſtop the ravages of this fever,

Dr. Ruſh's experience.

* Vide Dr. Rush's account of the bilious remitting yellow fever, as it appeared in the city of Philadelphia in the year 1793. Alſo Vol. II. page 174, where the hiſtory of this fever is given, and its *relation* to the *ſtate* of the *atmoſphere* is ſet forth.

fever, I anticipated all the numerous and complicated diftreffes in our city, which peftilential difeafes have fo often produced in other countries. The fever had a malignity, and an obftinacy which I had never before obferved in any difeafe, and it fpread with a rapidity and mortality, far beyond what it did in the year 1762. Neverthelefs I did not abandon a hope that the difeafe was curable, for I had long believed that good was commenfurate with evil, and that there does not exift a malady, but would yield to our knowledge of the laws of the animal œconomy. Under the impreffion of this belief, I applied myfelf with frefh ardour to the inveftigation of the prefent difeafe. I ranfacked my library, and pored over every book that treated of the yellow fever. The refult of my refearches for a while were fruitlefs. The accounts of the fymptoms and cure of the difeafe, by the authors I confulted, were contradictory and uncertain. Before I defifted from the inquiry to which I had devoted myfelf, I recollected that I had, among fome old papers, a MS. account of the yellow fever as it prevailed in Virginia in the year 1741, which had been put into my hands by Dr. FRANKLIN, a very fhort time before his death.

I had

I had read it formerly, and made extracts from it. I now read it a fecond time. I paufed upon every fentence; even words in fome places arrefted and fixed my attention. In reading the hiftory of the effects of different modes of treatment, I was much ftruck with the following paffages.

" It muft be carefully noted, that *evacuations* are " more neceffary in the yellow fever, than even in " the inflammatory. The abdominal vifcera are the " parts principally affected in this difeafe,—and by " this timely evacuation, their feculent, corruptible, " and irritating contents are difcharged before they " overpower the whole conftitution. They always " require fome *evacuation* to bring them to a perfect " crifis. Where the primæ viæ, but efpecially the " ftomach, is loaded with the poifon of the conta- " gion, and convulfed with the irritation of this fti- " mulus, there is no procuring a defirable fweat, " until this is removed. Alfo by *evacuating* the " bowels, the feeds of the difeafe, which is mixed " with the bilious and inguiline matters in the in- " teftinal canal is nipped in its birth, and a breathing " fweat then breaks out of its own accord: I can " affirm, that I have often given *evacuants*, when

" the pulſe has been ſo low that it could be hardly " felt, and the debility extreme, yet both one and " the other have been reſtored by it."

In my attendance upon the military hoſpitals during the late war, I had often ſeen, continues Dr. Ruſh, calomel combined with jalap adminiſtered in the bilious autumnal fever by Dr. YOUNG. His uſual doſe was ten grains of each of them. This was given once or twice a-day, until it procured large evacuations from the bowels. It was adopted by ſeveral of the ſurgeons of the hoſpitals, and was univerſally known, and ſometimes preſcribed, by the ſimple name of *ten* and *ten*. I reſolved therefore, after mature deliberation, to preſcribe this purge in the preſent fever. Finding ten grains of jalap inſufficient to carry the calomel through the bowels in the rapid manner I wiſhed, I added fifteen grains of the former to ten of the latter. I then iſſued three doſes, each conſiſting of fifteen grains of jalap, and ten of calomel; one to be given every ſix hours until they procured four or five large evacuations. The effect of this powder not only anſwered, but far exceeded my moſt ſanguine expectations. It perfectly cured four out of the firſt five patients to whom I gave it, not-

withſtanding

withſtanding ſome of them were advanced ſeveral days in the diſorder! Mr. Richard Spain, a block-maker, in Third-ſtreet, took eighty grains of calomel, or rather more, with rhubarb and jalap mixed with it, on the laſt day of Auguſt, and on the firſt day of September. He had paſſed twelve hours, before I began to give him this medicine, without a pulſe, and with a cold ſweat on all his limbs. His relations had given him over, and one of his neighbours complained to me, of my not adviſing them to make preparation for his funeral. But in this awful ſituation I neverthelefs gave them hopes. My medicine operated well. His pulſe immediately roſe, and an univerſal moiſture on his ſkin ſucceeded the cold ſweats on his limbs. In a few days he was out of danger, and he now lives in good health, as the firſt fruits of the efficacy of *mercurial purges* in the yellow fever. After ſuch a pledge of the ſafety and ſucceſs of my new medicine, I gave it afterwards with confidence. I imparted the preſcription to the college of phyſicians on the third of September, and endeavoured to remove the fears of my fellow citizens, by aſſuring them that the diſeaſe was no longer *incurable*. Mr. Lewis, Dr. M'Ilvaine, Mrs. Bethel, her two fons, and a fervant-maid, and Mr. Baynton's whole family, nine in number, were fome of the firft trophies of this *new* remedy. The credit it acquired brought me an immenfe acceffion of bufinefs. It was uniformly effectual in all whom I attended, either in my own perfon, or by my pupils. Dr. GRIFFITH, Dr. SAY, Dr. PENNINGTON, and my former pupils who were fettled in the city, Drs. LEIB, PORTER, ANNAN, WOODHOUSE, and MEAR, were among the firft phyficians who adopted it. In my note-book I put down, "Thank God! "out of one hundred patients, whom I have vifited, or prefcribed for, this day, I have loft *none*;" nor fhall I ever forget the tranfport with which Dr. PENNINGTON ran acrofs the ftreet to inform me, a few days after he began to give ftrong purges, that the difeafe yielded in every inftance.—But I did not rely on purging alone to cure the difeafe. Conceiving it to depend upon a morbid *ftimulus* acting upon and overpowering the fyftem, I was led to ufe thofe remedies which we know abftract ftimuli in general. Thefe were blood-letting, cool air, cold, watery, and fub-acid drinks, low diet, and the application of cold water to the body. My fuccefs with

8 this

this practice was beyond meafure great, never before did I experience fuch fublime joy. It repaid me for all the toils and ftudies of my life: and the conqueft of this difeafe was not the effect of accident, nor of the application of a fingle remedy; but it was the triumph of a PRINCIPLE in *Medicine!*

" During the courfe of my extenfive practice, the " exhibition of calomel purges produces frequently " *falivation.* By this accidental effect of mercury I " was taught to adminifter it with other views, than " merely to cleanfe the bowels, and with a fuccefs " which added much to my confidence in the power " that this medicine has over the difeafe *. I began " by prefcribing the calomel in fmall dofes, at fhort " intervals, and afterwards I directed large quantities " of the ointment to be rubbed upon the limbs. The " effects of it, in every cafe where the mouth was af- " fected, was very falutary and fpeedy, and even fe- " veral perfons appeared to be benefited by the mer- " cury introduced in the fyftem in the form of an " ointment, where it did not produce falivation. In

* Vide Vol. III. page 650, where mercury is fhewn to be a cure of *hydrophobia*, and hereafter it may be found to be the fovereign antidote againft all other animal and moft vegetable poifons.

" the

" the loweſt ſtage of the fever I ordered, in one caſe, " an ounce of mercurial ointment to be rubbed in. " The next day the gentleman complained of a ſore " mouth, and in the courſe of twenty-four hours he " was in a moderate ſalivation. From this time, his " pulſe became full and ſlow, and his ſkin moiſt. His " ſleep and appetite ſuddenly returned, and in a day or " two he was out of danger. Dr. WOODHOUSE im- " proved upon Dr. RUSH's method of exciting ſaliva- " tion, by rubbing the gums and inſide of the cheeks " with calomel, in the manner directed by Mr. *Clare*, " and it was obſerved to be more ſpeedy in its opera- " tion this way, and equally ſucceſsful."

Dr. Wood's diſcovery.

LVIII. Since the diſcovery, that mercurial oxyds (mercury combined with OXYGEN) is of great efficacy in the cure of putrid fever, another remedy has been much recommended by Dr. WOOD. " From " the accurate obſervations, which have been lately " made," ſays this ingenious phyſician, " on the effects " of VITAL AIR on the blood, both in the ſtate " of circulation, and when drawn from a vein, and " allowed to cool; from the difference of colour of " the returning blood, with that which has juſt paſſ-

ed

" ed through the lungs; and from our knowledge, " that the red globules are oxydes; and from the " ſimilar appearance, which the blood, in a perſon " labouring under typhus, has with the returning " venous blood; and from the anxiety of reſpiration, " which they who labour under typhus fever always " diſcover,—we can have little doubt, I think, for " ſuppoſing that the deficiency of OXYGEN is the " cauſe of the ſymptoms of typhus, the principal of " which are, beſides thoſe above mentioned, uni- " verſal debility, and a rapid tendency to a putreſcent " ſtate. Hence we may conclude that OXYGEN " is the general and only corrector of this ſtate, that " it is the grand antiſeptic of nature, and therefore " with the decreaſe of OXYGEN, will increaſe " the tendency to putrefaction, and with the in- " creaſe of the tendency to putrefaction, will the " *irritability* be exhauſted, and ſymptoms of *debility*, " in both body and mind, be progreſſively evident. " The proximate cauſe of typhus fever can therefore " only be removed, as muſt appear from what has " preceded, by the application of OXYGEN in a " ſufficient quantity to correct this deficiency, and " to reſtore the ſtate of equilibrium. OXYGEN

taken

" taken into the ſtomach in the combined ſtate of
" many different *acids**, may anſwer this intention;
" but in the ſtate of *nitre*† it ſeems to me the moſt
" powerful form of exhibiting it; the proceſs for
" obtaining OXYGEN in the ſtate of *gas*, in order
" to throw it into the ſyſtem by the lungs, is not
" only tedious but difficult. In the ſtate, therefore,
" of combination with *nitre*, it appears to me at pre-
" ſent the moſt effectual mode of throwing it into
" the ſyſtem. I have lately, continues Dr. Wood,
" exhibited *nitre* to more than fifty patients labouring
" under typhus; many of whom, when I ſaw them,
" had all the ſymptoms of this diſeaſe in a moſt vio-
" lent degree. I did not give any previous antimo-
" nial; but I exhibited immediately the ſolution of
" *nitre*. In ſome of the patients, the pulſe which
" was from 100 to 130 was diminiſhed in fre-
" quency, and increaſed in ſtrength, before the expi-

* The yellow fever prevailed at the Caraccos, in South America, in October 1793, with great mortality. Nearly all died who were attended by phyſicians. Recourſe was finally had to an old woman. Her remedy was a liquor called narcncado, a ſpecies of *lemonade*. With this ſhe drenched her patients for the firſt two or three days. It induced plentiful ſweats, and probably, after correcting, diſcharged the acrimony of the bowels.—Dr. Rush.

† Vide Vol. I. page 44.

ration

"ration of the firft 24 hours; the change, indeed,
"was often fo great and fudden, that I could fcarcely
"credit my own fenfes, until repeated experience
"ftampt the firmeft conviction upon my mind.
"Previous to the practice which I now purfue, I
"never vifited in typhus, without experiencing fome
"of thofe feelings, which the phyfician is obliged to
"fuffer, who expects an unfuccefsful iffue; but now
"I have no fears, and I truft that one of the moft
"crowded avenues to the grave is at length clofed,
"and, judging from the rapid progrefs acquired in the
"knowledge of philofophy and medicine within a
"very few late years, I may venture to predict,
"that, by fimilar attempts, every difeafe, whofe
"nature is at prefent obfcure, will be at laft clearly
"explained, and the profeffors of medicine be finally
"in poffeffion of the *ne plus ultra* of their fcience."

LIX. In thefe trials the *vital principle* was attempted to be reftored as faft as it was confumed by the exceffive ftimulus of the contagious matter taken into the fyftem, and producing the putrid fever, or this ftimulus was attempted to be evacuated; but this enlightened age has alfo produced another philo- *Rev. Mr. Cartwright's difcovery.*

 fophical

ſophical method, namely, its *correction.* " Seven-
" teen years ago I went," ſays the Rev. Mr. Cartwright, " to reſide at Brampton, a very populous
" village near Cheſterfield. I had not been there
" many months before a putrid fever broke out
" among us. Finding by far the greater number of
" my new pariſhioners much too poor to afford
" themſelves medical aſſiſtance, I undertook, by the
" help of ſuch books on the ſubject of medicine as
" were in my poſſeſſion, to preſcribe for them. I
" early attended a boy about fourteen years of age,
" who was attacked by this fever. He had not been
" ill many days before the ſymptoms were unequivo-
" cally putrid. I then adminiſtered bark, wine, and
" ſuch other remedies as my books directed. My
" exertions however were of no avail; his diſorder
" grew every day more untractable and malignant,
" ſo that I was in hourly expectation of his diſſolu-
" tion. Being under the abſolute neceſſity of taking
" a journey, before I ſet off I went to ſee him, as I
" thought for the laſt time, and I prepared his pa-
" rents for the event of his death, which I conſidered
" as inevitable, and reconciled them in the beſt
" manner I was able, to a loſs which I knew they
" would

" would feel feverely. While I was in converfation " on this diftreffing fubject with his mother, I ob- " ferved in a corner of a room a fmall tub of wort " working. The fight brought to my recollection " an experiment I had fomewhere met with, *of a* " *piece of putrid meat being made fweet by being* " *fufpended over a tub of wort in the act of fermenta-* " *tion.* The idea inftantly *flafhed* into my mind " that the *yeaft* might correct the putrid nature of " this difeafe, and I inftantly gave him two large " fpoonfuls. I then told the mother, if fhe found " her fon better, to repeat this dofe every three " hours. I then fet out for my journey. Upon my " return after a few days I anxioufly enquired about " the boy, and was informed he was recovered. I " could not reprefs my curiofity, though I was " greatly fatigued with my journey, and night was " come on; I went directly to where he lived, which " was three miles off in a wild part of the moors. " The boy himfelf opened the door, looked fur- " prifingly well, and told me he felt better from the " inftant he took the yeaft.

" After I left Brampton I lived in Leicefterfhire. " My parifhioners being there few and opulent I

" dropped my medical character entirely, and would " not even prefcribe for any of my own family. " One of my domeftics falling ill, accordingly the " apothecary was fent for. His complaint was a " violent fever, which in its progrefs became putrid. " Having great reliance, and defervedly, on the " apothecary's penetration and judgment, the man " was left folely to his management. His diforder " however kept daily gaining ground, till at length " the apothecary confidered him in very great danger. " At laft, finding every effort to be of fervice to him " baffled, he told me he confidered it as a loft cafe, " and that, in his opinion, the man could not fur- " vive four and twenty hours. On the apothecary " thus giving him up, I determined to try the effects " of *yeaft*. I gave him two large table fpoonsful. " In fifteen minutes from taking the yeaft his pulfe, " though ftill feeble, began to get compofed and full. " He, in thirty-two minutes from his taking the " yeaft, was able to get up from his bed, and walk " in his room. At the expiration of the fecond " hour, I gave him a bafon of fago, with a good " deal of *lemon*, wine, and ginger in it; he eat it " with an appetite: in another hour I repeated the

" yeaft:

" yeaſt: an hour afterwards I gave the bark as be-
" fore: at the next hour he had food: next he had
" another doſe of yeaſt, and then went to bed, it was
" nine o'clock. I went to ſee him the next morning
" at ſix o'clock; he told me he had a good night,
" and was recovered. I however repeated the medi-
" cine, and he was able to go about his buſineſs as
" uſual.

" About a year after this, as I was riding paſt a
" detached farm-houſe at the out-ſkirts of the village,
" I obſerved a farmer's daughter ſtanding at the door,
" apparently in great affliction. On enquiring into
" the cauſe of her diſtreſs, ſhe told me her father
" was dying. I diſmounted and went into the houſe
" to ſee him. I found him in the laſt ſtage of a
" putrid fever; his tongue was black; his pulſe was
" ſcarcely perceptible; and he lay ſtretched out, like
" a corpſe, in a ſtate of drowſy inſenſibility. I im-
" mediately procured ſome *yeaſt*, which I diluted
" with water, and poured it down his throat. I then
" left him with little hopes of recovery. I returned
" to him in about two hours, and found him ſenſible
" and able to converſe. I then gave him a doſe of
" bark. He afterwards took at a proper interval ſome
" refreſhment.

"refreſhment. I ſtaid with him till he repeated the "yeaſt, and then left him with directions how to "proceed. I called upon him the next morning at "nine o'clock. I found him apparently well, walk-"ing in his garden. He was an old man, upwards "of ſeventy.

"I have ſince adminiſtered the yeaſt to above fifty "perſons labouring under putrid fever, and what is "ſingular, continues this benevolent clergyman, I "have not loſt one patient."

Dr. Thornton's practice in putrid fever.

LX. Another method of cure, combining all the three foregoing, is that adopted by Dr. Thornton, and recorded by the Rev. Mr. Townsend in *the Guide to Health* *. Dr. Thornton conſiders the contagious matter, productive of putrid fever, as a violent ſtimulus, which reſembles the operation of wine † or opium ‡, firſt increaſing the action of the heart

* This admirable popular work treats of *the ſymptoms and nature of diſeaſes, and their cure*; and is compriſed in two volumes octavo.

† I once ſaw an inſtance, ſays Dr. Beddoes, in which I could not doubt that complete *intoxication* was produced by the contagion of typhus, to which the perſon had been much expoſed. One morning, immediately upon riſing, and I knew he had drank nothing the night before, I was aſtoniſhed to obſerve that flighty vivacity and diſpoſition to wild disjointed talk,

heart and arteries, and after a few days, having worn down the excitability, the fthenic diathefis is fucceeded by the afthenic or putrid. He therefore advifes to *expel* this morbid and exceffive ftimulus by evacuations *; fecondly, to *correct* this ftimulus, which may be accomplifhed by antifeptics †; and thirdly, to *fupply the principle of irritability*, which may be done by oxyds, or the inhalation of factitious vital air.

" When my phyfician, Dr. THORNTON," fays the Rev. Mr. *Townfend*, " who had recovered me, " when in the worft ftage of a putrid fever, was re- " turned to town, he was called in for his advice,

talk, together with the other figns which infallibly denote a certain degree of intoxication, efpecially when you are well acquainted beforehand with the manners of the party. In the courfe of the day, during which I faw him frequently, he became heavy, had febrile fhiverings, and complained of head-ach. The next day he became more feverifh, but was not confined till the fifth day, though the head-ach and other fymptoms never quitted him. He then paffed into putrid fever, which continued until the 21ft day, when he recovered. Does not the alkaline urine in fuch perfons denote, continues Dr. BEDDOES, a deficiency of the oxygen?

‡ Vide Vol. III. page 625. Sect. LII. *Of Afphyxia from opium.*

* During the late war in America an *emetic* feldom failed of preventing an attack of putrid fever when given in its forming ftage. Vide RUSH *on the Yellow Fever*, page 336.

† Chiefly fuch as impart *fixed air.*

" respecting two children labouring under the same " species of fever. As the eldest child appeared to " be in the greatest danger, with a becoming diffi- " dence of a *new practice* *, he desired the father to " allow him to accept her only as his patient, and " that the apothecary should go on with the young- " est. He gave instantly an emetic of tartarized an- " timony and ipecacuanha; and after the operation " was fully over, and a litle nourishment got down, " he followed it up with rhubarb and tartarized kali, " supporting the patient at intervals with wine. " When the bowels were clear he ordered at regular " intervals an infusion of bark in port wine impreg- " nated with FIXED AIR, and her drink was wa- " ter acidulated with FIXED AIR and tamarinds. " Mild cathartics were exhibited each night, and the " antiseptic remedies were lessened, and his patient " inhaled air blended with factitious VITAL AIR. " Dr. THORNTON then went into the country to " see some particular friends, and on his return he " hastened to visit these children. He found his " little patient in perfect health and blooming; but

* *Evacuations* in putrid fever. This practice was followed previous to the appearance of the *yellow fever* in America. Vide the Letters of Dr. THORNTON, &c. to Dr. BEDDOES.

" the

" the ſituation of the other child was far different.
" As he entered the houſe, the father informed him,
" that his child was at the point of death, and all he
" could hope from him now was, in ſome degree to
" palliate her ſufferings. For three days and as many
" nights every thing taken into her ſtomach had been
" rejected. During this time ſhe had had no ſleep.
" When Dr. THORNTON entered the room ſhe had
" been juſt convulſed, was ſpeechleſs, and gaſping
" for breath. Her eyes were fixed and ſunk, and
" ſurrounded with a circle of a darkiſh colour. The
" muſcles of the face ſtill quivered. He immediate-
" ly opened the window, for the room had but one,
" and ordered the fire to be put out. The room was
" then darkened, and filled with fine ſprays of *vinegar*,
" which, by abſorbing the heat of the room, cooled
" the chamber, and became aeriform, when, to the
" great ſurpriſe and ſatisfaction of the perſons who
" were preſent, ſhe revived, and her ſpeech, after a
" few minutes, returned to her. As ſhe ſeemed ex-
" hauſted for want of food, Dr. THORNTON order-
" ed her the white of an egg, which of all nutritious
" ſubſtances he judged the leaſt ſubject to putrefac-

"tion, mixing it with white wine, warm water, "cinnamon, and *lemon juice*; he gave her very "ſmall quantities at a time, and finding it remained, "he ſoon after tried bark and red wine, which was "impregnated with FIXED AIR, directing the "ſame manner of adminiſtration, namely, to ſtop "whenever the ſmalleſt inclination to vomit-"ing came on. She had water impregnated with "FIXED AIR to drink, and was recovering faſt "under this treatment, when ſome officious ignorant "nurſe interfered, and the fire was renewed in the "apartment, and the child was loaded with flannels; "in conſequence of which ſhe was again ſeized with "ſimilar convulſions, and became ſpeechleſs: but "in leſs than five minutes ſhe was reſtored as before "by breathing a *ſuperoxygenated air*. In the courſe "of a few days, from the evacuant, antiſeptic, and "tonic treatment, ſhe was out of danger, and able "to leave her bed."

LXI. We ſhall not detain the reader with any fuller detail concerning putrid fever, as the ſubject will

be

be again refumed *, but fhall haften briefly to relate the new trials which have been lately made in *fcurvy*. From the refemblance of the blood taken from the arm with that of a perfon labouring under a putrid fever (for the blood does not, or very feebly coagulates), from the fallownefs of the countenance,—the black and blue fpots fuffufed over the furface,—the coldnefs of the body,—&c. the illuftrious Dr. BEDDOES firft conjectured that in *fcurvy* there was a deficiency of OXYGEN in the blood, and fuggefted a plan of treatment according to this theory †. Soon after, a practical treatife ‡ appeared, written by Dr. TROTTER. "It is our duty," fays this learned and humane phyfician, "to draw philofophy from the

Of fcurvy.

Dr. Beddoes's hypothefis

firft realized by Dr. Trotter.

* We fhall then do juftice to the *difcovery* of Sir William FORDYCE, and relate the extraordinary recovery of the fon of Lord BUTE, by means of the MURIATIC ACID, which from the hurry of writing was omitted; and we fhall then likewife confider the practice of Dr. JAMES, and enter fully into the merits of his juftly celebrated powder.

† Vide *Obfervations on the Nature and Cure of Calculus, Sea Scurvy, Confumption, Catarrh, and Fever*; by Thomas BEDDOES, M. D.

‡ *Medical and Chemical Effays: containing obfervations on fcurvy; communications from South Wales; the cafe of a blue boy; and thoughts on the chemical nature and decompofition of water, with a certain method of preferving it pure and fweet in long voyages.* By THOMAS TROTTER, M. D. Phyfician to his Majefty's Fleet under the command of Admiral Richard Earl Howe.

 "laboratory

" laboratory of the chemift, and make her fubfervient " to the practical purpofes of life. Whilft I had the " advantage of collecting facts on the fubject of " fcurvy, Dr. BEDDOES had fuperior advantages to " me, in improving and extending the doctrine " which I had adopted. A fituation infinitely more " favourable to philofophical retirement, a know- " ledge of chemiftry inferior to none in our age, a " love for the ftudy, and a defire to reduce it in " practice, to the relief of his fellow-creatures, have " brought us to an æra in the hiftory of medicine, " that has unfolded to our view, fecrets of nature, " on which our predeceffors in fcience were not even " able to form a plaufible conjecture. In February " 1793, I was removed," fays Dr. TROTTER, " from the Centurian to the Vengeance of 74 guns, " then at Spithead, and fitting to receive the broad " pendant of Commodore Charles Thomfon, now " Rear Admiral; and intended for the Leeward " Ifland ftation. The work * of Dr. BEDDOES was " at this time put into my hands. The company of " the Vengeance had a quart of cocoa a man, with

* *Obfervations on Calculus, Sea Scurvy*, &c. Vide note, page lxxxvii.

 " fugar

" fugar enough to fweeten it, for breakfaft, in lieu " of oatmeal, butter, and cheefe. They had for " dinner excellent falt meat. Yet fcurvy was not " prevented from making its inroad. The officers of " this fhip, who at firft had always plentifully fhared " their frefh ftock with the fick, could in the prefent " inftance afford them no affiftance, for they had " but a very fmall ftore on board, not fufficient to " laft them a third of the prefent voyage. Many " perfons were in confequence violently afflicted with " fea-fcurvy.

" Robert Bell, aged thirty, was a feaman, and " impreffed: his fymptoms of fcurvy were fpungy " gums, hardened and contracted hams, livid fpots " on the thighs and legs, very much depreffed in " fpirits, and apprehenfive. He was ordered vitrio- " lic acid diluted in water, in as great a quantity as " his ftomach and bowels would bear without pain. " For the firft two or three days Bell had better " fpirits and looked more lively; but the benefit did " not continue, for he grew much worfe at the end of " a week. It was then changed for juice of LIMES, " which in a few days effectually cured him. The " effect of LIME JUICE, as I have had many occa- " fions

Dr. Trotter's difcovery.

" ſions ſince to obſerve, was apparent always in leſs
" than twenty-four hours. Five caſes of nearly the
" ſame deſcription followed the above; and the reſult
" was uniformly the ſame. In the fond attachment
" to the philoſophy of phyſic, and the enthuſiaſm of
" ſcientific enquiry, one may be ſometimes betrayed
" into fallacious concluſions. But diveſting myſelf of
" all partiality for a favourite opinion, I can have no
" doubt," continues Dr. TROTTER, "that the good
" effects of the CITRIC ACID in the cure of *ſcurvy*,
" are entirely owing to its imparting OXYGEN to
" the blood, however difficult it is to reconcile it
" with the want of efficacy in the other acid in curing
" this diſeaſe."

" In December, 1793, I was appointed phy-
" ſician to the royal hoſpital at Haſlar, Portſmouth.
" This hoſpital is attended by two phyſicians. The
" ſouth ſide fell to the lot of Dr. John LIND, and
" the north to me. The firſt patient in ſcurvy, who
" came under my care, was John Driver, belonging
" to the Queen Charlotte, the flag ſhip of Earl
" Howe. His ſymptoms were inveterate, and the
" hams ſo contracted that he could not walk. He
" was by the aſſiſtant diſpenſer put on the *vinum an-*

" *tiſcorbuticum*

" *tiſcorbuticum* of the hoſpital, the ſame as preſcribed
" by Lind ſenior. At the time I viſited him, he
" had taken his medicine for two days, and was on a
" diet of mutton and greens; yet he found himſelf
" worſe. He was immediately ordered two ounces of
" the citric acid three times a day. On calling to
" ſee him next morning, I found him ſtill worſe,
" and ordered him two ounces of the ſame acid four
" times a day. On the day following, I was yet
" more ſurpriſed, that his complaints were not be-
" ginning to yield. He was now yellow or livid all
" over, and his pains at night tormenting. The
" nurſe and other people in the ward aſſured me that
" his medicine was faithfully taken. From this I
" was led to examine the bottle at the head of his
" bed, where, inſtead of *lime juice*, it was the *di-*
" *luted ſulphuric acid.* There were, it appeared,
" no lime juice in the diſpenſary, and the *ſucceda-*
" *neum* had nearly coſt the man his life. I now ſup-
" plied him with ſixteen ounces of the citric acid,
" concentrated by congelation. With this prepara-
" tion he recovered in a few days; and was ſoon after
" diſcharged to his ſhip."

LXII. " While

Mr. Patterson's discovery.

LXII. " While a surgeon in the royal navy, I " have, oftener than once, had occasion," says Mr. Patterson, " to lament the limited power of me- " dicine, and in no particular instance more than in " scurvy. In various stations, and in opposite cli- " mates, I have had frequent opportunity of ob- " serving this disease, in all its variety; and, at " times, obliged to witness it, in all its hideous " shapes, without having it in my power to put a " stop to its destructive career. Such scenes as these " are well calculated to make a medical man atten- " tive. I could not fail to observe the great desire " that scorbutic patients have for *acids*. People, la- " bouring under this disease, have been known to " use, in the way of drink, and in seasoning their " food, one pint of vinegar in the course of the day, " and with impunity. One patient drank during " a night a whole quart, without any painful or " disagreeable symptoms supervening. Having seen

* Vide *A Treatise on the Scurvy: containing a new, easy, and effectual, method of curing that disease; the cause, and indications of cure, deduced from practice; and observations connected with the subject; with an Appendix consisting of five letters, respecting the success of a new antiscorbutic medicine.* By Mr. Patterson, Surgeon in the Royal Navy.

" the

"the good effects of *nitre* (nitrous acid combined
"with alkali) in feveral cafes of fcurvy, and kowing,
"from the difcovery in chemiftry, that it contained
"a vaft quantity of the *acidifying principle*, or VI-
"TAL AIR, I was led to make a folution of this
"falt in *vinegar*. Before I adminiftered this new
"remedy, I made the following experiments out of
"the body. I took the blood from a patient in
"fcurvy, and from a man in health, and having cut
"off the florid furface of the coagulum, I poured
"fome diluted *vitriolic acid* on the dark coloured
"coagulum, and it affumed a *blacker* appearance in
"both cups. On the contrary, when I poured this
"folution of *nitre* in *vinegar*, the colour of the coa-
"gulum was immediately changed to a beautiful *red*,
"more bright than even arterial blood, it even turn-
"ed to a bright *red* that dark coagulum which the
"diluted vitriolic acid had nearly rendered black.
"Upon the firft favourable occafion, I was refolved
"to try this folution, and I had foon occafion to put
"it to the teft of experiment; and with inexpreffible
"pleafure I found it, in a vaft variety of cafes, fuc-
"ceed beyond my moft fanguine expectation. By
"means of the *nitrous vinegar*, the belly, in general,

" is kept gently lax; the difcharge of urine is in-
" creafed, and changes from an alkaline to a healthy
" nature; the fkin becomes open, and more agree-
" able to the touch; the chillinefs is changed to a
" pleafing warmth; and the pulfe acquires fteadinefs
" and healthy ftrength. Sleep comes to be more
" natural. The fallow and the gloomy countenance
" is gradually changed into the cheerful. The gums
" heal and grow firm. The lower extremities lofe
" fafter than could be fuppofed their livid hue; they
" gradually become fofter, lefs painful, and more
" flexible; and ulcers put on an healthy appearance,
" and foon fkin over. The great oppreffion about
" the breaft gives way; and the cough and breathing
" become lefs laborious. The appetite and the fenfe
" of tafte is reftored. The depreffion of fpirits and
" the laffitude are forgot. The ftrength increafes;
" and, at laft, health is re-eftablifhed. In the month
" of July 1794, I made comparative trials with this
" folution, and the juice of *limes*, and after having
" duly weighed all circumftances, I am inclined to
" decide in favour of the former; one advantage,
" however, it certainly poffeffes over the latter, as it
" confifts of articles which may at all times, and
" with

" with very little expence, be obtained, and without " difficulty preferved; in fhort, it is the *defideratum* " which Dr. BEDDOES has attempted to eftablifh."

LXIII. We are now arrived at the moft brilliant æra in phyfic, The different factitious airs were foon after tried at the Hotel Dieu in Paris, many of which proved fuccefsful, but fome turning out inaufpicious *, and the revolution fucceeding, with the tyranny of ROBIESPIERRE, who put to death LAVOISIER, and many other literary characters, a veil was drawn over this new branch of fcience for a time, but as FOURCROY juftly obferves, " the " analogy of action which has been difcovered be- " tween digeftion, refpiration, circulation, and in- " fenfible perfpiration, has begun to eftablifh on " new views, more folid than were heretofore pof- " feffed, *a fyftem of* ANIMAL PHYSICS, which pro- " mife an abundant harveft of difcoveries and im- " provements. Unqueftionably it will be, in pur- " fuing the chemical changes that are undergone in " the fyftem, that an EDIFICE equally *novel* and *folid*

* The trial of vital air in confumption. For a remark on this, confult Vol. III. p. 655, note †.

"will be erected. Every thing is ready for this "ground-work; feveral philofophers purfue this un- "beaten path of experience; frefh ardour, fpringing "from thefe new conceptions, animates thofe who "are engaged in this branch of phyfics; and the "track they have juft begun to explore appears fuch "as muft lead them to more precious and accurate "refults, than any that have hitherto been advanced "on the functions which conftitute animal life."

Dr. Beddoes. LXIV. Whilft the progrefs of the pneumatic practice of phyfic was ftopped in France by the revolution, Dr. BEDDOES, the celebrated profeffor of chemiftry at Oxford, endeavoured to turn the attention of the faculty in *England* to this new branch of fcience. His works foon paffed into the hands of every one: for he poffeffed the rare art of diffufing through his writings that lively intereft, that enchanting colouring, and that delicate and vigorous touch, which influence, attach, and fubdue the mind. The profundity of his reafoning is every where united to all that agreeable imagery, which the moft brilliant imagination can furnifh. The facred fire of genius animates all his productions; his theories conftantly exhibit

exhibit the moſt ſublime proſpects in their totality, and the moſt perfect correſpondence in their parts; and even whilſt he raiſes *hypotheſes*, we are inclined to perſuade ourſelves that they are eſtabliſhed truths.

The higheſt commendation is certainly due to this ingenious philoſopher for his chemical inveſtigation of diſeaſes. The novelty of the attempt ſoon expoſed him to the malignity of ſome not equally well diſpoſed, and the ardour of purſuit was branded with the name of enthuſiaſm; but a virtuous mind, intent on a generous action, looks upon theſe as ſo many ſteps to diſtinction; for to be either very good or very great, is to be very much envied, and very much miſrepreſented. Even ſome who differed with this gentleman in political ſentiments ſided with the envious and intereſted againſt the *pneumatic remedies:* as monks formerly denied the Newtonian philoſophy, only becauſe NEWTON was a proteſtant. It is a great misfortune, ſays Dr. PRIESTLEY, "when "philoſophers forſake their purſuits of nature, which "are ever regular and uniform, to engage in the "confuſion of political conteſts."—And who is there but muſt regret the flight from this country of the author

author of this very remark, which ſome years ago he made to the illuſtrious FRANKLIN? And philoſophy droops her head; ſince LAVOISIER was guillotined........He requeſted but three days to finiſh an important experiment he had begun, and the ſtern tyrant* replied, "France has no need of "philoſophers; but of patriots;" and ordered him inſtantly to execution.—But Dr. BEDDOES may perhaps reply, "Homo ſum, et humani nihil a me "alienum puto,"—to which I confeſs I ſhould be at a loſs what to anſwer!—His theories of diſeaſes† will no doubt one day or other conſpire, with future diſcoveries in chemiſtry, to unravel the whole of their myſterious operations: and ingenious phyſicians, having learnt to manage their intricate and multifarious machinery, may ſee that art, which can reſt firmly upon no other foundation than a juſt theory of the functions of the body, riſing under their hands into a *beautiful* and *ſolid* STRUCTURE. Nor, however remote medicine may at preſent be from ſuch perfection, do I ſee any reaſon to doubt that, by taking advantage of various and continual acceſſions

* ROBIESPIERRE.

† Vide *Obſervations on the Nature and Cure of Calculus, Sea Scurvy, Putrid Fever*, &c.

as

as they accrue to ſcience, the ſame power will be acquired over living, as it is at preſent exerciſed over inanimate bodies; and that not only the cure and prevention of diſeaſes, but the art of protracting the faireſt ſeaſon of life, and rendering health more vigorous, will one day half realize the dream of alchemy.

The celebrated Dr. DARWIN, who has of late turned his attention much to this ſubject, obſerves, "that VITAL AIR penetrates the fine moiſt membranes of the air-veſſels of the lungs, and unites with the blood by chemical attraction, as is ſeen to happen, when blood is drawn into a baſon, for the lower ſurface of the craſſimentum is of a dark red ſo long as it is covered from the air by the upper ſurface, but becomes florid in a ſhort time on its being expoſed to the atmoſphere. The perpetual neceſſity of the mixture of VITAL AIR with the blood in the lungs, evinces that it muſt act as a ſtimulus to the ſanguiferous ſyſtem, as the motions of the heart and arteries preſently ceaſe, where animals are immerſed in air which poſſeſs no oxygen."—It may alſo ſubſequently anſwer another important purpoſe, as it probably affords the *Dr. Darwin.*

material

material for the production of the SENSORIAL POWER *; which is supposed to be secreted in the brain and medullary part of the nerves; and that the perpetual demand of this fluid in respiration is occasioned by the SENSORIAL POWER, which is supposed to be produced from it, being too subtle to be confined in any part of the system †.

Mr. Townsend.

The Rev. Mr. TOWNSEND, the learned author of *the Guide to Health*, observes, when speaking of the different FACTITIOUS AIRS, " that these pro-" mise, under the skilful management of Dr. BED-" DOES at the Hot Wells, Bristol, and Dr. THORN-" TON in London, to be a remedy well worthy the " attention of the medical practitioner. The VI-" TAL AIR, properly diluted with common air, " is a stimulus the most natural and diffusive. It " promotes the insensible perspiration, greatly aids " digestion, favours sleep, exhilarates the spirits, " and relieves difficult respiration. It is found of " the highest advantage in most nervous diseases. " The AZOTIC AIR abates inflammation, and is

* For an explanation of this term, vide Vol. III. page 461.

† Vide *Zoonomia, or the Laws of Organic Life*, Vol. II. A work which occupied, as this philosopher says, thirty years deep meditation.

" the

" the only remedy with the HYDROGEN AIR, " that is found capable of arreſting the progreſs of " conſumption, and the CARBONIC ACID AIR " is a moſt powerful antiſeptic."

The effects of the vital air when given in a properly diluted form as a remedy.

It being aſcertained by direct experiment, that the heart and arteries can be *raiſed** from 64 to 120 pulſations in a minute, by the inhalation of pure OXYGEN, or VITAL, AIR, and that by abſtracting this VITAL GAS from atmoſpheric air, their actions can be *leſſened*† from 120 to 64 beats in a minute, the PNEUMATO-CHEMICAL *phyſician* has therefore a complete power over the heart and arteries, juſt as a

* Although Mr. TAYLOR was not more than 22 years of age, his natural pulſe was only 64 previous to the experiment. During the inhalation of the pure OXYGEN AIR, his pulſe, as Dr. HIGGINS remarked, was quickened to 90 beats in a minute, and was conſiderably increaſed in *fulneſs* and *ſtrength*. The veſſel being immediately charged again with 19 pints of OXYGEN GAS, he reſpired theſe alſo, and conſumed them entirely in ſix minutes. His pulſe was in conſequence increaſed to 120 beats in a minute, and was *vigorous withal*. See *Minutes of the Society for Philoſophical Experiments*, p. 146. Alſo Dr. GOODWIN's Experiment, p. 79, and note *, p. 110.

† One conſumptive patient, contrary to my judgment, ſays Dr. BEDDOES, uſed to inhale at times air wholly deprived of *oxygen*. During this proceſs I have felt the pulſe nearly *obliterated*. He loved to indulge in it, and deſcribes the incipient inſenſibility produced on him as a ſtate highly delightful. Vide Dr. BEDDOES's *Obſervations*, p. 30.

watch-maker has a power over the movement of a watch by means of the regulator.

It being likewife proved, that the blood and folids are compofed in part of VITAL AIR, he has alfo the power of altering the *mafs of blood* *, and therefore of changing the conftitution. He poffeffes in the VITAL AIR a means of unlocking *obftructed veffels* †, promoting the *infenfible perfpiration* ‡, quickening the *digeftion* ‖, increafing the *animal heat* § and *mufcular powers* **, and of raifing the *fpirits* ††. He can render the *refpiration eafy* ‡‡, and give *bloom* ‖‖ to the complexion.

* Vide the celebrated Experiment of Dr. BEDDOES, which at the rifk of life he generoufly undertook in the caufe of humanity, and for the improvement of fcience. Vide Vol. II. p. 254.

† Vide Dr. BEDDOES's *Obfervations on the Medicinal Ufe of different Airs*, p. 44.

‡ Vide the *Phyfician's Vade Mecum*, by the Rev. J. TOWNSEND, p. 113.

‖ Vide Vol. I. Sect. VII. *On the Balance betwixt Digeftion and the Oxygenation of the Blood*, p. 88.

§ Vide Vol. I. Sect. VIII. *On Animal Heat*, p. 81.

** Vide Vol. I. Sect. XI. *On the Caufe of Voluntary Action*, p. 125.

†† Vide Vol. III. Sect. XXXIV. *On Oxygen as related to Senfibility*.

‡‡ Vide Vol. I. page 89, line 15. Alfo note *, p. 126.

‖‖ See *Minutes of Philofophic Experiments*, p. 169. Alfo Vol. II. p. 257.

The

The VITAL AIR in the form of *acid fumes* has been adminiſtered, as was before obſerved, in PUTRID FEVER by Dr. CARMICHAEL SMITH. It has been alſo ſuccefsfully inhaled, when diluted with atmoſpheric air, in the ſame dreadful calamity, under Dr. THORNTON. It has been in this way adminiſtered in HYDROCEPHALUS, HYDROTHORAX, and in ACITES, under Drs. BEDDOES, DARWIN, and THORNTON:—in ASTHMA and DYSPNŒA by Drs. BEDDOES, THORNTON, FERRIAR, and CARMICHAEL; in CHLOROSIS by Drs. THORNTON, CARMICHAEL, PEARSON, and ALDERSON; in HEAD-ACH by Drs. DARWIN and THORNTON; in HYSTERIA by Dr. THORNTON; in DYSPEPSIA by Dr. THORNTON; in HYPOCHONDRIASIS and MADNESS by Dr. THORNTON; in ULCERS OF THE LEG by Dr. THORNTON and Mr. HILL; in SCURVY and SYPHILITIC DISEASES by Dr. THORNTON and Mr. HILL; and laſtly, in PALSY, EPILEPSY, and AMAUROSIS, by Drs. BEDDOES, THORNTON, and PEARSON *.

The diſeaſes in which the vital air has been ſucceſſfully employed.
Putrid fever.
Dropſy of the brain, of the cheſt, and of the abdomen.
Aſthma and difficult reſpiration.
Green ſickneſs.
Head-ach.
Hyſteric fits.
Want of appetite.
Dejection of ſpirits.
Melancholy madneſs.
Ulcers.
Syphilis.
Palſy.
Epilepſy.
Loſs of Sight.

* Vide Dr. BEDDOES's *Conſiderations of the Medicinal Uſe of Factitious Airs*, the Rev. Mr. TOWNSEND's *Guide to Health*, and Dr. DARWIN's *Zoonomia*; where the reader will find theſe trials recorded.

Attention is undoubtedly not lefs due to the OTHER ELEMENTS of *organized bodies*; and if the importance of OXYGEN feems to have been chiefly infifted on in the foregoing obfervations, it is only becaufe we have very few facts which afford a foundation for reafoning concerning the connection of an excefs or deficiency of CARBON, HYDROGEN, or AZOT, with the functions of life: and yet much obfcurity and many difficulties muft be expected to remain, till we acquire the knowledge of fuch facts. Let us however fet a due value on our prefent knowledge, though it be imperfect; and reftrain thofe rude hands that are ever ready to pluck up the tender plants of fcience, becaufe they do not bear *ripe fruit* at a feafon when they can only be putting forth their bloffoms.

The difeafes in which the mephitic airs have been fuccefsfully employed.

Confumption.

Cancer.

The CARBONIC ACID AIR, or *fixed air*, has however been applied in PHTHISIS by Drs. PERCIVAL, WITHERING, BEDDOES, and EWART. It has been alfo employed by the latter phyficians in CANCER, whofe fœtor it corrects, and whofe torture it alleviates. The HYDROCARBONATE (which appears to be a mixture of *fixed*, and *inflam-*

mable,

mable, airs) has been applied in PHTHISIS by Drs. BEDDOES, ALDERSON, CARMICHAEL, FERRIAR, and THORNTON; in HÆMOPTOE by Drs. REDFEARN and THORNTON; and the HYDROGEN AIR (or *inflammable air*) has been applied in PHTHISIS by Drs. BEDDOES and THORNTON; in CATARRH by Drs. THORNTON, BEDDOES, and Mr. BARR; in CROUP by Dr. THORNTON; and in PLEURISY by Drs. BEDDOES, THORNTON, FERRIAR, and MACDONALD.

Confumption.

Spitting of blood.

Catarrh.

Croup.

Pleurify.

To conclude.—The pneumatic doctrine of phyfic has met with a welcome reception, not only among the learned of our own country, but in foreign parts. Dr. RUSH has endeavoured to apply it to the explanation of fome appearances exhibited in the late deftructive fever at Philadelphia. In other parts of *America* phyficians of the greateft celebrity have fpoken in favourable terms of this inveftigation. Dr. GARNET has gone out from this country, with an appointment of three hundred a year, to *North America*, as a profeffor of experimental and natural philofophy, and is deeply engaged in unfolding the nature of eruptive diſeaſes upon the new doctrines. In *India* this inveſtigation has proceeded with rapidity, and has been ably applied by Dr. Briggs in illuſtrating the cauſe of hepatic affections. At *Vienna*, where the ſubject was early introduced by a letter from Dr. Ingenhouz to Dr. Scherer, it has been warmly taken up. Above three hundred trials with the VITAL AIR have already been made there, and a premium for determining the medicinal effects of elaſtic fluids has been offered by one or more German academies. *Spain*, which can boaſt of medical men of the moſt enlarged views, has adopted meaſures ſtill more deciſive. The Engliſh tracts, in which the uſe of airs in medicine is recommended, have, I am informed, been tranſlated by order of government; and what is more to the purpoſe, I certainly know that a ſmall *pneumatic hoſpital* has been eſtabliſhed at Madrid. In *Pruſſia* it has been purſued by Dr. Acard. In *France*, when that infatuated people ſhall have conquered leiſure, it will be revived. In ſhort, the ANTI-PNEUMATISTS, if I may ſo denominate thoſe who are eager to ſtifle the enquiry, whatever be their *local vogue*, will principally be found among phyficians, neither *liberal* in *their conceptions*, nor *converfant in that great branch of natural philofophy, which unfolds the properties of* PERMANENTLY ELASTIC FLUIDS.

Mr. CLINE, the juftly admired lecturer on anatomy at St. Thomas's Hofpital, inftead of an introductory lecture, immediately enters upon his courfe, and defers this general account of the progrefs of the fcience, as a fummary, at the conclufion, when it can, as he fays, be better underftood: but we have here followed the plan of the late Dr. HUNTER, father of a no lefs illuftrious fchool, thinking that this preface may be read with *fome* advantage at the commencement; it muft infpire ardour, and command attention, in the reader, and may be *re-perufed* at any fubfequent time, fhould the indulgent reader confer on it that honour.

PART I.

A SUMMARY

OF THE

PNEUMATIC CHEMISTRY.

Other ages may have furpaffed the prefent in the greatnefs of fome fingle event, fuch as the rapid conqueft of half the globe by an Alexander or a Tamerlane. Neverthelefs, the age in which we live, feems to me, of all the periods in hiftory, the moft diftinguifhed for the fudden and extenfive impulfe which the human mind has received, and which has extended its active influence to every object of human purfuit. The diffufion of a general knowledge, and of a tafte for fcience, over all claffes of men, in every nation of Europe, or of European origin, feems to be the characteriftic feature of the *prefent age*. The ftudy of the fciences principally has expanded the mind, and laid it open for the reception of every kind of truth. Some individuals of rare genius in former times may perhaps feem to excel thofe of the prefent day; although in juftice to thefe, it fhould be remembered that luminous bodies fhine brighteft in obfcurity. But in no former age, was ever the light of knowledge *fo extended*, and fo *generally diffufed*. Knowledge is not now confined to public fchools, or to particular claffes of men. It is not at this day, that fome celebrated and immenfely learned profeffor delivers from his academic chair dictates to his auditors, who prefs from all quarters to catch the oracular founds, and afterwards to revibrate his ipfe dixits. In *this age*, the flame that paffes over all, kindles the fparks of genius wherever they may happen to lurk, and every man forms an opinion for himfelf.

Keir.

*P 2

INTRODUCTION.

OF THE ATTRACTION WHICH TAKES PLACE BETWEEN BODIES OF THE SAME KIND, OR THE ATTRACTION OF COHESION.

PREVIOUS to our explaining the laws of *chemical attraction*, we ſhould firſt briefly contemplate the *attraction of gravitation*, or that power which draws bodies to the center of the earth. It is from this law that different bodies in the creation aſſume their proper ſtation, heavy bodies deſcend, and light ones aſcend; by this, projectiles are directed, vapours and exhalations riſe, and rains fall; by this, rivers glide, the air preſſes, and oceans ſwell. If we extend our mind, we ſhall perceive that this law alſo governs all the planetary worlds. Projected by the almighty FIAT, they would roll on through the infinitude of ſpace in ſtraight lines, but the central ſuns overcoming in part this power by *the law of* *of gravity*, hence each planet forms his own refpective circle: but *chemical attraction*, or the *attraction of cohefion*, we are about to confider, is that principle which joins and combines into little fyftems thofe feveral and diftinct corpufcules which form different fubftances. It is that *attractive force* by which they tend mutually towards each other; which force only exifts in the very point of clofe contact, at little diftances is lefs, and at a little further diftance is quite infenfible.

The *attraction of gravitation* acts only upon large bodies, and is always in proportion to their maffes; whereas *chemical attraction* affects only minute bodies, and has abfolutely no influence upon fuch as are of any confiderable bulk. *Gravitation* acts upon bodies placed at immenfe diftances from each other; whereas *chemical attraction* never acts but with bodies in mutual contact.

We fee then that thefe two attractive powers are different, and they are not natural to inert bodies, but a property implanted by the CREATOR no lefs confounding to the philofopher than that amazing property in animal bodies, which we denominate the life or foul.

This

This property of dead matter is of three kinds.

The firſt is where the integrant parts are united by a very conſiderable force, and forms the *hard* or *ſolid aggregate.* Thus two ſmooth plates of any metal placed in contact, will ſo firmly adhere as to ſupport many hundred pound. Thus the particles of a diamond are ſo cloſely united, as to make one of the hardeſt ſubſtances in nature. This genus comprehends many ſpecies from the hardneſs of rock-cryſtal to the yielding contexture of the ſofteſt wood.

The ſecond is called the *pliant*, or *ſoft*, or *fluid aggregate*, where the parts may be eaſily moved backwards and forwards ſo as to change their relative ſituation: as wax, putty, and water.

And third, the *aeriform*, or *gaſeous*, *aggregate*, the tenuity of whoſe integrant particles renders them imperceptible, and in which the attraction of coheſion is the leaſt poſſible.

Theſe *three ſtates* are however, properly ſpeaking, but *one* and the *ſame power*, and moſt probably owe their diſtinctive difference to *caloric* or *matter of heat*, which pervades all bodies. The better to determine our ideas relating to this ſubject, which has not hitherto

been

been fufficiently confidered, let us, for a moment, conceive what would take place in the various fubftances which compofe our earth, if its *temperature* were fuddenly altered. If, for inftance, we were tranfported into the region of the planet MERCURY, where probably the common temperature is much fuperior to that of boiling water. The rivers of the earth, and all the other fluids which are fufceptible of the gaffeous ftate, at the temperature near to that of boiling water, would become rarefied; and all thefe fubftances would be changed into permanent aeriform fluids or gaffes, which would become part of the new atmofphere.

By a contrary fuppofition to the one we have been forming, if the earth was fuddenly tranfported to where the GEORGIUM SIDUS is, or fome planet equally cold, the water which compofe our feas, rivers, and fprings, and probably the greater number of the fluids we are acquainted with, would be converted into folid mountains and hard rocks, at firft tranfparent and homogeneous, like rock cryftal, but which, in time, being mixed with different coloured earths, would form opake ftones of various colours. In this cafe the air would lofe its elafticity for want of a fufficient temperature to retain it in that ftate: it would return to the liquid ftate of ex-

iftence,

iſtence, and new liquids would be formed, of whoſe properties at this moment we have not the moſt diſtant idea.

Although theſe two hypotheſes may give a tolerable diſtinct idea of our poſition, that *ſolid*, *liquid*, and *aeriform aggregates* are only three different ſtates of exiſtence of the ſame matter, or three particular modifications, which almoſt all ſubſtances are ſuſceptible of aſſuming ſucceſſively, and which ſolely depend upon the degree of *temperature* to which they are expoſed; or upon the degree of *caloric* with which they are penetrated; yet as this opinion is the baſis of all chemical ſcience, I ſhall enter a little further into the conſideration of this very important ſubject.

GENERAL LAW RESPECTING HEAT.

I. ALL BODIES ARE EXPANDED BY HEAT.

1ſt. State of Expanſion.

As compariſons with ſenſible objects are of great uſe in aſſiſting us to form diſtinct notions of abſtract ideas, we ſhall endeavour to illuſtrate this poſition, by inſtancing the phænomena which takes place between

 water

water and bodies which are penetrated by it. If we put a loaf of bread into water, this fluid will gradually infinuate itfelf into its pores, and the bread is foon confiderably augmented both in weight and magnitude.—Or if we put a piece of wood into water, it will fwell by admitting the water into its fubftance.—Or if a dry fponge be dipped in water, the fponge fwells, its particles are feparated from each other, and all its intervals are filled up by the water. The fame circumftance undoubtedly takes place with regard to bodies which are immerfed in free Caloric *. Thus if you take an iron tube, which is filled up exactly by a rod, and heat this rod, it will be found too large for the tube, and will not enter it: and if you put it by the fide of the tube, you will find it alfo longer than the tube, which when cold it appeared fo exactly to fit. Its dimenfions are therefore *increafed* both in diameter and length. It is fo with rings on the finger. The ring which in health appeared exactly to fit, will drop off in the cold fit of an ague, and will be found on the contrary immoveable during the hot fit. It is upon this principle, that veffels and the wheels of carriages are bound with hoops heated red hot, and applied in this their expanded ftate, after which they

* Diftinguifhed thus from latent or combined heat.

pour cold water upon them, when the iron contracts with fuch force as to make a deep impreffion on the wood, and in this way the veffels are bound much fafter than they would be by any other means. It is alfo upon this principle that our *thermometers* are conftructed.

The Thermometer.

The firft invention of this curious and ufeful inftrument is fomewhat obfcure: but previous to the time of SANCTORIUS it does not appear that the expanfive power of heat was much obferved. SANCTORIUS's thermometer was a hollow glafs ball, with a long cylindrical tube attached to it, with a fmall opening at the top, and therefore containing a quantity of air, and in order to obferve the variation of the bulk, or elafticity which the air in the ball and tube underwent from the application of heat, he firft expelled a fmall quantity of air out of the veffel by applying heat to it. In confequence of which the air expands, and a fmall quantity of it comes out. He then puts the extremity of the tube immediately into a coloured liquor, and allows the veffel to become cool again; the confequence is, that the air lofes the increafe of its elafticity, and the internal air preffes up* a quantity of the fluid into the tube to fill up the room of the air that had been expelled by the heat, and

* Vide Vol I.

having thus ſet up his thermometer, he then applied to the tube a ſcale of equal parts or degrees, which divides the cavity of the tube into a number of ſmall and equal parts; and as the tube is cylindrical, we can ſee by theſe diviſions, how the bulk of the air is increaſed at one time, and diminiſhed at another. This kind of thermometer was uſed for a conſiderable time, when at laſt it was objected to by the Honourable Mr. BOYLE, that it could not be employed to aſcertain the temperature of fluids, and owing to the changes which are known to take place in the weight of the atmoſphere, it was fallacious even in thoſe caſes in which it could be employed; he therefore attempted to conſtruct a thermometer on ſome other ſubſtance than air, and *ſpirit of wine* was firſt thought on, upon account of its being eaſily tinged, and the conſiderable change of bulk that it undergoes; and it was very eaſy to contrive the manner of confining the ſpirit of wine, or any other fluid, ſo as to obſerve diſtinctly the ſmalleſt variation of its bulk by putting it into a ball and tube, whereby a quantity riſes in a ſmall and ſlender thread, which can be eaſily meaſured, and divided into a number of ſmall parts, the extremity of the tube being ſealed hermetically, ſo that the preſſure of the atmoſphere could not effect it, nor could it ſuffer

any

any lofs from exhalation; thus the firft ufeful thermometer was contrived by the Honourable Mr. Boyle. Thefe thermometers were ufed for twenty or thirty years, till Dr. Hally and Sir Ifaac Newton preferred *mercury*.

The pulfe glafs.

The *pulfe glafs*, as it is improperly called, depends alfo upon this principle. It is a bulb with a long neck to it. As the heat of the hand, following its natural tendency, immediately paffes into the colder fpirit of wine, in proportion as it enters it increafes its bulk, and makes it gradually rife higher into the neck of the veffel, till it has acquired its utmoft limit, when it appears to bubble; and to fhew that it depends upon heat merely, it will do the fame if immerfed in hot water; and then if it be removed it will again diminifh in bulk, and return to its former place.

Before I quit the fubject of *expanfion*, it may not be improper to notice, that a knowledge of this law enables us to underftand the effect produced upon bodies that are remarkably brittle. Chemifts know this but too well, and in private families glaffes are repeatedly broken by pouring into them warm water, and even the backs of grates are foon cracked if cold water be thrown upon them after they are quickly heated. In thefe cafes the particles

particles are torn from the colder parts by the expanſive power of heat.

2d. State of Expanſion, or that of Fluidity.

The firſt expanſion carried a little further produces the ſtate of *fluidity*. That this depends upon *abſorbed heat* merely, is proved by the following experiment. If you take a quantity of ice, and put it into a baſon, and carry it to a room in which the thermometer is at 50 degrees, from the increaſed temperature owing to a fire in the chamber, and leave this ice for ſome time in the room, part of it will be melted. Apply then a thermometer, and it will point to 32 degrees. The ſame in five minutes, though evidently more heat has entered the mixture, and ſo continually until every particle of ice, or ſnow, has been melted. This can only be accounted for by ſuppoſing that the free caloric, or heat, has entered into combination with the water, and remains, as chemiſts are wont to call it, in a *latent* ſtate. That is, the capacity of water for heat is greater than that of ice.

We may readily form an idea of the word *capacity*, by by ſuppoſing a veſſel filled with marbles, into which a quantity of fine ſand is poured, which, inſinuating into the intervals between the balls, will fill up every void. The marbles, in this compariſon, are to the ſand which ſurrounds them exactly in the ſame ſituation as the particles of bodies are with reſpect to the caloric, with this difference only, that the marbles are ſuppoſed to touch each other, whereas the particles of bodies are not in contact, being retained at a ſmall diſtance from each other by the intervention of the caloric. If, inſtead of ſpherical balls, we ſubſtitute ſolid bodies of a hexahedral, octohedral, or any other regular figure, the capacity of the intervals between them will be leſſened, and conſequently will no longer contain the ſame quantity of ſand. The ſame thing takes place with regard to natural bodies, the intervals left between their particles are not of equal capacity, but vary in conſequence of the different figures and magnitude of their particles, and of the different figures and magnitude of their particles are maintained, according to the exiſting proportion between their inherent attraction, and the repulſive force exerted upon them by the caloric. In this manner we muſt underſtand the following expreſſion, introduced by the Engliſh philoſophers, who have given the firſt preciſe

ideas

ideas upon this ſubject, the capacity of bodies for containing the matter of heat.

Of frigorific mixtures.

It is upon this principle alſo that *frigorific mixtures* are formed. The city of *Peterſburgh*, which is contiguous to the ſea, is expoſed to a very intenſe degree of cold, and that of the year 1760 being very exceſſive, the mercury ſtood even at 40 degrees below that of Farhenheit's ſcale. This being the caſe, Profeſſor Brown, of the academy there, had the curioſity to try whether by mixing together ice and ſtrong nitrous acid he could congeal even mercury itſelf; and the artificial cold this produced was ſo great, that he actually accompliſhed his experiment, and the mercury in the bulb was converted into a tough metal, which bore a ſtroke or two of the hammer; and what was in the bore turned out a very fine and flexible thread. Thus if a mixture of ſal ammoniac and ſnow be put over a fire, and we place in the middle of this a bowl with ſome water in it, whilſt the ſnow and ſal ammoniac is melting into a liquid, the water in the bowl will be congealed into a maſs of ice. We can have no doubt here, but that heat enters into bodies as they become *fluid*, ſeeing it torn in ſo ſurpriſing a manner from water during the melting of the ſnow. We ſee then, that as the

the change of the ice from the *folid* to the *fluid form*, it *abforbed* a quantity of HEAT, even fo much as to render mercury fimilar in its properties to all the other metallic bodies.

3d. State of Expanfion, or the Aeriform State.

If you put a cup of æther in a bafon of water, and place them in the exhaufted receiver of an air-pump, the æther will affume an aeriform ftate, and the water in the bafon will be frozen. In this experiment we fee, that in the ordinary temperature of the earth, æther would always exift in an aeriform ftate, but for the preffure of the atmofphere, and that the paffing of the æther from the liquid to the aeriform ftate is accompanied with a confiderable diminution of heat; becaufe during the evaporation a part of the caloric, which was before either free or latent in the furrounding bodies, combines with the æther, caufing it to affume the aeriform ftate.

The effect of the preffure of the atmofphere in the converfion of bodies into thefe different ftates was firft noticed by the honourable Mr. Boyle. He found, when making experiments with the air-pump, that water boiled at 90 degrees when the preſſure of the atmoſphere was taken off, and that therefore both the freezing and boiling points upon thermometers were in ſome meaſure defective, being dependant upon the height of the barometer *; for when the preſſure was greateſt the water bore more heat, and vice verſa.

Papin's digeſter.

In conſequence of this diſcovery Papin formed his *digeſter*. In this inſtrument bones may be diſſolved, and the water may be made to acquire ſo great a degree of heat, that an iron wire will melt in it. For a deſcription of this inſtrument ſee Vol. II. page 229.

Before we quit this ſubject, let us for a moment conſider the cauſe of the *elaſticity* of *air*. It is by no means difficult to perceive that this elaſticity depends upon that of *caloric*, which ſeems to be the moſt eminently elaſtic body in nature. Nothing is more readily conceived, than that one body ſhould become elaſtic by entering into combination with another body

* Vide Vol. I. page 3.

poſſeſſed

poſſeſſed of that quality. Elaſticity is nothing more than that quality of the particles of bodies by which they recede from each other when forced together. We ſhall be ſatisfied of this, when we conſider that air is ſuſceptible of undergoing great compreſſion, which ſuppoſes that its particles were previouſly very diſtant from each other; for the power of approaching together certainly ſuppoſes a previous diſtance, at leaſt equal to the degree of approach.

The acquiſition of this property exhibits ſome of the moſt curious phænomena we are acquainted with. As children we have been often delighted with *candle-crackers*, but we ſhould now contemplate them as men. They are hollow pieces of glaſs formed upon the extremity of a tube. This tube is made to contain a drop or two of water, and it is then hermetically ſealed. When this is put near the flame of a candle, the water ſoon acquires the form of ſteam, the elaſticity of which is gradually increaſed, until it burſts the glaſs with an exceeding loud crack, and with ſuch violence, that uſually the wick of the candle is beat down upon the tallow as if it had received the blow of a hammer. *Glaſs booms.*

Alembics. The diſtillation of ſubſtances depends wholly upon this principle. Steam or vapour is produced by the elaſtic power of heat. This we have before ſhewn to vary with the preſſure of the atmoſphere. Accordingly it is found, that when the air is light (indicated by the barometer being low) the fluid will boil ſooner. When the barometer ſtands at 30 inches, water boils at the temperature of 212 degrees. If it ſtand ſo low as 28 inches, water will boil at 208. Hence in diſtillation we ſhould diminiſh the preſſure of the atmoſphere. It is undoubtedly of great advantage to be able by the ſecluſion of air to work with ſmaller fires, and this would ſecure us alſo in a great meaſure from thoſe fatal accidents which are often attended with the moſt terrible effects. Monſ. LAVOISIER was employed with his chemical friends on this important ſubject, when the Goth * of the eighteenth century, and his colleagues in iniquity, deprived the world of this great philoſopher. The flimſy pretext was that he occupied the place of farmer-general, a receiver of taxes under the former government, but the real motive which produced this execrable action was the juſtly acquired riches which he was known to poſſeſs. Thus was cut off the NEWTON

* ROBESPIERRE.

of

of the prefent age in the midft of his ufeful labours; his houfe, filled with the moft expenfive chemical apparatufes, free for his numerous vifitants, was defpoiled; and the honourable rendezvous of men of letters was converted into a den of political thieves. The fubject we hope, however, will not be dropt. The laws which regulate the formation of elaftic vapour, and the phænomena they exhibit, give us that link which clofely connects chemiftry with mechanical philofophy. Here we fee chemical agents and mechanical forces fet in immediate oppofition to each other, and the one made the indication and meafure of the other.

The *fteam engine*, is the name of a machine which derives its moving power from the elafticity of the fteam of boiling water. It is the moft valuable prefent which the arts of life have ever received from the philofopher. The mariner's compafs, the telefcope, and other moft ufeful difcoveries, were the refult of chance, and we do not know to whom we are indebted for them; but the fteam-engine was, in the very beginning, the refult of reflection, and the production of a very ingenious mind; and every improvement it has received, and every alteration in its conftruction and principles, were alfo the refults of philofophical ftudy. This invention was made *Steam engine.*

in the reign of Charles II. by the Marquis of Worcester, which he publifhed with ninety-nine other contrivances of his own, which he extols, as of the higheft importance to the public. It does not, however, appear that the noble inventor could ever intereft the public by thefe accounts. He was branded as a projector, and the many failures which perfons of this turn of mind daily experience, probably prejudiced people againft him, and prevented all attention to his projects. The fcheme however was revived in the year 1696 by Captain Savary, but it owes its prefent improved ftate to the philanthropic Mr. Watt, a perfon of a truly philofophical mind, eminently converfant in all branches of natural knowledge, and the pupil and intimate friend of Dr. Black, whofe illuftrious name will be often mentioned in this work, having of late turned his attention much towards the improvement of medicine by the formation and introduction of new aerial remedies *.

Without entering more diffufely into examples of the confequences of the change of capacity in bodies when they are altered in their form, it may be obferved, and repeated once more, that as the powers of

* Vide p. 608. note *.

gravity

gravity and *projection*, in continual oppofition to each other, produce all the beautiful effects in the great fyftem of the univerfe; fo, among the actions of the minute parts of bodies, the *cohefive attraction*, and the *repulfion* of *heat*, are in continual oppofition to each other, and are concerned in almoft every procefs by which changes are produced in the peculiar properties, or chemical combination, of bodies.

To conclude. Befides the extenfive influence of *heat*, chemifts, in order to deftroy as much as poffible THE ATTRACTION OF COHESION, employ the mechanical operations of *pounding*, *hammering*, *rafping*, *filing*, or *cutting*, and not unfrequently the operation of *folvents*. Hence that adage, " Corpora non agunt nifi fint foluta;" by which means they give free fcope for THE ATTRACTION OF COMPOSITION, or AFFINITY, or that attraction which takes place between bodies of different natures.

SECT. I.

THE MECHANICAL PROPERTIES OF AIR.

ONE of the firſt things that our ſenſes inform us of, is, that although THE AIR we breathe is too fine for our *ſight*, it is very obvious to our *touch*. Although we cannot *ſee* the *wind* contained in a bladder, we can readily *feel* its reſiſtance; and though the *hurricane* may want *colour*, we often fatally experience that it does not want *force*. So far the ſlighteſt experience reaches; but by carrying experiment a little farther, we learn that *the air* alſo is HEAVY.

A glaſs veſſel being *emptied of its air* and accurately weighed, has been found *lighter* than when it was weighed with the air in it. Upon computing the *ſuperior weight* of the full veſſel, a *cubic foot of air* is found to weigh *rather more than an ounce*.

Again, if the air be exhauſted out of any veſſel, and this veſſel be ſet with the mouth downwards in water, the *water will riſe up* into the empty ſpace, and fill the inverted glaſs; the external air will in this caſe preſs upon the water ſurrounding the glaſs, and force it up into *the vacuum*; and juſt as the beam of a balance *riſes*, the other extremity having a weight on it, ſo will the

water

water *riſe* in the glaſs, and continue *to riſe* (if the empty glaſs were tall enough) 32 FEET, and NO HIGHER *.

Pipes have been made purpoſely above 32 feet high; in which, upon being exhauſted, the water has always riſen to the height of 32 feet: there it has *conſtantly reſted*, and *never aſcended higher* †.

From this fact we learn therefore the EXACT WEIGHT of *the air*, which preſſing up the water 32 feet, is equal to a column of water of that height, as it is juſt able to raiſe ſuch a column, and no more.

In other words, the ſurface of the earth is every where ſurrounded with *a weight of air*, which is *equivalent* to a flood of water 32 feet deep, or to a covering of 29 inches and an half of quickſilver, which is known, though occupying leſs ſpace, to be juſt as heavy as the former ‡.

Thus we ſee that the air at the ſurface of the earth is juſt as heavy as 32 feet of water, or 29 inches and an half of quickſilver; and it is eaſily found that to raiſe water 32 feet, *will require a weight of* 15 *pounds upon every ſquare inch.*

* It is on this principle that *pumps* raiſe water.

† Pumps, therefore, raiſe water no higher than 32 feet.

‡ *Barometers* which determine the weight of air are conſtructed on this principle.

 Now

Now if we are fond of computations, we have only to calculate *how many ſquare inches* are in the *ſurface* of an ordinary human body, and allowing *every inch* to ſuſtain 15 *pounds*, we may amaze ourſelves at the weight of air we ſuſtain.

It has been computed that our *ordinary load*, though from its *equal preſſure* we are not ſenſible of it, *amounts* to within a little of 20,000 *pounds*: this is wonderful! but it is not by wondering we acquire wiſdom.

Notwithſtanding this be our ordinary load, there are at *different times*, as the barometer ſhews †, *ſome variation*.

The air is not equally heavy at all ſeaſons; but ſometimes it is *lighter*, and ſometimes *more heavy*. This, therefore, makes a *very great difference* in the weight we ſuſtain; and we are actually known, by computation, to carry at one time 4000 pounds of air more than at another.

† When the barometer *riſes*, a greater weight of air preſſes up the mercury in the tube, and the clouds uſually aſcend; when the barometer *ſinks*, the weight of incumbent air being leſs, the clouds gravitate below. Hence the *variations* of the barometer denote the *changes* of the weather. The effects of a *moiſt* or *dry* air, and the viciſſitudes of *cold* and *hot* winds on the animal body, will be conſidered afterwards.

Again,

Again, as in the ſea, a man at the depth of 20 feet, ſuſtains a greater weight of water than a man at the depth of but 10 feet; ſo will a man at the bottom of a deep valley have a greater weight of air over him, than a man at the top of a very high mountain *.

Our conſtitutions ſeem alſo to correſpond with theſe changes; they are braced, ſtrong, and vigorous, with a *large body of air* upon them;—they are languid, relaxed, and feeble, when *the air is light*, and refuſes to give our fibres their proper tone.

* The art of taking the heights of mountains by the barometer determines this curious point. As the air grows *lighter* the higher we aſcend, the fluid in the tube will *ſink* alſo in due proportion. It is found to *fall* at the rate of the tenth part of an inch for every 90 feet; ſo that in going up a mountain, if the quickſilver has fallen *an inch*, I conclude I am got up an aſcent of near 900 *feet*. GOLDSMITH.

SECT.

A CHEMICAL TABLE.

SIMPLE BODIES.			COMPOUND BODIES.
Oxygen - - -	and { *Caloric* *, or Fire, }	- - - - -	is { OXYGEN GAS, or VITAL AIR; formerly called Dephlogisticated Air.
Oxygen - - -	and *Carbon*, - -	- - - - -	is CARBONIC ACID.
Oxygen - - -	and *Phosphorus*, -	- - - - -	is PHOSPHORIC ACID.
Oxygen - - -	and *Sulphur*, -	- - - - -	is { SULPHURIC ACID, or Vitriolic Acid.
Oxygen - - -	and *Mercury*, -	- - - - -	is { OXYD OF MERCURY, or Calx of Mercury.
Oxygen - - -	and *Iron*, - -	- - - - -	is { OXYD OF IRON, or Rust of Iron.
Oxygen, - - -	*Azot*, - - -	and *Caloric*, - -	is { ATMOSPHERIC AIR, or Common Air.
Oxygen, - - -	*Carbon*, - - -	and *Caloric*, - -	is { CARBONIC ACID GAS, or Fixed Air.
Azot - - -	and *Hydrogen*, -	- - - - -	is { AMMONIAC, or Alkali.
Hydrogen - -	and *Caloric*, - -	- - - - -	is { HYDROGEN GAS, or Inflammable Air.
Hydrogen, - -	*Carbon*, - - -	and *Caloric*, - -	is { HYDROCARBONIC GAS, or Hydrocarbonate.

* *Caloric* is here considered as *light*, though in the course of this work these two bodies will be distinguished.

SECT. II.

THE CHEMICAL PROPERTIES OF AIR.

FORTUNATELY for my readers, the chemical knowledge neceſſary firſt to be learnt in order *clearly* to underſtand the INFLUENCE of the AIR on the BLOOD, and THENCE on the ANIMAL ECONOMY, compriſes the *moſt beautiful diſcoveries* in that ſcience; *diſcoveries* that have done honour to this age, and have immortalized the names of PRIESTLEY, LAVOISIER, FOURCROY, and CAVENDISH.

The Honourable Mr. BOYLE has conſidered OUR ATMOSPHERE as *one large chemical veſſel*, in which an infinite number of various operations are conſtantly performing. In it all the bodies of the earth are continually ſending up a part of their ſubſtance, by evaporation, to mix in *this great alembic*, and to float a while in common. Here minerals from their loweſt depths aſcend in noxious vapours to make a part of the general maſs; ſeas, rivers, and ſubterraneous ſprings, furniſh their copious ſupplies; plants receive and return their ſhare; and animals that by living upon conſume this general ſtore, are found to give it back in vaſt quantities when they die.

THE

The air, therefore, which every where preffes on us, and upon which we fubfift, bears very little refemblance to that *pure*, *fimple*, *elementary body* formerly imagined; and which is rather a fubftance that can be conceived, than experienced to exift.

Modern chemistry, however, has made great advances in *this curious refearch*, and it will foon appear that the compofition of atmofpherical air has been more *rigoroufly* determined.

Chemiftry affords two general methods of afcertaining the conftituent principles of bodies, the method of analysis *, and that of synthesis †.

When, for inftance, by combining *water* with *alkohol*, we form the fpecies of liquor called brandy, we certainly have a right to conclude (by this fynthefis) that brandy is compofed of *alkohol* and *water*.

And when by diftillation of brandy, we obtain feparate, *water*, and *alkohol* (by this analyfis), our evidence of the conftituent principles of brandy is then rendered complete; and in general it ought to be confidered as *a principle* in chemical fcience, never to reft fatisfied without *both thefe fpecies of proofs*.

* From the Greek word αναλυσις. The *feparation* of any *compound* into its *feveral parts*.

† From the Greek word συνθεσις. The *putting together* the *feveral parts* of a *compound body*.

THE MODERN ANALYSIS OF ATMOSPHERIC AIR;

Or its Separation into 2 ELASTIC FLUIDS,	*The* ONE *ſupporting Life and Flame.* *The* OTHER *adverſe to both.*

LAVOISIER'S EXPERIMENT.

THIS illuſtrious chemiſt having placed a certain quantity of MERCURY in a *retort*, adapted to a *bell glaſs*, which encloſed 100 *cubical inches* of COMMON AIR, he kept up in his furnace a conſtant fire, of ſuch force, as to keep the QUICKSILVER almoſt always at its *boiling point*.

On the ſecond day ſmall RED PARTICLES began to appear on the ſurface of the MERCURY, which gradually increaſed in ſize and number for 4 or 5 days.

Convinced that the *calcination* of the MERCURY after that time did not go on, he extinguiſhed the fire; and when the veſſel was cool, he found in his bell-glaſs, inſtead of 100 *cubical inches of air*, only 86, and therefore A LOSS of 14 *cubical inches* of AIR.

Now,

Now, 14 *cubical inches* of AIR weighs 7 *grains*, and the RED PARTICLES, or CALX OF MERCURY, being carefully collected, *theſe* had an *increaſe of weight* of 7 *grains*, the *exact weight* of AIR which ſeemed LOST *.

The 86 *cubical inches* of AIR remaining in the glaſs after this calcination was ended being examined, it was found to poſſeſs THESE PROPERTIES.

An animal being put into it was *ſuffocated* in a few minutes,—and when *a taper* was plunged into it, it was *extinguiſhed*, as if it had been immerſed in water †.

THIS GAS, or AIR, has been called *phlogiſticated air*, *non-reſpirable air*, *noxious or mephitic air*, *impure air*; but the French chemiſts have preferred the term AZOTIC GAS (*lethal air*) from the Greek words α, *privative*; and ζωη, *life*.

* The concluſion is obvious, and in the next experiment, we ſhall find, that the 14 *cubical inches of air*, which was *abſorbed* by the MERCURY, and converted it to a CALX, was the *vital* or *reſpirable part* of air.

† Not from any peculiar properties, but becauſe the *vital* or *reſpirable part* was abſtracted from it.

LAVOISIER'S

LAVOISIER'S SECOND EXPERIMENT.

HAVING taken 90 *grains* of the CALX OF MERCURY, the product of the *laſt proceſs*, LAVOISIER put it into a glaſs retort fitted to a proper apparatus for receiving aerial products.

Having applied a *much ſtronger heat* than in the former experiment, he obſerved that at firſt, in proportion as the CALX of MERCURY became heated, the intenſity of its colour augmented; but ſoon after the CALX began gradually to decreaſe in bulk, and in a few minutes *its red colour altogether diſappeared*, and the 90 *grains* of CALX OF MERCURY was converted into the 83 *grains* of RUNNING MERCURY, and 14 *cubical inches* of an AERIAL FLUID paſſed over into the recipient.

Now theſe 14 *cubical inches* of air weighed 7 *grains*, the *exact weight* of the air *conſumed* by the CALCINATION of the MERCURY in the firſt experiment*; and the 83 *grains* of the CALX of MERCURY *reduced*† to a *metallic ſtate* being examined, had *loſt in weight* 7 *grains*, the

* Had the 100 *cubical inches* of atmoſpheric air contained a larger ſhare of *oxygen* or *vital air*, *more* MERCURY would have been *calcined*. For *calcination*, as this experiment ſhews, is nothing more than the *combination* of VITAL AIR with *any metallic* body.

† From the Latin word REDUCO, *to bring back*. REDUCTION is the bringing back a *metal converted to a calx* to its *priſtine ſtate*.

exact weight of the air now obtained. THIS AIR poſſeſſed theſe PECULIAR PROPERTIES.

An animal, being placed in IT, became *remarkably lively*; a *taper* burnt in it with a *dazzling ſplendour*; and *charcoal*, inſtead of conſuming quietly away, as it does in common air, burnt *with a flame*, attended with a decrepitating noiſe, and threw out ſuch a *brilliant light* that the eyes could hardly endure it.

This ſpecies of air was *diſcovered* * almoſt at the ſame time by Dr. PRIESTLEY, Mr. SCHEELE, and LAVOISIER.

* Dr. MAYOW, a philoſopher of the laſt century, undoubtedly was well acquainted with *this ſpecies* of AIR, and has moſt accurately deſcribed it in his works under the denomination of the *nitro-aerial ſpirit*. (See Dr. Beddoes's Analyſis of Mayow's Works). Near about the ſame period Dr. MUNDY, alſo of Oxford, publiſhed a treatiſe on *Vital Air (De Aere Vitali)*, and, if we may credit hiſtory, great advantage was made of this vivifying ſpirit. Boyle relates, "that CORNELIUS DREBELL is affirmed, by many creditable perſons, to have contrived a veſſel for King James I. to be rowed under water; it carried twelve rowers, beſides paſſengers, and was firſt eſſayed in the river Thames; for DREBELL conceived, that it is not the whole body of air, but a certain *ſpiritual part* of it, that fits it for reſpiration; which being ſpent, the remaining air is unable to cheriſh the vital flame reſiding in the heart. So that, beſides the mechanical contrivance of his boat, he had a chemical preparation, which, by unſtopping the veſſels wherein it was contained, the fumes of it would ſpeedily reſtore to the air, fouled by reſpiration, ſuch a proportion of *vital particles*, as would make it again fit for that office." Dr. PRIESTLEY, in 1774, ſeems, without knowledge of theſe obſolete and antiquated, I might ſay, rejected, ideas of MAYOW and MUNDY, to have diſcovered a permanently elaſtic fluid purer than common air; but amidſt the variety of objects in the purſuit of his experimental enquiries, he then overlooked, or rather neglected to conſider the phænomena of this wonderful fluid, which by chance, of modern

 philoſophers,

SIER. Dr. PRIESTLEY gave it the name of *Dephlogisticated* or *Pure Air*; Mr. SHEELE called it *Empyreal Air*; and LAVOISIER first named it *Highly respirable Air*, or *Vital Air*; and afterwards, as it forms acids, by combining with certain bodies, the French chemists adopted the term OXYGEN GAS *(Acid-making Air)*, from the Greek words ὀξυς, *sour*; and γεινομαι, *to beget* *.

philosophers, was first presented to his view. Nearly about the time that Dr. PRIESTLEY discovered the *Dephlogisticated air* in England, Mr. SHEELE, of Sweden, was engaged in making experiments on air and fire, which he published in German; and in those experiments we find also the discovery of *vital air*, called by Mr. SCHEELE, *Empyreal air*; both of whom appear wholly unacquainted with each other's discovery, which is confirmed by each of these philosophers arriving at the same *conclusion* by different roads: but undoubtedly LAVOISIER was the *first* who proved, by direct and exact experiments, that the weight which metals gain by *calcination* corresponds with that of the air which they absorb; he was the *first* who ascertained, by the most decisive experiments, that the atmosphere consists of *two distinct fluids*, the *one* fit for the purposes of respiration and combustion, which he therefore called VITAL, or PURE AIR; the *other* unfit for either purpose, and thence called FOUL, or MEPHITIC AIR; he *first* proved that PURE VITAL AIR contained more FIRE, or CALORIC, than any other air; and that during combustion, as this air, or rather its *base*, was uniting to the substance, and adding its weight to the burning body, it gave out this FIRE in the form of HEAT and LIGHT.

* If *sulphur* or *charcoal* be burnt in *oxygen* or *vital air*, in a close vessel, and the fumes be condensed in water, *this water* will acquire an ACID TASTE, and be increased *in weight* exactly *corresponding* to the *weights* of *sulphur* or *charcoal* consumed, and *that* of the *oxygen air* destroyed. *Sulphur* united thus with *oxygen*, the fumes being collected in water, will form VITRIOLIC ACID; and *charcoal* combined with *oxygen*, and diffused in water, will form SELTZAR, or the AERIAL ACID WATER. The *calces* of metals the French chemists call OXYDS, which signifies a body impregnated with a *certain quantity* of *oxygen*, but not *sufficient* to render it *perceptibly acid*.

THE SYNTHESIS.

Lavoisier then repeated the fame experiments as before related, and *re-combined* the 2 ELASTIC FLUIDS, which he had feparately obtained in the two experiments of *calcination* and *reduction*, viz. the 84 *cubical inches* of the AZOTIC AIR, and the 14 *cubical inches* of the OXYGEN AIR, and he produced from *this combination* an ELASTIC FLUID *precifely fimilar in all its properties to* ATMOSPHERIC AIR, contributing in the fame way to a repetition of the fame experiments, and poffeffing the fame power of fupporting animal life and combuftion.

The philofopher can have no remaining doubt as to the *compofition* of ATMOSPHERIC AIR: but the circumftances of thefe experiments might appear to him *more correct*, though probably at the time *lefs clear* to others, were it faid, that MERCURY, at a certain temperature, overcoming the affinities* of *caloric* † and *azotic air* for OXYGEN,

* If you take a bullet and divide it with a knife into *two parts*, provided thefe be fmooth and rubbed together, they will ftrongly unite and form *one whole*. This is from a law impreffed on matter called the *attraction of cohefion*. But fhould a particle of fand, or any roughnefs exift, the particles being divorced

† *Fire*, or the *matter of heat*.

OXYGEN, attracts and fixes within itself OXYGEN *, (the *base* of oxygen air, for oxygen air is oxygen combined with a certain quantity of caloric :)—hence its *increase of weight*, and its *conversion into an oxyd or calx*, and hence the AZOTIC, or LETHAL, AIR *left us* in the bell-glass.—That, the temperature being increased †, the affinity of

divorced from each other, beyond the *sphere of mutual attraction*, they are no longer actuated by this law.—*The attraction of cohesion* in *mercury*, at the common temperature, hinders the admission of OXYGEN, for which it has an *elective attraction* or *affinity*. But when exposed to a strong heat, the *caloric* expands this fluid ; that is, insinuates itself through the body, and separates its particles (thermometers depend on this expansive power of fire), and, like the pieces of the bullet where sand interposed, the divided particles are no longer subject to the *law of cohesion* ; then it is they obey the *law of attraction*, and each atom of MERCURY *attracts to itself* a particle of OXYGEN, just as a loadstone would draw to itself a particle of iron.—The loadstone *only attracts* iron. This represents the term *affinity* in chemistry. The mercury did not attract the AZOT, because chemists would say it had no *affinity* for it.

* An experimentalist would illustrate this by placing a NEEDLE between *two magnets* of different powers. This would represent OXYGEN between the two attractions of the *caloric* and *azotic air*. As we may suppose a *loadstone* to have an attraction for the NEEDLE superior to the *two magnets*, so would it draw THE NEEDLE to itself from *these*, just as the *mercury* draws away from the *azotic air* and *caloric*, the OXYGEN.

† This is a curious fact ; the temperature being increased, the CALORIC *alone* overcomes the elective attraction of *mercury* for *oxygen*, and depriving it of *that principle*, the *attraction of cohesion* takes place with the particles of *mercury*, and we obtain then RUNNING MERCURY and OXYGEN GAS. To have recourse to the note on page 12, the *oxygen* and *mercury* being separated beyond their *sphere of attraction*, the *caloric* attracts to itself the *oxygen*, just as either of the *magnets* (in the preceding note) would again attract to itself the NEEDLE, were it placed within its *sphere of attraction*, but *beyond that* of the *loadstone*.

the

the *caloric* for OXYGEN becoming now ſuperior to the attraction of the MERCURY, the OXYGEN is withdrawn from the OXYD OF MERCURY by the ſuperior attraction of the *caloric*;—hence its *decreaſe in weight*, and its *reſtoration to fluidity and ſplendour*, and hence the produce of OXYGEN, or VITAL, AIR, clearly diſplaying to us this important truth,

" THAT ATMOSPHERIC AIR IS ACTUALLY A
" COMPOUND OF TWO HEAVY SUBSTANCES, AZOT *
" AND OXYGEN; WHICH BODIES, WHEN COMBINED
" WITH CALORIC, OR THE MATTER OF HEAT, BE-
" COME AERIFORM, AND ARE THEN AZOTIC AND
" OXYGEN AIRS."

Although theſe experiments furniſh us with a very ſimple means of obtaining, ſeparate from each other, the two elaſtic fluids which compoſe our atmoſphere, yet do

* That AZOT is a *ſolid ſubſtance* as well as OXYGEN, can be eaſily proved by experiment. That the application of heat ſhould render *oxygen*, and *azot*, *gaſeous* is not wonderful, ſince we often obſerve *ice* by the admixture of *caloric* rendered a *fluid*, and heated to 212, converted into an aeriform and tranſparent gas. The hardeſt ſubſtance in the world, the DIAMOND, may be volatilized in the ſame way. Mon. D'Arcet took a ſphere of porcelain china, and after cutting it into halves, confined a *diamond* in the middle; he then joined the two ſections ſtrongly together. Putting theſe balls into a furnace, he afterwards unſcrewed them, and found the diamonds evaporated, and the place which they occupied empty, though he could perceive no chink or fracture any where over the ſurface of the ball!

they

they not give us an exact idea of *the proportion* in which *these two* enter *its composition* *. For the attraction of the MERCURY for OXYGEN is not sufficiently strong to overcome all the circumstances which oppose this union, such as the mutual adhesion of the *oxygen* and *azotic airs*, and the strong affinity which unites *oxygen* to *caloric*, in consequence of these, though the OXYGEN is torn by the MERCURY from its union with the *azotic air* and *the caloric*, yet towards the end, when the *azotic air* is more abundant, there will still remain some portion of the *oxygenous principle*, combined with the *azotic air*, which the MERCURY could not separate.

* In our climate the proportion generally is 4 of *azotic air* to 1 of *oxygen air*, as will be hereafter proved.

THE

THE ANALYSIS OF OXYGEN AIR.

THAT OXYGEN GAS, is compofed of { OXYGEN, HEAT, & LIGHT, } will be *evident* from the following very elegant experiment made by Dr. INGENHOUST.

A fine *iron wire*, twifted into a fpiral *, being heated at its extremity red hot, and thruft into a jar containing only *oxygen air*, it inftantly took fire, and burnt away rapidly †, exhibiting a bright light fimilar to that of Chinefe fire-works, and throwing out brilliant fparks, which fell to the bottom in the form of round globules ‡.

At the beginning of the combuftion there is a flight augmentation in the volume of the air in the bell-glafs, from the dilatation caufed by the heat; but prefently

* This was done to render the experiment more ftriking.

† This experiment fhews that *azotic air* retards the union of *oxygen* with bodies attracting it, and in fome cafes altogether prevents it.

‡ Thefe were found floating on the mercury, and are natural *Martial Æthiops*. How much flower is the *calcination* or *rufting* of *iron* in other circumftances!

after a *rapid diminution* takes place, and *the mercury riſes in the glaſs*, inſomuch that when the *quantity of iron is ſufficient*, and the AIR *operated on is very pure*, almoſt the *whole air employed* is *abſorbed* *,—or ſhould the *quantity of* IRON *be inſufficient*, the REMAINING AIR *unabſorbed* will be found PERFECTLY PURE†.

The *theory* of this experiment is the ſame as the laſt. At a certain temperature IRON has a *ſtronger affinity* for the OXYGEN, than CALORIC and LIGHT have. IT *therefore* attracts to itſelf the OXYGEN, and CALORIC and LIGHT becoming diſengaged ‡, are rendered *active* and *evident* to the ſenſes.

Previous

* That is, if 100 *grains* of IRON be conſumed in 70 *cubic inches* of *oxygen air*, the whole volume of air will diſappear; and as 70 *cubic inches* of *oxygen air* weigh 35 grains, the 100 *grains* of *iron* will weigh, in its ſtate of *oxyd* or *calx*, 135 grains.

† As the *pure* or *oxygen air* is found unaltered, the *mephitic air* left us in the *calcination of the mercury* could ariſe only from the *abſtraction* of the *oxygen air*. Vide Experiment the Firſt, p. 8. Note *.

‡ As the calcination of the *mercury*, in the firſt experiment, laſted ſeveral days, the *diſengagement* of CALORIC and LIGHT was extremely ſmall for each particular moment of time, and therefore not perceptible to the ſight. The heat, alſo, of the furnace was confounded with it, which made it neceſſary to relate the experiment above, where *the combuſtion* of the metal was more rapid, or rather *the decompoſition* of the OXYGEN GAS.

When we are ſailing on the water in a ſtill day, *diſtant objects appear to meet us*, but our reaſon corrects the deluſion. When we behold the ſun, moving from eaſt to weſt, philoſophy again aſſumes its empire, and we are convinced

it

Previous to our entering upon the ſubject of the effects of air on the animal economy, it will be neceſſary to ſhew, alſo, that WATER, though it be the ſolvent of a vaſt variety of bodies, is neither that *compound* or *ſimple element* formerly ſuppoſed, but made up of two VERY DISTINCT and DIFFERENT PRINCIPLES.

The new and beautiful doctrine of the French chemiſts, reſpecting the compoſition of air, the nature of combuſtion, calcination, &c. was daily gaining ground, and obtaining the applauſe of every one, when an experiment performed by Dr. PRIESTLEY made it for a while totter on its baſis.

In the middle of a long glaſs tube this excellent experimentaliſt put ſome CALCINED LEAD, and affixed to the extremities *bladders* which were filled with INFLAM-

it is *ſtationary*. If we take a PRISM, it diſplays to us a variety of colours; our reaſon tells us here alſo, that *theſe colours* ariſe from the RAYS OF LIGHT, and are not *in* THE PRISM,—ſo of the combuſtion of bodies, the *caloric* and *light* are not from THE WAX of our candles, but from the OXYGEN AIR, which, as we have ſeen in this experiment, becomes, under certain circumſtances, *decompoſed* Vide alſo the latter part of note ‡, page 24.

MABLE

MABLE AIR *. Having applied a ſtrong heat to the middle of this tube, he next ſqueezed the bladders, and forced the INFLAMMABLE AIR along the tube.

The INFLAMMABLE AIR ſoon diſappeared: no OXYGEN GAS was evolved: but the RED LEAD quickly *reaſſumed* its original metallic ſplendour.

A queſtion then aroſe, whence *this property* in INFLAMMABLE AIR which the ANTIPHLOGISTIANS would aſcribe to the evolution of OXYGEN GAS.

The favourers of the NEW SYSTEM were not able to deny the fact; and as the INFLAMMABLE AIR, which was now called PHLOGISTON, had in this experiment *diſappeared*, they found ſome difficulty to perſuade *the ſupporters of the* OLD DOCTRINE that the *revival of the metal* could not be from the *abſorption* of the INFLAMMABLE AIR, as the RED LEAD had *loſt* a good deal of its *weight*,

* *This air* Dr. PRIESTLEY obtained from *diluted* vitriolic acid poured on iron. *Iron* was therefore ſaid to contain a great quantity of *this air*. But the fact will ſoon appear that the air aroſe from *the decompoſition of the water* mixed with the vitriolic acid. INFLAMMABLE or HYDROGEN AIR, being 15 times lighter than common air, it is employed for balloons.

Inflammable air quickly deſtroys life, whereas *oxygen gas* appears to be the very principle of life. *It* is conſiderably lighter than either *oxygen* or *common air*. *It* explodes when it comes into contact with *common air*, but more eſpecially with *oxygen air*, provided any body in actual inflammation be preſent.

and

and the *effect* of an *addition of matter* (if *inflammable air* be *matter*) could be no other than to give it *an increase* of *weight*.

Fortunately for chemistry the Honourable Mr. CAVENDISH, by passing an electric shock through *oxygen air* blended with *inflammable air* †, produced WATER. *The reduction* of the RED LEAD in Dr. PRIESTLEY'S experiment was then no longer a matter of surprise. At a *certain temperature* the INFLAMMABLE AIR overcoming the attraction of the *lead* for OXYGEN divorced it of *that principle*, and uniting with it formed WATER.

But that no doubt may be entertained on this head, I must beg leave to relate an experiment which was performed by MEUSNIER before a large assembly of the Academy of Sciences at Paris.

† 85 grains, by weight, of *oxygen air*, and 15 grains of *inflammable* or *hydrogen air*, produced here precisely 100 grains of WATER. In this experiment *caloric* is disengaged, and the 85 parts of *oxygen* and 15 of *hydrogen* unite, which, being naturally *solid substances of themselves*, become, if nearly all the *caloric* be extracted from them, ICE; if less, WATER.

THE

THE ANALYSIS OF WATER;

Or its ſeparation into its 2 CONSTITUENT PARTS, { HYDROGEN, and OXYGEN.

MEUSNIER'S FAMOUS EXPERIMENT.

HE took a GUN-BARREL, into which he put ſome thick pieces of IRON-WIRE flattened by the hammer. He *weighed* the whole with a ſcrupulous exactneſs. He then *luted* the gun-barrel to ſecure it from the immediate contact of the fire. It was then placed in *a furnace*, but ſo *inclined* that water would readily glide down it. He adapted to the upper extremity a *funnel* containing water, from which it could not eſcape into the gun-barrel but drop by drop. This funnel was *cloſed at the top* to avoid any the leaſt evaporation of the water. At the lower extremity *veſſels* were adapted to receive any aerial product. To uſe every precaution *theſe* were exhauſted of their air.

The

The *gun-barrel* was now made red hot, and the WATER from the funnel paſſed into it drop by drop.

An aſtoniſhing quantity of INFLAMMABLE AIR* was quickly obtained.

Having removed the luting, the *gun-barrel* with its *contents* weighed conſiderably *heavier* than *before*; and *the acquired weight* of the gun-barrel being *added* to the *weight* of the *inflammable air* thus produced, was *preciſely* the *weight* of the WATER *expended* in the proceſs: and the IRON-WIRE found in the barrel (the proceſs being over) reſembled in every reſpect *iron* that has been conſumed in *oxygen air*, that is, it was become an OXYD † OF IRON.

Before we enter upon the main object of this work, it will be neceſſary alſo to give the analyſis of FIXED AIR.

* This INFLAMMABLE AIR was generated from the *hydrogen* of the water, which united with the *caloric* of the furnace in its paſſage through the barrel. INFLAMMABLE AIR the French chemiſts call HYDROGEN GAS, from the Greek words *υδωρ* water, and *γεινομαι* to beget.

† A CALX, which accounts for the *oxygen*, the other conſtituent principle of WATER.

THE ANALYSIS

OF

CARBONIC ACID AIR, OR FIXED AIR;

Or its Separation into its 2 CONSTITUENT PARTS, { CHARCOAL, and OXYGEN AIR.

MR. TENANT, of Emanuel College, Cambridge, having procured a glafs tube hermetically fealed at one end, luted it over with clay and fand to prevent the fudden action of the fire. He then introduced into it fome PHOSPHORUS and powdered MARBLE*, and having clofed the open extremity, he applied to the tube a quick heat, and the refult was, when cold,

1. PHOSPHORIC ACID † combined with *calcareous earth.*

2. PHOSPHORUS combined with the *fame earth.* And

3. A BLACK SUBSTANCE, which differed in nothing from CHARCOAL made from vegetables.

* If *vitriolic acid* be poured on *marble*, FIXED AIR is given out in great abundance. Mr. Tenant therefore affumes this data, *that marble contains* FIXED AIR. As the refidue is *vitriolic acid* and CALCAREOUS EARTH, *marble* is known alfo to contain CALCAREOUS EARTH.

† *Phofphorus* and *oxygen.* The anfwer to this natural queftion, *Whence this oxygen?* is clearly demonftrated over leaf.

If

If VITRIOLIC ACID * be poured on MARBLE, THIS ACID poſſeſſing a ſuperior power of combination or attraction for the *calcareous earth* of the marble, than the *carbonic acid* † has, it unites with the *calcareous earth*, and the *carbonic acid*, becoming diſengaged, attracts to itſelf *caloric* ‡, and eſcapes in the form of *gas* ||.

MARBLE is therefore a compound of 3 *bodies*, { OXYGEN, combined with CHARCOAL, or *the carbonic acid*; and CALCAREOUS EARTH.

The *theory of this experiment* will be now eaſily underſtood.

At a certain temperature PHOSPHORUS (which is a ſimple body) overcoming the attraction of the *charcoal* for *oxygen*, deprives the CARBONIC ACID of its *oxygen*, and becomes, in conſequence,

1. PHOSPHORIC ACID §, which unites with the *calcareous earth*.

* *Sulphur* and *oxygen*.

† *Charcoal* and *oxygen*. FIXED AIR is *charcoal*, *oxygen*, and CALORIC.

‡ The CALORIC proceeds in part from the *vitriolic acid*; which acid, if poured on *water*, will almoſt make it *boiling hot*, to the no ſmall aſtoniſhment of perſons unacquainted with chemical operations. Since *two cold bodies*, coming into contact with each other, give out *heat*, CALORIC, we ſee, may be in a *dormant* or *neutralized ſtate*.

|| Viz. CARBONIC ACID GAS, or FIXED AIR; which is *charcoal* (carbon), *oxygen*, and a certain quantity of *caloric*. Vide p. 23, Note *.

§ *Phoſphorus* and *oxygen*.

The

The *phosphoric acid* being *saturated* * with the *calcareous earth*, we have also,

2. PHOSPHORUS united with *calcareous earth*. And,

3. The CHARCOAL of the marble is left us in its *simple state* †.

The proof, by synthesis, that the constituent principles of FIXED AIR ‡, are *charcoal*, and *oxygen* AIR, is more beautiful, as being easier understood. See over leaf.

THE

* If *diluted vitriolic acid* be poured on marble, an effervescence denoting the extrication of *fixed air* is seen; when the union of the *vitriolic acid* and *calcareous earth* is *complete*, it is said to be SATURATED, the effervescence now ceasing.

† The OXYGEN, with which it was before combined, being separated from it, by the *superior attraction* of the PHOSPHORUS.

‡ We owe our first knowledge of FIXED AIR to Dr. BLACK, but that *water* absorbed *this air* upon agitation, and was made Seltzer or Pyrmont water, and that if *iron filings* be put into *this acidulated water*, it became a *chalybeate*, we are indebted to the happy industry of Dr. PRIESTLEY.

The reader may, from the above account, doubt whether MARBLE contains FIXED AIR *(charcoal, oxygen,* and *caloric)*, or only the CARBONIC ACID *(charcoal* and *oxygen)*. We see, indeed, *water* absorbing a large bulk of FIXED AIR. But does not some portion of its *caloric* pass into the *cold water*, and hence the condensation (if I may be allowed the expression) of the FIXED AIR; for if a small heat be applied to the *aeriated water*, it parts with its FIXED AIR. The subject is yet somewhat obscure. If *sulphur* be burnt in *oxygen air (oxygen* and *caloric)*, VITRIOLIC ACID is gradually formed from the combination of the *sulphur* with the *oxygen*, and the *caloric* is disengaged. If *hydrogen* or *inflammable air* be burnt in *oxygen air*, the combination of the

THE SYNTHESIS.

THIS CHARCOAL * Mr. TENANT then burnt in *oxygen air*, which was converted into an ACID GAS, whose *weight* equalled the sum of the *weights* of the *charcoal* which had been burnt, and the *oxygen air* employed †.

THIS ACID GAS had all the *properties* of FIXED AIR. It was readily upon agitation *imbibed by water*, which acquired the sparkling appearance and taste of Pyrmont and Seltzer water. *This acidulated water* dissolved iron filings, and became a perfect chalybeate water. THIS AIR weighed *heavier* than *common air*. A *candle* being put in it, was quickly *extinguished*, and *an animal* died *convulsed in it*.

hydrogen with the *oxygen* is very rapid, and WATER is formed, and *the caloric* is suddenly disengaged: but if VITRIOLIC ACID be poured on WATER, a considerable quantity of *caloric* is then *also* disengaged, which seems to prove, that *in the condensation of airs*, on their change into solid substances, only a *portion* of their CALORIC is disengaged.

* ANY CHARCOAL would have had the same effect.

† FIXED AIR, or the CARBONIC ACID AIR, is composed of 28 parts of *charcoal* to 72 of *oxygen air*; or, in other words, 144 cubic inches of *that air* will saturate or take up 28 grains of *charcoal*.

THE ANALYSIS OF ADEPS, OR ANIMAL FAT;

Or its ſeparation into its 2 CONSTITUENT PARTS, { HYDROGEN, and CHARCOAL.

ANIMAL SUBSTANCES give the ſame products in diſtillation as the *cruciform* * tribe of plants, viz.

ELEMENTS.

	1.	2.	3.	4.	5.
1. WATER, - -	*oxygen,*	& *hydrogen,*	- -		
2. OIL, - - -	- -	*hydrogen,*	& *charcoal.*		
3. CARBONIC ACID,	*oxygen,*	- -	& *charcoal.*		
4. CHARCOAL, -	- -	- -	- -		
5. PHOSPHORATED CHARCOAL, -	- -	- -	*charcoal,*	& *phoſphorus.*	
6. AMMONIAC, -	- -	*hydrogen,*	- -	- -	& *Azot.*

But as theſe ſubſtances contain more *hydrogen* and *azot* than ſuch vegetables, they therefore produce a greater quantity of OIL and AMMONIAC.

That

* From moſt vegetable ſubſtances, excepting the cruciform plants, we obtain, by ſlow diſtillation,

FIRST EXPERIMENT.

	ELEMENTS. 1.	2.	3.
1. WATER, - -	*oxygen,*	& *hydrogen.*	
2. OIL, - - -	- -	*hydrogen,*	& *charcoal* (as will be proved).
3. CARBONIC ACID,	*oxygen,*	- -	& *charcoal.*
4. CHARCOAL.			

or, in other words, we obtain WATER acidulated with CARBONIC ACID, on the furface of which floats ESSENTIAL OIL,—and there remains in the retort unvolatalized by *caloric,* CARBON or CHARCOAL.

But had the heat at firft been confiderable in the furnace, we fhould have had *from the fame materials,* inftead of WATER,

SECOND EXPERIMENT.

	ELEMENTS. 1.	2.	3.	From the furnace. 4.
1. CARBONIC ACID GAS,	*oxygen,*	- -	*charcoal,*	& *caloric.*

The *oxygen* under thefe circumftances has a greater affinity for *carbon* than for *hydrogen.* And inftead of OIL,

	1.	2.	3.	4.
2. HYDROGEN GAS, -	- -	*hydrogen,*	- -	& *caloric.*

The *hydrogen* having in this cafe a greater affinity for *caloric* than for *charcoal.* And,

3. CHARCOAL.

It is an axiom in chemiftry, that in all its operations nothing is *created,* but only a new *arrangement of parts* takes place: for *the quantity of matter* ftill remains the fame after every procefs.

In the SECOND EXPERIMENT we have feen *vegetable matter* reduced to *its primeval elements,* HYDROGEN, OXYGEN, and CHARCOAL. If we carefully afcertain the quantity of HYDROGEN and CHARCOAL produced in the firft experiment, and *compare this quantity* with the quantity of HYDROGEN and CHARCOAL produced in the fecond experiment, we fhall find a *lofs* or *deficiency* of thefe *two fimple elements* in the produce of the FIRST EXPERIMENT, which correfponds exactly with *the weight* of the OIL.

VEGETABLE OIL is compofed therefore of *hydrogen* and *charcoal.*

I cannot

That ANIMAL OIL or ADEPS is compofed, like VEGETABLE OIL, of *charcoal* and *hydrogen*, will appear evident from the following *analyfis*, or feparation of ANIMAL OIL into its conftituent principles.

In the firft rectification of *animal oil* a fmall quantity of WATER is formed by the union of the *oxygen* contained in the air of the diftilling veffel, and the *hydrogen* of the oil. We can at length, by frequent diftillations, decompofe the *whole oil*, and convert it into WATER *(oxygen* and *hydrogen)* and CHARCOAL, and the weights of the CHARCOAL and WATER will be found exactly correfponding with thofe of the OIL and the OXYGEN AIR confumed.

I cannot help here obferving the ufe that vegetation is of to animal life as firft difcovered by Dr. INGENHOUST, in furnifhing the atmofphere during the day with abundance of VITAL or OXYGEN AIR. Dr. PRIESTLEY's experiments likewife prove that vegetables abforb the NOXIOUS AIR *(fixed air)* produced from combuftion, refpiration, and putrefaction; for which difcovery he received the thanks of the Royal Society.

Dr. FRANKLIN, in writing to this illuftrious experimentalift, fays, "That the *vegetable creation* fhould reftore the air, which has been fpoilt by the *animal part of it*, looks like a rational fyftem, and feems to be of a piece with the reft." Having obferved the rapid increafe that plants had in *air fatal* to animals (fixed air), he adds, "This feems to prove that fomething is taken from the air."

It now appears that the veffels on the under furface of leaves abforb WATER from the air, which paffing along the capillary tubes of the fuperior furface, by the action of the *fun*, and the influence of *light*, becomes decompofed, and the HYDROGEN of the *water* unites with the *fubftance* of the plant as one of its principles, while the fuperabundant OXYGEN is thrown out in the form of the PUREST VITAL, or OXYGEN GAS.

But

But ſhould the reader have any remaining doubts on this ſubject, he will be convinced by the peruſal of the following *curious account.*

By an arrêt from government *the burying ground* of the Innocents at Paris, which had been the common receptacle of a great part of the dead of that city for *many centuries*, was directed to be removed. It was compoſed of different burying-places. This name was given to excavations about 30 feet deep, and 20 in breadth, dug in the cemetery of the Innocents, in which were placed in tiers the bodies of the poor, incloſed in their coffins. The neceſſity they were under of aggregating together a great number, obliged the men employed in this buſineſs to place the coffins ſo near to each other, that theſe graves may be conceived as filled with a maſs of dead bodies, ſeparated from each other only by ſlight boards. Each of theſe graves contained about 1500 bodies. When full, the laſt row was covered with about a foot of earth, and a new cavity was opened at ſome diſtance. Each cavity was filled in about three years. The number of the dead, relative to the extent of the church-yard, regulated the *re-opening* of the *ſame ground* at periods of various extent. The ſhorteſt time, however, before an opening was made in the ſame ſpot was 15 *years.* Experience had taught thefe grave-diggers that *this period* was not fufficient for the total deftruction of the bodies, whilft it made them acquainted with the change which we are about to defcribe.

The opening which the *French chemifts* ordered to be firft made, was that of a grave which had been filled and clofed up for near 15 years. On raifing the covers of fome of the coffins, which were in perfect prefervation, we faw, fay they, the bodies enveloped in linen, which marked out the fhapes of the different regions; but when thefe were lifted up, there was prefented to us nothing but *fhapelefs irregular maffes of a foft, ductile, whitifh fubftance.*

Thefe maffes every where furrounded the bones. They poffeffed little folidity, and yielded to preffure. This fubftance had no unpleafant fmell. The grave-diggers had not the fmalleft repugnance to handle it, and they called this fubftance, which fo much ftartled the French philofophers, by the term FAT.

After examining feveral bodies with great attention, they found that all the bodies were not *equally advanced* in this procefs. In *feveral, portions of mufcular flefh,* diftinguifhed by its *fibrous texture* and *reddifh colour,* were

ftill

ſtill viſible, amid great maſſes of a WHITE FATTY SUBSTANCE.

In the bodies of women, the exterior part of the cheſt often ſhewed the glandular ſubſtance of the *breaſts*, changed into an homogeneous matter of peculiar whiteneſs, very much reſembling SPERMACETI. The *face* was not recogniſable in the greater number of bodies. The various parts of the *mouth* were not to be diſtinguiſhed. The *jaws*, ſeparate from each other, were ſurrounded with various portions of fat, and lumps of the ſame matter occupied the *cavity of the mouth*. The cartilages of the *noſe* underwent a ſimilar alteration. In the place of *eyes*, the orbits contained only maſſes of fat; and the *ears* were changed in a ſimilar manner. The *hairy ſcalp*, though altered like the other parts, ſtill retained the hair. The *brain* was conſtantly found changed into the ſame ſubſtance as the other organs.

In the *abdomen* there were found irregular maſſes of the ſame fat of various ſizes. In the *thorax* were ſmall pieces of a fatty matter, of a reddiſh colour; and ſometimes there were obſerved irregular round maſſes, which ſeemed to be formed of the fat and fibres of the heart.

The

The *marrow*, alfo, in the center of the cylindrical bones was wholly converted into a very pure fat; it even infinuated itfelf between the bony plates, filling up their interftices.

Although there is no doubt but that the quantity of this matter is larger in the bodies of fuch as have been fat than in thofe who have been lean, the facts we have mentioned, prove that other parts, befides the cellular texture, and fat it contains, are fufceptible of this alteration. The following obfervations are decifive with regard to this point. It is to be prefumed, that the greater number of bodies found in this common grave, were, previous to their death, emaciated by difeafe, and in thefe the bodies were found *univerfally* converted into fat, which we cannot fuppofe to have had a previous exiftence.

Our curiofity was fufficiently roufed, continue thefe chemifts, to extend our refearches into other church-yards. In thofe where bodies were buried in common graves, we found fimilar appearances. We met with the fatty matter in a fufficient variety of cemeteries to convince us, that the formation of this fingular fubftance was by no means peculiar to the foil in which we had at firft obferved it, but that it takes place every where,

where bodies are depofited in great numbers, clofe to one another, excluded from the action of external agents, and expofed folely to the effects of their conftituent principles.

We could obtain no pofitive information relative to what became of the bodies after they have been once changed into fat; the oldeft and moft experienced grave-digger knew nothing of this matter.

This converfion of the feveral parts of the human body into *true animal fat*, muft arife, fays Monf. LAVOISIER, from the difengagement of AZOT, naturally contained in all animal fubftances, leaving behind the *hydrogen* and *carbon*, which are the elements proper for the production of FAT or OIL.

Such are the phenomena taking place during the fpontaneous diffolution of bodies buried in the earth; phenomena heretofore equally unknown and undefcribed, fo that even words were wanting to convey our ideas. The prefent muft merely be confidered as a very imperfect outline of the picture, which pofterity muft fill up and finifh. For this purpofe it will be neceffary to live among the tombs, to follow up a long and repeated examination of various graves, and beftow indefatigable attention on the moft unpleafant, as well as the

the moſt melancholy of all purſuits. But even theſe obſervations, which an accident, fortunate for philoſophy, created, deſerve we think a place among the records of uſeful ſcience *.

* The juſtly celebrated Spaniſh traveller, the Rev. Mr. TOWNSEND, who unites with the accompliſhments of a gentleman, the profoundeſt erudition, has, we have been informed, buried a cow, which died by accident, in a water meadow at PEWSEY. The grave is but ſlightly covered with earth, and a conſtant ſtream of freſh water continually paſſes over it.

Should the reſult be, the total converſion of the muſcular fleſh of this cow into *ſpermaceti*, or the *fatty ſubſtance much reſembling it*, which is expected to take place in about ſix months, we make no doubt, but that the public will be favoured with the theory, and method, of this truly admirable and uſeful experiment.

The *ſpermaceti* formed by this converſion, will be, probably, worth about *four* or *five pounds*.

ON PUTREFACTION;

OR

THE RESOLUTION OF ORGANIZED MATTER

INTO

ITS CONSTITUENT PRINCIPLES.

PUTREFACTION is the great procefs appointed by the CREATOR, for the refolution of animal and vegetable fubftances into *the elements* from which they were firft formed. By this procefs, the oak and the bramble, the cedar and the hyffop, fruits, whether delicious, or nutritive, or acrid, or poifonous, the moft beautiful of the human fpecies, and the moft frightful of the other tribes of animals, are all reduced to one common lot: they finally return back to their original and primeval elements*.

* WATER and AIR, fays Sir ISAAC NEWTON, compofed of old worn particles and fragments of particles, would not be of the fame *texture* and *nature* now as at the beginning, did not the *primitive particles* of MATTER continue *entire*, and *compofe bodies* of *one* and the *fame nature and texture in all ages*. The *changes* of *corporeal things* are to be placed *only* in the *various feparations* and *new affociations* of *thefe permanent particles*. OPTICS, p. 376.

This

This resolution of bodies, when philosophically considered, is equally wonderful with their formation; and is alike governed by *regular* and *invariable laws.* Every plant brings forth its own kind, and every animal its own species. These live, they are nourished, and silently hasten to decay; they pass back to their *elementary state*, and are *again employed* as the *constituent parts* of *other vegetables* and *other animals.* Such, with respect to the material part of the creation, is the amazing circle of LIFE and DEATH! A circle in which nature keeps her steady rounds, and moves agreeably to laws established by the ALMIGHTY.

Vegetable substances which consist of HYDROGEN, OXYGEN, and CARBON, maintain for a long while their organised structure, and putrefy with difficulty. Having passed through first the *vinous* * and then the *acetous fermentations*,

* The first effect we see produced on vegetable substances which have lost their VITAL PRINCIPLE, is the destruction of the equilibrium, or just union of their three constituent principles (*hydrogen, oxygen,* and *carbon*), by the action, or operation, of *heat* and *moisture.* The OXYGEN unites with the CARBON, and the fermenting juice is covered on its surface with *carbonic acid gas.* The specific gravity of the liquor is now considerably diminished, and if exposed to distillation, it affords a *light inflammable substance*, called ALKOHOL, or SPIRIT OF WINE: which, as we might reasonably expect from the volatilization in great part of the *carbon* and *oxygen,* is almost entirely made up of

fermentations *, they at length become ſubject to the *putrefactive ferment* †, and the HYDROGEN of the vegetable eſcapes in the form of *hydrogen gas*, while the OXYGEN and CARBON evaporate in the form of *carbonic acid gas*, leaving nothing behind but a ſmall reſiduum of carbon and vegetable earth.

It is different with ſubſtances containing a portion of AZOT. The *equilibrium of parts* is ſoon deſtroyed. Hence it is that animal excrements, which contain, like other animal matters, a quantity of AZOT ‡, are added to the elements, capable of putrefaction, to form compoſts or dunghills.

of the other vegetable principle, *hydrogen:* for if 8 ounces of SPIRIT OF WINE or ALKOHOL be burnt in a confined apparatus containing only *oxygen gas*, the product will be 9 *ounces* of WATER. The ALKOHOL, having in this caſe increaſed its weight *an ounce*, muſt have attracted *ſomething*, and *this ſomething* can be *nothing elſe* but OXYGEN, the baſe of *oxygen air*, and the CALORIC of the *oxygen air* being diſengaged, is ſeen in its active form during the combuſtion.

* This *ſecond ſtage* of ſpontaneous decompoſition, as it is called, is nothing more than the *abſorption* or *imbibing* of OXYGEN from the air.

† When the ſpontaneous decompoſition is ſuffered to proceed beyond the *acetous proceſs*, then the *third ſtate*, or PUTREFACTIVE FERMENT, takes place.

‡ The putrefactive proceſs is moſt eminently perceived in *animal bodies*. Theſe either putrefy immediately; or, if the putrefaction be *preceded* by either of the other ſtages, their duration is too ſhort to be perceived.

The

The addition of AZOT not only accelerates the putrefactive procefs, but the *azot* combining with the *hydrogen* affords a new product, which is AMMONIAC or VOLATILE ALKALI*. Monf. Bertholet has proved, by a variety of experiments, that AMMONIAC is produced by the union of *azot* and *hydrogen*, for if the *azot* in the *animal fubftances* be difengaged by the action of diluted nitrous acid, NO AMMONIAC will be produced, and in all cafes putrifying fubftances furnifh AMMONIAC only in proportion to the *azot* they contain.

The following experiment alfo fully proves the compofition of AMMONIAC.

If AMMONIAC be combined, fays Monf. FOURCROY, with a METALLIC OXYD, the *hydrogen* of the AMMONIAC will unite with the *oxygen* of the METALLIC OXYD, and form *water*, whilft the *metal* is revived, and the *azot*, being left free, will unite with the *caloric* and affume the form of a *gas* or *air*.

AMMONIAC has a peculiar penetrating odour. In the putrefaction of animal fubftances fometimes AMMONIAC predominates, which is eafily perceived by its fharpnefs

* *This compound* did not naturally exift in the animal fubftance, but is formed by the combination, in a certain proportion, of two of its conftituent elements.

upon

upon the eyes, and ſometimes, as in putrid herings, the PHOSPHORATED HYDROGEN GAS is moſt abundant.

PHOSPHORUS is found in almoſt all animal ſubſtances, and in ſome plants which give indeed a kind of animal analyſis.

It is chiefly to AMMONIAC *(hydrogen* and *azot)* and PHOSPHORUS diſſolved in HYDROGEN GAS, that the fœtor iſſuing from the putrefaction of animal ſubſtances depends. This vapour is highly hurtful to animal life. When accumulated, if the pick-axe of the grave-digger unfortunately ruptures the coffin, it burſts forth, and oftentimes proves fatal to the ſexton, and is ſeen to affect even perſons *at a diſtance* with vertigo, nauſea, and uneaſineſs. May we not conceive, that a poiſon ſufficiently ſubtle to produce the immediate death of many when it firſt eſcapes from the place where it is confined, may even after it is diffuſed in the air retain virulence enough to injure the delicate animal fibre? After having obſerved the conſtant dread that grave-diggers have for this poiſonous vapour, after having ſeen the cadaverous paleneſs of countenance, and other marks of the gradual action of a ſlow poiſon ſo evident in the appearance of *all men employed much in church-yards*, it is impoſſible not to believe that the air in their immediate neighbour-

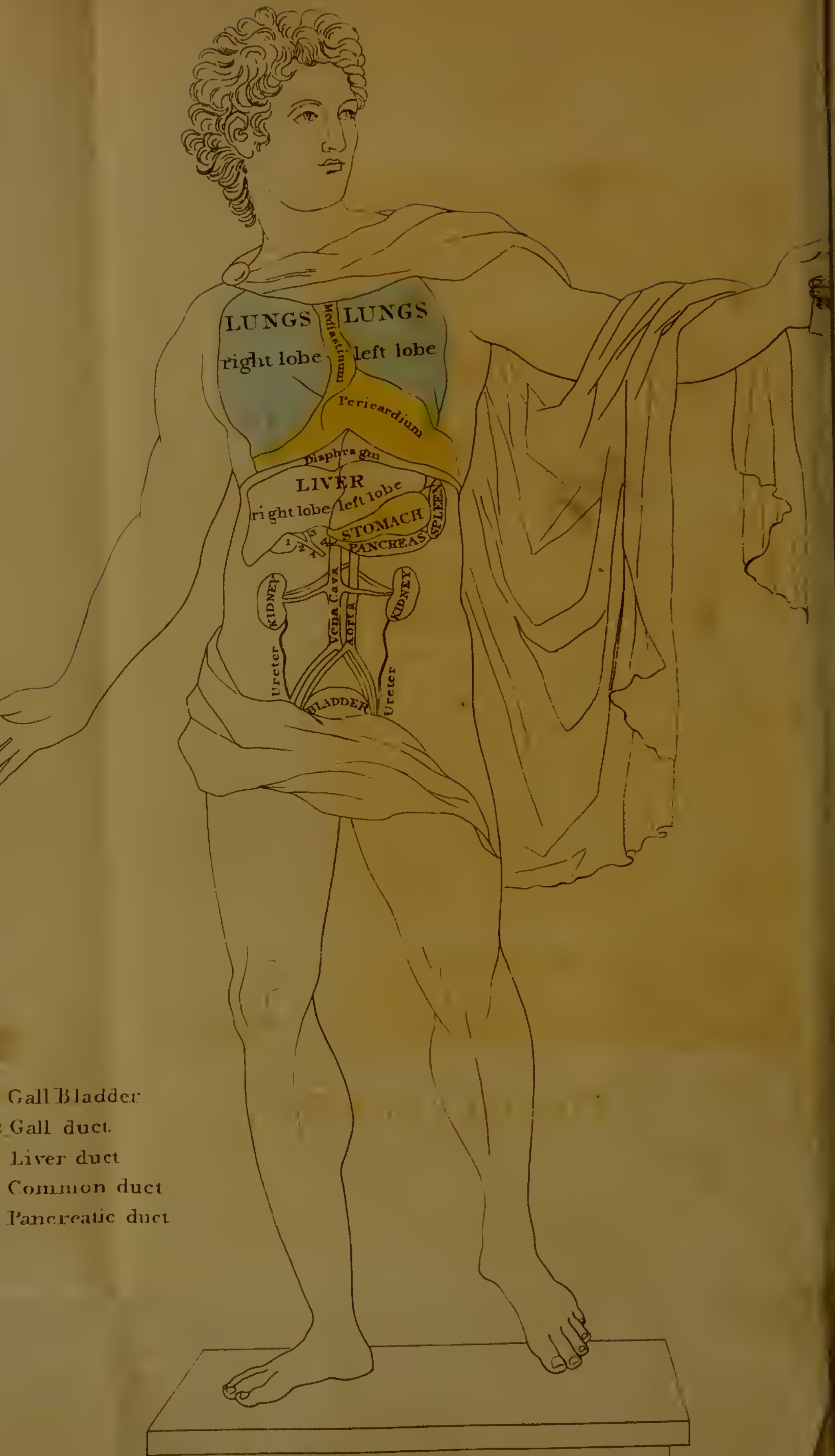
 hood

hood muſt, in ſome meaſure, injure the health of the inhabitants*.

* The ſame ſqualid appearance is obſerved alſo in perſons who live in places where animal ſubſtances are allowed to putrefy. Mr. CAREY, in deſcribing the dreadful *fever* which laſt ſummer prevailed in PHILADELPHIA, and ſwept off above 4000 perſons, emphatically ſays, "Shall I be pardoned for paſſing a cenſure on thoſe, whoſe miſtaken zeal led them, during the moſt dreadful ſtages of this calamity, to crowd our churches, and aid this frightful enemy in his work of deſtruction? who, fearful leſt his prayers and adorations at home would not find acceptance before the Deity, reſorted to *churches filled with bodies,* where, with every breath, they inhaled a CONTAGIOUS AIR. To *this ſingle cauſe* I am bold in aſcribing *a large proportion of the mortality.* I hope," he continues, "the awful leſſon ſome of our congregations hold forth on this ſubject, by a *mortality* out of *all proportion* to their numbers, will ſerve as a MEMENTO at all future times."

This benevolent gentleman would not ſurely wiſh to prevent perſons from aſſembling together, eſpecially in times of calamity, to pay their worſhip to THE SUPREME BEING, from whom every bleſſing that we enjoy flows, and on whom we utterly depend; but he ſhould rather caution us againſt *ſmall* churches, and the abominable practice of *burying the dead* in them, and thus converting *the temples of* GOD literally into *bone houſes.*

The pariſh church of St. LAWRENCE, in the ISLE OF WIGHT, would be crowded, if the congregation conſiſted of more than 20 perſons; with a ſtick of a moderate length you may reach to nearly two thirds of its height. MEETING-HOUSES uſually carry with them the *ſame objection.*



Gall Bladder
Gall duct
Liver duct
Common duct
Pancreatic duct

MAP of the VISCERA

INTRODUCTION.

A CONCISE VIEW OF THE WHOLE ANIMAL OECONOMY.

LET us begin with the lefs adorned, but more SOLID PARTS, which *fupport* and *defend* the reft.

First, we have a SYSTEM OF BONES, made in a *variety* of fhapes,—in a *variety* of fizes:—all *ftrong*, that they may bear up the machine, yet *light*, that they may not weigh us down:—*hollowed* with an inward cavity, to contain the moiftening marrow, and *perforated* with fine ducts, to admit of the nourifhing veffels. *General Obfervations refpecting the Bones.*

They are *larger* at their extremities,—and *infenfible*,—that they may be *joined* more firmly, and may not be *hurt* by preffure.

The manner of their *articulation* is *truly admirable*, and remarkably various: yet *never varied* without

7 demonftrating

demonſtrating ſome wiſe deſign, and anſwering ſome valuable end.

Frequently, when *two bones* are *united*,—the *one* is nicely *rounded* and capped with a ſmooth ſubſtance; the *other* is *ſcooped* into a hollow of the ſame dimenſions to receive it: and *both* are *lubricated* with an *unctuous fluid* to obviate the evil of *friction*, and to facilitate *rotation*.

Theſe are connected by LIGAMENTS,—a tough and ſtrong arrangement of fibres, which *render*, what would *otherwiſe* be an *elegant*, yet *uſeleſs aſſemblage* of *parts*, a *well compacted* and *manageable* SYSTEM.

Obſervations on particular Parts.

The Feet.

The FEET compoſe the firmeſt pedeſtal, infinitely beyond all that ſtatuary can accompliſh,—capable of *altering* its *form*,—and *extending* its *ſize*,—as different circumſtances require.

The undermoſt part of the heel, and the extremity of the ſole, are ſhod with a TOUGH INSENSIBLE SUBSTANCE: a kind of *natural ſandal*, which never wears out, never wants repair; and which prevents an undue compreſſion of the veſſels by the weight of the body.

The

The LEGS and THIGHS are like ſtately columns, ſo *articulated*, that they are commodious for *walking*, and yet adapted for the eaſy poſture of *ſitting*. *The Legs and Thighs.*

The RIBS, turned into a regular arch, are gently *moveable*, for the act of reſpiration:—they form a *ſafe lodgment* for the *lungs* and *heart*, the two moſt important organs of life. *The Ribs.*

The BACK-BONE is deſigned, not only to *ſtrengthen* the body, but to *ſhield* the continuation of brain, uſually termed the SPINAL MARROW, an almoſt infinite aſſemblage of nerves! *The Back-bone.*

By commodious *outlets* it tranſmits *theſe ſilver cords* to different parts of the body.

Had it been a *ſingle bone*, the *loins* muſt have been *inflexible*; to avoid which, it conſiſts of a number of *ſmall bones*, which *articulate* together, and are *ſtrengthened* by compact *ligaments*.

By this means it is capable of various *inflections*, without *injuring* the *cords of life*, or *diminiſhing* that *ſtrength*, which is ſo much required here.

This *peculiarity of ſtructure* gives the BACK-BONE the *pliancy* of an *oſier*, with the *firmneſs* of an *oak*.

Such

Such a formation in any other of the solids must have occasioned *great inconvenience.* Here it is *unspeakably useful*, a *master-piece* of *creating skill!*

The Arms. The ARMS are exactly *proportioned* to each other, to preserve the *equilibrium* of the structure.

These being—the *guards* to *defend*,—and the *ministers* that *serve* the whole body,—are fitted for *the most diversified* and *extensive operations:—firm* with *bone*, yet not *weighty* with *flesh*,—and *capable of performing all useful motions*, they bend *inward*, and turn *outward:* they move *upward*, or *downward.* They *wheel about* in *whatever direction* we please.

The Hands. To these are added HANDS, terminated by the FINGERS,—not of the *same length*,—nor of *equal bigness*,—but in *both respects* different, which gives *more beauty*, and *far greater usefulness.*

Were they *all flesh*, they would be *weak:*—were they *one entire bone*, they would be utterly *inflexible:*—but, consisting of *various little bones* and *muscles*,—*What shape can they not assume!*

Being placed at *the end* of the arm, the *sphere* of their action is exceedingly *enlarged.*

Their

Their *extremities* are *an aſſemblage* of the *fineſt nerves, acutely ſenſible*:—which, notwithſtanding, are deſtined to almoſt inceſſant employ, and frequently among *rugged objects*.

For *this reaſon* they are overlaid with NAILS, which preſerve them from any violent injury. *The Nails.*

The HAND is the original and univerſal ſceptre, which not only *repreſents*, but *aſcertains* our *dominion* over *all the elements*, and over *every creature*.

To theſe HANDS we owe thoſe *beautiful ſtatues*, this *melodious clarinet*.

By *the ſtrength* of the HAND *the talleſt firs* fall, and the *largeſt oaks* deſcend from the mountain.

Faſhioned by the HAND they become a *floating warehouſe*, and carry the *productions of art* from BRITAIN to the remoteſt corner of the univerſe.

Though we have not the *ſtrength* of the *horſe*,—*ſwiftneſs* of the *greyhound*,—or the *quick ſcent* of the *ſpaniel*,—yet, *directed* by the *underſtanding*, and *enabled* by the HAND, we can, as it were, make them all our own.

Theſe *ſhort* HANDS have found a way to *penetrate* the *bowels* of the *earth*.

These *feeble* HANDS can *manage* the *wings of the wind*,—*arm* themfelves with the *violence of thunder*,—and prefs into *their fervice* the *forcible impetuofity of water!*

How greatly then are we indebted to our infinitely wife CREATOR, *for this diftinguifhing, this invaluable member!*

The Head.

Above all is the HEAD, for the refidence of the *brain*, rounded to *receive*, and firm to *defend* it.

This is *fcreened* from *heat*,—*defended* from *cold*,—and at the fame time *beautified* by the HAIR:—a decoration *fo delicate*, as no art can fupply;—fo *perfectly light*, as no way to encumber the wearer.

While *other animals* are *prone* in their afpect, the attitude of *man* is *erect*, which is by far the moft commodious for profecution of all his extenfive defigns. Does it not *remind* us of our *noble original*, and our *fublime end?*

The Countenance.

Struck with the grandeur of the fubject, we would fain fet forth all its beauties; but our pencil, which is too faint, cannot correfpond with the vivacity of our conceptions. How indeed can any one defcribe with

with due energy—thefe admirable *proportions:—thefe features*, full of force and dignity, expreffing to all beholders the emotions and paffions as they arife in the heart;—this open and elevated *brow:*—thefe lively and piercing *eyes*, eloquent interpreters of the fentiments of the foul;—this *mouth*, the feat of fmiles;—thefe *ears*, whofe delicacy catches even the fofteft whifpers!

Obfervations on other Parts of the Body.

If you take a ftill further furvey of THIS BEAUTIFUL EDIFICE;—the *prodigious number* of its parts,—their *furprifing diverfity*,—*admirable conftruction*,—*wonderful harmony*,—and *infinite art*, difplayed in the diftribution of them,—it will throw us into fuch an *ecftafy*, as we fhall no fooner recover from, than *complain* of our want of *fufficient inclination* and *ability* to *admire* fuch MARVELLOUS EXCELLENCY.

The Arteries.

Here are ARTERIES, the *rivers* of our little world, that, ftriking out as they go into *numberlefs fmall canals*, vifit *every ftreet*, yea *every apartment*, in *the vital city*.

They are not, like feveral of the veins, *near the furface*, but placed at a *fufficient depth*, and thereby are more *fecure* from *external injuries*.

The ARTERIES alſo *communicate* by *collateral branches* with *each other*; ſo that if any thing *block up* or *ſtraiten* the *direct paſſage*, the *current*, by *diverting* to *this new channel*, eludes the impediment, flows on, and ſoon regains its wonted courſe.

The Pulſe.

The blood thrown from the heart *dilates* inſtantly the ARTERIES, whoſe fibres by their *irritability*, or *elaſtic power*, *react* on the blood: by which means as they propel it onward, they *vibrate* againſt the finger, and much aſſiſt the phyſician in the diſcovery and cure of diſeaſes.

The Veins.

The extreme branches of ARTERIES terminate in VEINS, which may be conſidered as uniting again into larger branches; then again into branches ſtill larger, and ſo on continually, till at laſt they form *one large pipe* or *trunk*, which *reconveys* the blood to the heart.

The *Diſtinction* betwixt a *Vein* and an *Artery.*

The ARTERIES are compoſed of ſeveral principal membranes placed on each other. One of theſe is highly elaſtic.

The VEINS, not being deſigned to exerciſe the ſame function as the arteries, *want this elaſtic coat*, and

and the texture of the reſt is conſiderably *ſlighter*; ſuch an *exact œconomiſt* is nature amidſt *all her liberality!*

At the root of the ARTERIES, and in the inner part of the VEINS are placed little SLUICES or VALVES, which by ſinking, and riſing again, *open*, and *ſhut* the canal. *The Valves.*

Theſe are found only where the blood is conſtrained to *climb*, for where *the aſcent ceaſes*, they *ceaſe alſo*.

In the centre of the breaſt, between two *ſpungy maſſes*, known by the name of THE LUNGS, is depoſited a fleſhy and hollow pyramid, called the HEART. This pyramid has its apex turned towards the left ſide, and is the MAIN SPRING of the animated machine. *The Heart.*

The ramifications of the BRONCHIA, or WIND-PIPE, which are diſperſed throughout the LUNGS, carry thither the *vivifying air*, which, by acting on *their ſpungy maſs*, opens, dilates, and extends them, and by that means facilitates the courſe of the blood. *The Lungs.*

Such

General Observations on the Organs performing the Circulation of the Blood.

Such indeed are the admirable organs deftined for *the circulation of the blood.* But how greatly does this imperfect fketch fall fhort of the reality! How incapable are thefe outlines of expreffing the beauties of this noble fubject!

There is in the confideration of the organs performing the circulation of the blood, an air of *grandeur* that feizes forcibly on the mind, and penetrates it with the higheft admiration.

Far *lefs magnificent* in its plans, *lefs fkilful* in the execution of them, HYDRAULICS offer us but *faint images* of this miracle, in thofe machines, by means of which water is diftributed into every quarter of a great city.

The works of the CREATOR muft be compared to the *emanations* of the fame INFINITE MIND. Ever like himfelf, HE has impreffed on all *his* productions a character of noblenefs and excellence, which demonftrate their *divine original.*

But what are thofe excellent difcoveries *philofophy* has made, compared with the beauties that are ftill *concealed* from our view! The gloom of night veils many important truths concerning the animal body, and you are defirous of feeing it chafed away. Will the

the dawn of that day ere long gild the horizon of the learned world? or is the time of its breaking forth upon us yet afar off?

The GLANDS are an aſſemblage of *tortuous veſſels*, *complicated* with *ſeeming confuſion*, yet *perfectly regular*. *The Glands.*

We cannot as yet *penetrate* into the *myſtery* of SECRETION; all that we know is, that thoſe fluids ſaid to be *ſecerned* are not *abſolutely contained within the blood*, any more than the *peach*, *nectarine*, or *other fruits*, are principles *filtered* from the earth, and water, which nouriſh the tree.

Neverthelefs as the *ſeven notes* of muſic *differently combined*, and the *twenty-four letters*, form the whole of *harmony*, and *language*, ſo may *all theſe fluids* ariſe from the *change* of *combination* of *primitive parts*, by a machinery that no chemiſt may ever be able perfectly to imitate.

But if we cannot unlock the whole of theſe ſublime operations, we ſhall at leaſt ſee *enough* to excite our admiration; and, from *the ſketch* I have already given of SOME LATE CHEMICAL DISCOVERIES, and the view I am about to take of THE

AGENCY

AGENCY OF OXYGEN AIR IN THE ANIMAL BODY, we may yet entertain fome feeble hope, that a glimmering of light will, in this age of inveftigation, be darted on thefe fubtle and hitherto impenetrable fubjects.

The Nerves. We have NERVES, which fhoot out their fibres from the brain, and when remote from their fource are *furprifingly minute*,—which *fet the mufcles to work* at the command of the will,—and diffufe *fenfation* throughout the body,—and upon any impreffion from without give *all needful intelligence* to the foul.

The Membranes. We have MEMBRANES, thin and flexible coverings,—to *enwrap* the flefhy parts,—to *connect* fome,—and form a *feparation* between others.

The Mufcles. We have MUSCLES, compofed of the *fineft fibrils*, yet endued with *incredible ftrength*;—fafhioned after a *variety* of patterns, but all in the higheft tafte for elegance and ufe. Thefe execute their functions as quick as *lightning*.—Were we to remove mountains, we could not be more aftonifhed, than that this arm, thefe fingers fhould obey the order of the will.

To turn the fcrew, or work the lever, is laborious and wearifome. But we work the vertebræ of the neck, with all their appendant parts; we advance the leg with the whole incumbent body; we rife, we fpring from the ground; and though fo great a weight is raifed, we meet with no difficulty or fatigue.

That all this fhould be effected without any toil, by *a bare act of the will*, is very furprifing. But *that it fhould be done*, even *while* we are *entirely ignorant* of the *manner in which it is performed*, is moft aftonifhing!

Who can play a fingle tune upon the fpinnet, without learning the difference of the keys? Yet *the mind* touches *every fpring* of the human machine, with the moft mafterly fkill, though fhe knows nothing at all of the nature of her inftrument, or the procefs of her operation.

More than two hundred reins are put into her hands; yet fhe manages all, conducts all, without the leaft perplexity or irregularity. Rather with a promptitude, a confiftency, and fpeed, that nothing elfe can equal!

We have FAT, an *unctuous fluid* contained in *veficles*, which have the appearance, if viewed through a microfcope, of a clufter of grapes. *The Fat.*

c This

This *flanks* and *fortifies* our mufcles like a ftrong baftion, *fupports* and *warms* them like a foft pillow. —In other places they *fill up* the vacuities, and *fmooth* the irregularities of the flefh.—*Inwardly*, they fupple the machine for motion; *outwardly*, they render it fmooth and graceful.

The Skin.

The SKIN is a curious furtout which covers the whole, formed of the moft delicate net-work, whofe mefhes are minute, and whofe threads are multiplied, even to a prodigy; the mefhes are fo minute, that nothing paffes them, which is difcernible by the eye; though they *difcharge*, every moment, myriads and myriads of fuperfluous incumbrances*. Thefe threads are fo multiplied, that neither the point of the fmalleft needle, nor the infinitely finer lance of a gnat, can pierce any part, without drawing blood, and caufing an uneafy fenfation. Confequently, without wounding, by fo fmall a puncture, both a *nerve* and a *vein!*

The Ufes of the other Parts of the Body.

But a courfe of inceffant action muft exhauft the folids, and wafte the fluids, and unlefs both be properly *recruited*, the machine would be deftroyed.

* The perfpirable fluid is fuppofed to be, 2 parts FIXED AIR, and 1 part AZOTIC AIR; and 3dly, WATER impregnated with different *faline matters*.

For

For *this reason* our body is furnifhed with the ORGANS, and endued with the *power* of NUTRITION.

We have TEETH, tefts of heat and cold, the *foremoft*, thin and fharp, to bite afunder the food;—the *fide teeth* for the purpofe of tearing;—and the *hindermoft*, broad and ftrong, indented with fmall cavities, the better to grind into pieces what is tranfmitted to them. *The Teeth.*

Were the TEETH, like other bones, covered with the periofteum, chewing would give much pain. Were they quite naked, they would foon decay and perifh. To *guard* againft *both*, they are overlaid with a neat ENAMEL, harder than the bone itfelf, which gives no pain in chewing, and yet fecures them from various injuries.

The LIPS prevent the food from flipping out of the mouth, and, affifted by the tongue, return it to the grinders. *The Lips.*

While they do this in concert with the CHEEKS, they fqueeze a *thin liquor* from the adjacent glands. *This moiftens* the food, and prepares it for digeftion. *The Cheeks.*

When the mouth is inactive *thefe glands* are nearly clofed; but when we fpeak or eat, their moifture being then neceffary, is expreffed as needs require. *The Salivary Glands.*

 But

The Gullet. But *the food* could not *defcend* merely by its *own weight*, through a narrow and clammy paffage into the ftomach.

Therefore to effect this, *fibres* both *ftraight* and *circular* are provided. The *former* enlarge the cavity, and give an eafy admittance. The *latter*, clofing behind the defcending aliment, prefs it downward.

The Wind-pipe. But before the food enters the gullet, it muft of neceffity *pafs over* the *orifice* of the WIND-PIPE: whence it is in danger of falling upon the lungs, which might occafion inftant fuffocation.

To *obviate this*, a MOVEABLE LID is placed, which when the fmalleft particle advances, is *pulled down* and *fhut clofe*, but as foon as it is fwallowed, is again let loofe and ftands open.

Thus the important pafs is always *made fure* againft any noxious approaches; yet *left free* for the admiffion of air, and for refpiration.

The Stomach. The food defcending into the STOMACH, is not yet ready for the bowels. Therefore that great receiver is ftrong to bear, and fitted to detain it, till it is properly wrought into the fmootheft pulp by the folvent power of the GASTRIC JUICE, a fluid fecreted in the ftomach itfelf.

From

From hence it is *discharged* by a gentle force, and *passes gradually* into the inteftines. *Of the Intestinal Canal.*

Near the entrance of this canal are THE DUCTS of the PANCREAS and GALL-BLADDER, which being *ftimulated* by the chyme*, occafions their refpective glands to pour forth their falutary juices. *The Pancreas and Gall-bladder.*

The PANCREAS is *connected* with the SPLEEN, which, as the ftomach gets filled, becomes preffed thereby, and in confequence pours into *this gland* a greater quantity of blood, to be changed into *the pancreatic juice.* *The Spleen.*

The GALL-BLADDER is *attached* to the LIVER, and is the *refervoir* to detain the bile, which *purges* the inteftines, and *blends* the *oil* and *aqueous parts* into *one homogeneous mafs.* *The Liver.*

It is furnifhed with a VALVE of a very peculiar nature, namely of a *fpiral form*; through which the deterfive liquid can only gently ooze. Admirable conftructions, which give the needful fupply, as occafion may require, and no more!

* A term ufed to exprefs the aliment when diffolved in the ftomach.

The

The nutriment then purfues its way through the mazes of THE INTESTINES.

The Plaits of the Inteſtines.

Had theſe been ſtrait or ſhort, the food could not have reſigned a ſufficient quantity of its nouriſhing particles: Therefore it is artfully *convolved*, and filled with numberleſs *folds* or *plaits*, and of *great length*.

The Villous Coat of the Inteſtines.

Along the ſides of this winding paſſage, countleſs multitudes of MINUTE VESSELS protrude themſelves, and abſorb the nutritious juices.

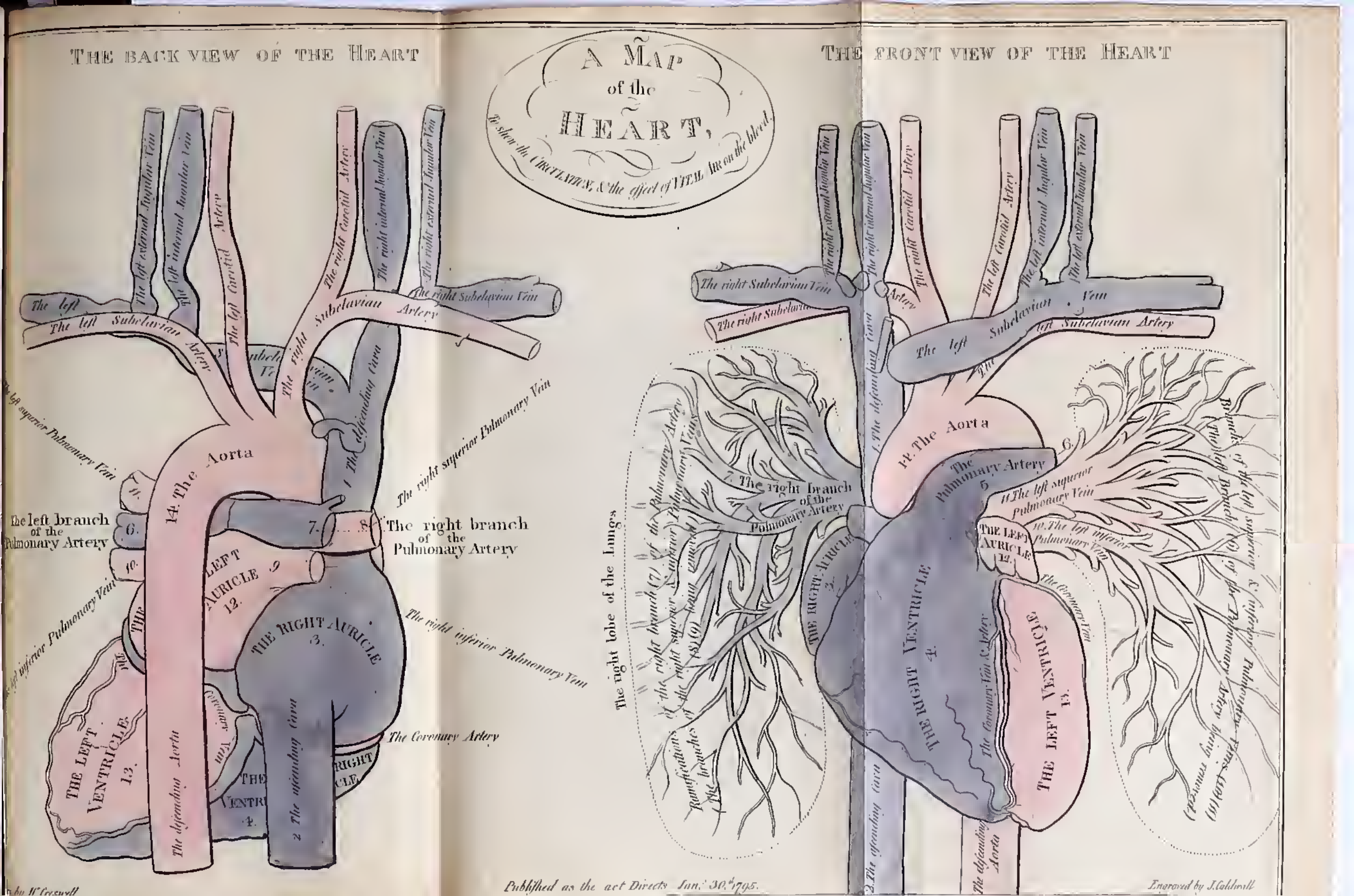
The Mucous Glands of the Inteſtines.

As the aliment proceeds, it is more and more drained of its nutritious juices.—GLANDS are therefore poſted in proper places to diſcharge a lubricating fluid. Theſe are ſmaller, or fewer, in and near the ſtomach, becauſe there the aliment is moiſt enough: whereas in the bowels, remote from the ſtomach, they are either multiplied or enlarged.

The Lacteals.

The *chyle* drawn off by the LACTEALS is carried through millions of tubes, whoſe perforation is too fine even for the microſcope to diſcover. To this it is owing that nothing enters the blood, but what is capable of paſſing through the *fineſt* veſſels.

It


THE BACK VIEW OF THE HEART
A MAP of the HEART, To shew the CIRCULATION, & the effect of VITAL AIR on the blood.
THE FRONT VIEW OF THE HEART
The left external Jugular Vein
The left internal Jugular Vein
The left Carotid Artery
The right Carotid Artery
The right internal Jugular Vein
The right external Jugular Vein
The left Subclavian Artery
The right Subclavian Artery
The right Subclavian Vein
The left superior Pulmonary Vein
14 The Aorta
1 The descending Cava
The right superior Pulmonary Vein
The left branch of the Pulmonary Artery
The right branch of the Pulmonary Artery
LEFT AURICLE 12.
THE RIGHT AURICLE 3.
The right inferior Pulmonary Vein
The left inferior Pulmonary Vein
The Coronary Artery
THE LEFT VENTRICLE 13.
The descending Aorta
2 The ascending Cava
The right Subclavian Vein
The right Subclavian Artery
The left Subclavian Vein
The left Subclavian Artery
The left Carotid Artery
The left internal Jugular Vein
The left external Jugular Vein
14 The Aorta
The Pulmonary Artery 5
7. The right branch of the Pulmonary Artery
11 The left superior Pulmonary Vein
10. The left inferior Pulmonary Vein
THE LEFT AURICLE 12.
The right lobe of the Lungs
THE RIGHT AURICLE 3.
THE RIGHT VENTRICLE 4.
The Coronary Vein & Artery
THE LEFT VENTRICLE 13.
The Coronary Vein
2 The ascending Cava
The descending Aorta
Published as the act Directs Jan. 30th 1795.
Engraved by J. Caldwall

It is then lodged in feveral commodious cells (the GLANDS of the MESENTERY) and there mixed with a thin diluting *lymph*, which makes it more apt to flow. *The Mefenteric Glands.*

Here it is conveyed to THE COMMON RECEPTACLE and mounts through a PERPENDICULAR TUBE to be poured into the LEFT SUBCLAVIAN VEIN *. *There* it *mixes* with the blood, and *lofes* the *name* of *chyle*. *Receptaculum Chili. The Thoracic Duct. The left Subclavian Vein.*

From THIS VEIN the *new blood* paffes into the UPPER BRANCH of the PRINCIPAL TRUNK of VEINS †, which carries it towards the heart. *The Vena Cava Superior.*

It then paffes into the RIGHT AURICLE ‡ of the heart, which *opens* at its approach, and, by *clofing* immediately, forces it into the RIGHT VENTRICLE ||, which is *dilated* to receive it. *The right Auricle of the Heart. The right Ventricle.*

The VENTRICLE inftantly *contracts* itfelf (the *valve*, with which it is furnifhed, raifing itfelf to

* Vide the engravings of the heart.
† Vide figure (1).
‡ Vide figure (3).
|| Vide figure (4).

oppofe

oppoſe the reflux into the auricle); and the blood is compelled to paſs into THE GREAT ARTERY *; which is appointed to carry it to the lungs.

The Pulmonary Artery.

The PULMONARY ARTERY, which is ſubdivided into *two trunks* †, which paſs to the right and left lobes compoſing the LUNGS (its *valve* preventing the reflux into the heart), by contracting, drives the blood into every part of that organ.

The Air Cells of the Lungs.

In the *ſpungy cells* of this amazing laboratory, the blood imbibes the *oxygen portion* of the external air, and aſſumes, in conſequence, *a more brilliant colour* ‡.

The left Auricle.

The 4 Pulmonary Veins.

Thus improved, it *enters* THE LEFT AURICLE of the heart ‖ by *the four* PULMONARY VEINS §, and, in *proportion* to the *oxygen air* contained within the blood, the LEFT AURICLE ⸸

* Vide figure (5), plate 11.

† Vide figures (6), (7), in plate 2. The right pulmonary branch is removed.

‡ This is proved page 70 of this work.

‖ Vide figure (12).

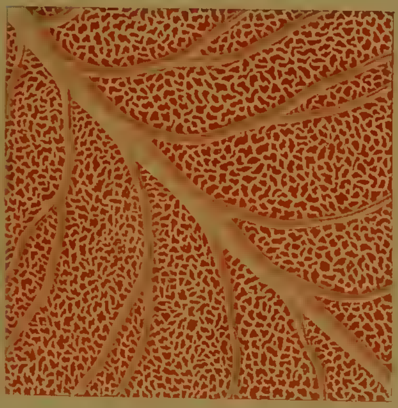
§ Vide figures (8), (9), (10), and (11). The two right pulmonary veins are repreſented in plate 2. the two left being removed.

⸸ Vide figure (12).

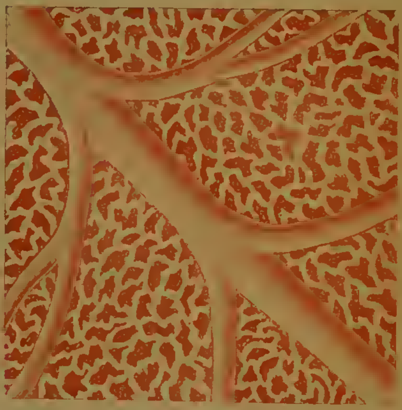
3 of

Two small portions of the Lungs
to shew,

The air-cells of the Lungs;



These cells magnefied.



The appearance of the air-cells
after expiration.

The Ramifications of the
Bronchia.or Windpipe.

of the heart, obedient to the ſtimulus, contracts, and forces it into THE LEFT VENTRICLE *. *The left Ventricle.*

This LATTER, by contracting itſelf, puſhes the blood into the AORTA †, which, by continually dividing and ſubdividing itſelf, diſtributes its balſamic liquor to all the parts of the body, in order to promote their *ſupport* or *growth*,—occaſion *different ſecretions*,—and diſtribute *the animal heat* ‡. *The Aorta*

By this aſtoniſhing mechaniſm, and dependence on the vital principle in the air, the powerful energy of the heart, ſeconded by that of the arteries, tranſmits the blood to the moſt remote parts of the body, notwithſtanding the reſiſtance which gravity, friction, and many other circumſtances make to it in its courſe.

The *large muſcles* of the arm or of the thigh are ſoon wearied: a day's labour, or a day's journey, exhauſts their ſtrength. But *the heart* toils whole weeks, whole months, nay years, unwearied: is equally a ſtranger to intermiſſion and fatigue.

The HEART receiving the *diſtending* and *ſtimu-*

* Vide figure (13) in the plate.

† Vide figure (14).

‡ Vide ſect. vii. page 81.

lating power of the BLOOD, contracts on it, and in *one minute*, ſuch is its amazing force, it propels, ſays Baron HALLER, fifty-one *pounds of blood* through tubes of different dimenſions; which if meaſured out, would extend to beyond 149 feet. In a healthy perſon it contracts not much leſs than 5000 *times* in an *hour*, perpetually in the ſame order, and never with fatigue.

The PULSE ariſes from the *dilatation* and *contraction* of the ARTERIES, which in ſome meaſure correſpond with *thoſe* of the HEART.

Impelled by the AORTA (for its *valve* prevents the reflux into the heart) part of the blood ſhoots upwards to the head; part rolls through the whole body. But how ſhall a ſtream divided into myriads of channels be *brought back* to its ſource?

For *this purpoſe* the allwiſe CREATOR has connected the *extremities* of all the ARTERIES with the *beginning* of the VEINS; ſo that the *ſame force*, which darts the blood through the *former*, helps to drive it through the *latter*.

The Vena Cava Superior and Inferior.

The blood entering into the right auricle by the *two oppoſite currents* of the VENA CAVA SUPERIOR

RIOR and INFERIOR *, that the ſtreams may not claſh, a FIBROUS EXCRESCENCE interpoſes, which, like a projecting pier, breaks the ſtroke of each, and throws both into their *proper receptacle* †.

Thus is the blood *re-conducted* to the great ciſtern, and thence played off afreſh, firſt THROUGH THE LUNGS, and then THROUGH THE BODY.

We ſee even from this imperfect ſurvey, that man is a very *complex machine.*

Two peculiar diſtinguiſhing Excellencies in the Animal Machine.

In it there is a *peculiarity* which claims particular notice,—a *power* which defies all human ingenuity and imitation, and diſtinguiſhes the natural from any artificial machine.

1. Self Reſtoration.

As our bodies are compoſed of flexible materials, whereby they are liable to receive injuries by too rude a ſhock from harder bodies;—and as the humours are alſo ſubject to receive alterations from changes of weather, irregularities in diet, and other accidents, it was needful, that the body, beſide the

* Vide figures (1) (2) in the plate.

† Namely, the right auricle.

power neceſſary for its performing all the functions requiſite in a healthy ſtate, ſhould be provided alſo with *other powers*, whereby the hurts, and deviations from a healthy condition, might be amended and reſtored.

Were there not *ſuch a power* in the body, we could ſcarce arrive at full age in any other than a disfigured condition, and the loſs of the due action of many parts. But our CREATOR has kindly provided, that the body, upon any wound received, ſhould ſupply *a cement*, whereby the divided parts are again united, or throw out *granulations*, and the breach is healed up. Thus a *broken bone* is made firm again by a callus; a *dead part* is ſeparated and thrown off; *noxious juices* are driven out by ſome of the emunctories; a *redundancy* is removed by ſome ſpontaneous diſcharge; a *bleeding* naturally ſtops of itſelf; and *a great loſs of blood* from any cauſe, is, in ſome meaſure, compenſated by a contracting power in the vaſcular ſyſtem, which accommodates the capacity of the veſſels to the quantity contained. Thus *the ſtomach* gives information when the ſupplies have been expended; repreſents with great exactneſs the quantity and the quality of what is

wanted

wanted in the prefent ftate of the machine; and, in proportion as fhe meets with neglect, rifes in her demand, urges her petition with a louder voice, and with more forcible arguments; and for its protection, the animal body is made capable of refifting heat and cold in a very wonderful manner, and preferves an *equal temperature* * in a burning and in a freezing atmofphere.

There is a ftill farther excellence or fuperiority in the natural machine, yet more aftonifhing, more beyond all human comprehenfion, namely, a power to *perpetuate*, as well as to *preferve* itfelf.

2. The Continuation of the Species.

A dead ftatue, a painted fhadow on a canvas, or, perhaps, a little brazen clock-work, is the fupreme pride of the art of man, his higheft excellence and boaft.

On the other hand, how glorious and fkilful an artificer would he be called, could he but make two of thefe pieces of clock-work, and fo contrive the hidden fprings and motions within them, that they fhould perpetuate their kind, and thus continue

* Vide fect. x. page 96.

the

the ſame ſort of clocks in more than a thouſand ſucceſſions down to the preſent day.

Such is the workmanſhip of God! *Such* the amazing power of *his* will! *Such* the long reach of *his* foreſight, who has long ago guarded againſt all poſſible deficiencies; who has provided energy in nature ſufficient to repleniſh the world with plants and animals to the end of time, by the wondrous contrivance of his creation, and the laws he then ordained.

Not all the united powers of human nature, nor a council of the niceſt artificers, with all their enginry and ſkill, can even form a ſimple gooſe-quill or a tulip. *Yet man can produce a man.* Admirable effect, yet artleſs cauſe! A poor, limited, inferior agent! The plant and the brute in this matter are *his* rivals and *his* equals too.

The human parent and the parent bird form their own images with equal ſkill, but are confined by a kind of divine patent each to his own work. So the iron ſeal transfers its own figure to the wax with as much exactneſs and curioſity as the golden one: both can transfer only their own figure.

Perhaps there is not a lily or a butterfly now in the world, but has gone through *ſix thouſand anceſtors*; and yet the work of the laſt parent is exquiſitely perfect in ſhape, in colour, and in every perfection of beauty: but it is all owing to the FIRST CAUSE.

Who can know and conſider, ſays the celebrated Dr. HUNTER, the thouſand evident proofs of the aſtoniſhing art of THE CREATOR, in forming and ſuſtaining an animal body ſuch as ours, without feeling the moſt pleaſing enthuſiaſm? Can we ſeriouſly reflect upon this awful ſubject, without being almoſt loſt in adoration? without longing for another life after this, in which we may be gratified with the higheſt enjoyment, which our faculties and nature ſeem capable of, the ſeeing and comprehending the whole plan of THE CREATOR, in forming the animal body, and in directing all its operations? The man who is really *an anatomiſt*, yet does not ſee and feel what I have endeavoured to expreſs in words, whatever he may be in other reſpects, muſt certainly labour under a dead palſy in one part of his mind. Milton could look upon the ſun at noon-day without ſeeing light: but the nerves of that organ were *inſenſible*.

5 But

Of the five Senses.

But farther. The great CREATOR has made us an *invaluable present* of the SENSES, to be the *inlets* of *innumerable pleasures*, and the *means* of the *most invaluable advantages.*

The Eye.

The EYE, in its *elevated station*, commands the most enlarged prospects.

Consisting only of *gelatinous fluids*, enclosed within coats, it shews us all the graces and glories of nature.

How wonderful, that an image of the hugest mountains and the widest landscapes, should enter the small PUPIL! that the rays of light should paint on the OPTIC NERVE, paint in an instant of time, paint in their truest colours and exactest lineaments, every species of external objects!

The EYE is so tender, that the slightest touch might injure the delicate frame.

It is *guarded, therefore*, with *peculiar care*, entrenched deep, and barricadoed round with bones.

As the smallest fly might incommode its polished surface, it is *farther protected* by two substantial CURTAINS.

The Eye-lids.

In sleep, when there is no occasion for the sense, but

but a neceſſity to guard the organ, the curtains *cloſe* of their own accord.

At other times, if danger threaten, they *fly together* as quick as thought.

They are lined with an extremely fine membrane, moiſt with its own dew.

Its BRISTLY PALISADES ward off the ſweat of the brow, and moderate the too ſtrong impreſſions of the light. *The Eye-laſh.*

As in our waking hours we have almoſt inceſſant need for theſe little orbs, they run upon the fineſt CASTORS, rolling every way with the utmoſt eaſe; which circumſtance, added to the flexibility of the neck, renders our two eyes as uſeful as a thouſand. *The Muſcles of the Eye.*

The EAR conſiſts of an *outward porch* and an *inner room.* *The Ear.*

The PORCH, ſomewhat *prominent* from the head, is of a cartilaginous ſubſtance, and wrought into *ſinuous cavities.*

Theſe, like *circling hills*, collect the wandering undulations of the air, and tranſmit them with a vigorous impulſe to the finely ſtretched membrane of the DRUM.

 This

This is expanded upon a circle of *bones*, over a polifhed reverberating cavity. It is furnifhed with BRACES that *ftrain* or *relax*, as *the found* is *faint* or *ftrong*.

The HAMMER and the ANVIL, the winding LABYRINTH and the founding GALLERIES, *thefe* and *other fpecies* of *mechanifm*, all inftrumental to hearing, are inexpreffibly curious.

Amazingly acute muft be the AUDITORY NERVES, fince they anfwer the fmalleft tremors of the atmofphere, and diftinguifh their moft fubtle variations, even when combined.

Thefe cords, turned by an Almighty hand, and fpread through the echoing chambers, receive all the impreffions of found, and propagate them to the brain. *Thefe* give the exiftence to the charms of mufic, and ftill nobler charms of fpeech.

The EYE is ufelefs amidft the gloom of night; but the EAR hears through the darkeft medium.

The EYE is on duty only in our waking hours; but the EAR is always acceffible.

As there are concuffions of the air, which are

 difcernible

discernible only by the instruments of HEARING, so there are *odoriferous particles* wasted in the air, which are perceivable only by the SMELL.

The Smell.

The NOSTRILS are *wide* at the bottom, that more effluvia may enter;—*narrow* at the top, that when entered they may act more strongly.

The streams that exhale from fragrant bodies, are *fine* beyond imagination.

Microscopes that shew thousands of animals in a drop of water, cannot bring one of these to our sight. Yet so exquisite are the OLFACTORY NERVES, that they arrest the vanishing fugitives. They imbibe all the roaming perfumes of the spring, and make us banquet even on the *invisible dainties* of nature.

Another capacity for pleasure our bountiful CREATOR has bestowed, by granting us the power of TASTE.

Taste.

This is circumstanced in a manner so benign and wise, as to be a standing plea for *temperance*, which sets the finest edge on the taste, and adds the most poignant relish to its enjoyments.

Touch. To all theſe, as a moſt neceſſary ſupplement, is added the ſenſe of FEELING.

The Mind. The crowning gift however, which augments the benefits accruing from all the ſenſes, is REASON.

Of the Superiority of Man above other Animals.

After having admitted, in its fulleſt extent, every fair *compariſon* that can be made between *man* and the moſt perfect of the *other animals*, acknowledging that *both* have bodies of matter organized in many reſpects alike; that the bodies of *both* are made up of bones, muſcles, and blood-veſſels, organs of reſpiration, circulation and digeſtion; that *both* have brain and nerves apparently of the ſame ſubſtance and texture; that in *both*, thoſe are the organs of will, of ſenſation, and of motion; that *both* poſſeſs five ſenſes of the ſame nature, and have a reſemblance in many of their appetites and inclinations; after all thoſe conceſſions, the *internal faculties* of the moſt intelligent of the brute creation will be found, upon a juſt eſtimation, at a *prodigious diſtance beneath* thoſe of men.

The actions of the one ſeeming to proceed from *the impulſe* of ſome want, the incitement of ſome ap-

petite,

petite, or ſome controlling ſpring within them, which obliges them to perform the ſame thing in the ſame manner; ſo that all their boaſted works, the labours of every ſpecies, and every individual of the ſpecies, are as uniform as if they had been all caſt in the ſame mould. This appears in their neſts, in their cells, for all their works which aſtoniſh us, are formed by an *inevitable neceſſity*, like *the growing* of a *plant*, or *the cryſtallization* of a *ſalt*.

One race of the moſt intelligent ſpecies *never improves* upon a *former*, nor *one individual* upon *another*.

At the end of the elephant's long life, what does he know that he did not know at the beginning? What does the *young elephant* learn from the experience of his father?

Even *attention to their young*, the moſt univerſal and moſt amiable part of the character of irrational animals, ſeems independent of ſentiment and reflection, and to proceed from *the ſame blind impulſe* which prompts them to build ſuch a kind of neſt and ſit ſuch a time on their eggs; for after a ſhort

period

period thofe young are *entirely neglected*, and *no trace of affection*, or *the fmalleft tender recollection*, feems any longer to fubfift between the parent and the offfpring.

How *different* is this from the fenfation of the *human fpecies?* where the *father* and *mother* feel their youth reftored, and their exiftence multiplied in *their children*, whom they endeavour to turn from the allurements of *folly*, and by creating in their minds a defire of *knowledge* and *ufeful attainments*, they fave from the wretchednefs of *vacancy*, and contempt, attendant upon *ignorance*; who *encourage* their exertions, *fupport* them under difappointment, whofe *chief happinefs* depends on *the profperity* of *their offspring*, and who *feel the approach* of *age without fadnefs*, while *the evening* of their lives is *brightened* by the *rifing reputation* of *their children*.

Sometimes with a ftrong and harmonious voice, *man* is found celebrating, in a poem, *the virtues* of a *hero*.

At other times, by *a ftroke* of *the pencil*, he *changes* a *dull* and *flat canvafs* into a *charming perfpective*.

Here do we fee him, with *the chiffel* and *graver* in his hand, *animating* the *marble*, and *giving life* to *brafs*.

There

There with the *plummet* and *ſquare*, erecting a *magnificent palace*.

Now do we behold him, by the aſſiſtance of a *microſcope* of his own invention, diſcovering *new worlds*, amidſt *inviſible atoms*, or penetrating *the ſecret exerciſe* and *ſtructure* of a particular organ.

At other times, by changing this *microſcope* into a *teleſcope*, he *pierces* into the heavens, and there contemplates *Saturn* and *his Ring*.

Returning home, he *preſcribes Laws* to *theſe celeſtial bodies*, *deſcribes* their paths, *meaſures* the *earth*, and *weighs* the *ſun*.

Afterwards, directing his attention towards the more uſeful ſtudy of organized beings, he dives into *the laws* of the animated fibre, examines the *relations* of different parts, and by an attentive view of their various perfections, he ſees a chain formed which comprehends the whole.

But the *moſt perfect mark* of the *greatneſs* of *man*, and of *his high exaltation above other animals*, is *the commerce* he holds with his Creator.

Wrapped in the thickeſt darkneſs, *the reſt* of the *animal creation* are *ignorant* of *the hand* that *formed them*.

They

They enjoy an exiſtence, but cannot trace the AUTHOR of life.

Man alone ſoars to GOD the principle, and proſtrate at the foot of the throne of the ALMIGHTY, he adores with the profoundeſt ſentiments of veneration, and with the moſt lively gratitude, the INEFFABLE GOODNESS that created him.

Having taken this *haſty ſurvey* of the ANIMAL ECONOMY, we now proceed to *the more particular conſideration* of the *relation we ſtand in with reſpect to the* EXTERNAL AIR, and ſhall *afterwards humbly attempt* to diſcloſe THE CAUSE of VITAL and INVOLUNTARY ACTION.

It has been computed by the Abbé Fontana, that a pound of *nitre*, calcined in a close vessel, yields 12,000 cubic inches of OXYGEN, or VITAL, AIR. It is singularly curious that a substance of such very humble pretensions as common *nitre* (salt-petre) should possess properties on which hangs the fate of the most powerful empires! Since by chemistry it may either be converted into a fulminating engine, to overturn fortified cities, and to enable the garrison to launch out death and destruction on the besiegers: Or,—that by a different process, it may be made to pour forth VITAL AIR, that VIVIFYING FLUID diffused through the atmosphere, which breathes in the zephyrs, which whispers in the breeze, and which cheers and supports all animated Nature!

How many thousand tons of *nitre* has Europe consumed of late, in making gunpowder, and that with the avowed intention of DESTROYING thousands of its inhabitants! Might not a small portion be spared for another purpose, at least equally humane and laudable, viz. that of PRESERVING an unfortunate fellow creature! Should the present advanced price of *nitre*, however, render the preparation of VITAL AIR too expensive a *remedy*, the latter may be obtained by a similar process from *manganese*. Besides, the VITAL AIR from *manganese* has been lately discovered to be of superior quality, and in greater abundance; a circumstance of *no small importance*, now that the demand for VITAL AIR, on account of *medicinal purposes*, is daily increasing; nor is that to be wondered at, since the new light, which it continues to reflect on the *œconomy*, has already began to dawn on the *pathology*, a circumstance which seems to denote, that a very material REVOLUTION in the practice of physic is at no great distance.—From Dr. Fothergill's Essay, *On the Suspension of Vital Action*, to which was adjudged, by the *Medical Society* of London, the *prize* of a GOLD MEDAL.

PART II.

THE AGENCY

OF

OXYGEN, OR VITAL, AIR

IN

THE ANIMAL BODY.

Aëra nunc igitur dicam, qui corpore toto
innumerabiliter privas mutatur in horas.
Semper enim quodcunque fluit de rebus, id omne
aëris in magnum fertur mare, qui niſi contra
corpora *retribuat* rebus recrectque fluentis,
omnia jam reſoluta forent, et in aera verſa.
Haud igitur ceſſat gigni de rebus, et *in res
recidere* aſſidue, quoniam fluere omnia conſtat.

LUCRET.

SECT. I.

To ſhew "THAT AIR IS ABSOLUTELY NECESSARY FOR THE PRESERVATION OF LIFE," many have been the animals that idle curioſity has tortured in the priſon of a receiver. We ſhall, from a thouſand inſtances, produce that of the *viper*, as it is known to be a reptile exceedingly tenacious of life, and as we ſhall feel but little compaſſion for its ſufferings.

Mr. Boyle took a new caught viper, and ſhutting it up in a ſmall receiver of an air pump, he exhauſted the air. At firſt the reptile began to ſwell, it then moved up and down as if in queſt of air, and after a while foamed, leaving the foam ſticking to the ſides of the glaſs. It continued in this ſtate 23 hours, and appeared by its poſture, even after the lapſe of two hours, lifeleſs. But upon the air being admitted, the viper opened and cloſed its mouth, and continuing theſe alternate motions for a few ſeconds, it ſtill argued ſome remains of life. Other creatures, in the exhauſted receiver, ſoon grow convulſed and die *.

* Why ſome animals are more tenacious of life than others, will hereafter be explained. Vide the Section on the Laws of the Nervous Syſtem.

SECT. II.

As in this inſtance AIR *is abſolutely neceſſary for the continuance of life*, "SO IS A DUE SUPPLY OF IT INDISPENSABLE."

The ſoubah, or viceroy of Bengal, dying in the month of April, in the year 1756, he was ſucceeded by his adopted ſon SUR RAJA AL DOWLAH, a young man of the moſt violent paſſions, without faith, principle, or fortitude.

In the month of *May*, he cauſed the Engliſh factory at CASSIMBUZAR to be inveſted, and invited Mr. Watts, the chief of the factory, to a conference; he detained him as a priſoner, and made himſelf maſter of the factory.

He then marched to CALCUTTA, and inveſted this ſettlement, which was in no poſture of defence. The *governor*, intimidated by the numbers and power of the enemy, abandoned the fort, and, together with ſome of the principal perſons reſiding in the place, took refuge on board a ſhip in the river, carrying with them their moſt valuable effects.

The

The defence of the place then devolved to Mr. Holwell, the fecond in command; who, with the affiftance of a few gallant officers, and a very fmall garrifon, maintained the place with fingular courage and refolution, till at length, the enemy having forced their way into the caftle, he was obliged to furrender; the foubah having firft promifed him, on the honour of a foldier, " that no injury fhould be offered him or his garrifon."

Having made them prifoners, he ordered them, to the number of 146 perfons, to be put into a place called the Black-Hole prifon, a cube of about 18 feet, open only to the weftward by *two windows* ftrongly barred with iron.

The humane reader will conceive, with horror, the miferable fituation to which they muft have been reduced, thus ftewed up, in a *clofe fultry night*, under the climate of Bengal, efpecially when he reflects that many were *grievoufly wounded*, and all of them *greatly fatigued* by the exertions of the preceding day.

A *profufe fweat* quickly broke out on every individual, attended with an *infatiable thirft*, which became the more intolerable as the body was drained of its moifture.

It was in vain that they ſtript off their clothes, or fanned themſelves with their hats.

A *difficulty in breathing* was next obſerved, and every one *panted for breath.*

Mr. HOLWELL, who was placed at one of the windows, accoſted the ſerjeant of the guard, and endeavouring to excite his compaſſion, he drew a pathetic picture of their ſufferings, and promiſed to gratify him in the morning with a thouſand rupees, provided he could find means to remove ſome of his people into another place of confinement.

The Indian, allured by the promiſe of ſo mighty a reward, aſſured him he would uſe his utmoſt endeavour, and retired for that purpoſe.

What muſt have been the impatience at this time of theſe unhappy objects? — — — — —
— — — — — — — —
— — — — — — — —
— — — — — — — —

In a few minutes the jemmadar returned, *but the tyrant*, by whoſe order alone ſuch a ſtep could be taken, *was aſleep, and no one durſt diſturb his repoſe!*

The deſpair of the priſoners now became outrageous. They endeavoured to force open the door, that they

might

might rufh on the fwords of the monfters, by whom they were furrounded, and who derided their fufferings; but all their efforts proved ineffectual. They then ufed execrations and abufe to provoke the guard to fire upon them.

The jemmaudar was at length moved to compaffion. He ordered his foldiers to bring fome fkins containing *water*, which, by enraging the appetite, only ferved to increafe the general agitation. There was no other way of conveying it through the two windows but by hats, and this mode of conveyance proved ineffectual, from the eagernefs and tranfports of the wretched prifoners who ftruggled for it in fits of delirium.

The cry of *Water! Water!* iffued from every mouth.

The confequence of this eagernefs was, that very little fell to the lot even of thofe who ftood neareft the window; and even thefe, who were efteemed the moft fortunate, inftead of finding their thirfts affuaged, grew more impatient.

The confufion foon became general and horrid; all was clamour and conteft; thofe who were at a diftance endeavoured to force their paffage to the window, and the weak were preffed down to the ground never to rife again.

Mr. HOLWELL obferving now his deareft friends in the agonies of death, or dead, and inhumanly trampled on by the living, finding himfelf wedged up fo clofe as to be deprived of all motion, he begged, as the laft mark of their regard, that they would for one moment remove the preffure, and allow him to retire from the window, and die in quiet.

Even in fuch dreadful circumftances, which might be fuppofed to have levelled all diftinctions, the poor delirious wretches manifefted a refpect for his rank and character: they forthwith gave way, and he forced his paffage into the center of the place, which was lefs crowded, becaufe, *by this time*, about one third of the number had perifhed, while the reft ftill crowded to both the windows.

He retired to a platform at the further end of the room, and lying down upon fome of his dead friends, recommended his foul to heaven.

Here his *thirft* grew infupportable; his *difficulty in breathing* increafed, and he was feized with a *ftrong palpitation of the heart.*

Thefe

Thefe violent fymptoms, which he could not bear, urged him to make another effort: he forced his way back to the window, and cried aloud, *Water for God's fake!*

He had been fuppofed already dead by his wretched companions, but finding him ftill alive, they exhibited another extraordinary proof of regard to his perfon: *Give him water, they cried*, nor would one of them attempt to touch it until *he* had drank!

He now breathed more freely, and the palpitation ceafed: but finding himfelf ftill more thirfty after drinking, he abftained from water, and moiftened his mouth, from time to time, by fucking the *perfpiration* from his fhirt fleeves, which tafted foft, pleafant, and refrefhing.

The miferable prifoners now began to perceive it was AIR and not *water* that they wanted.

They dropt faft on all fides, and a *pungent fteam* arofe from the bodies of the living and the dead, as *pungent* and *volatile* as *hartfhorn*.

Mr. HOLWELL being weary of life, retired once more to the platform, and ftretched himfelf by the Reverend Mr. Bellamy, who, together with his fon,

a young

a young lieutenant, lay dead, locked in each other's arms.

In this fituation he was foon deprived of fenfe, and feemed to all appearance dead, when he was removed by his furviving friends to one of the windows, where the frefh air brought him back to life *.

The faubah, being at laft informed that the greater part of the prifoners were *fuffocated*, inquired if the chief was alive; and being anfwered in the affirmative, fent an order for their immediate releafe, when NO MORE THAN 23 SURVIVED of 146 who entered into this prifon alive.

Mr. HOLWELL and his furviving companions were directly feized with a *putrid fever* †, and in this condition even dragged before the faubah to be queftioned about a treafure, which he believed they had fecreted.

* How perfons apparently dead are brought back to life by the means of *frefh air*, will be in the fequel better underftood. Vide Section on the Recovery of drowned Perfons.

† This throws great light on the *origin* and *nature* of CONTAGIOUS FEVERS. Vide the Section which treats on Fevers.

This

This gentleman, having denied the empty aſſertion, was, with three of his friends, loaded with fetters, and conveyed near three miles to the Indian camp, where they lay a whole night expoſed to a ſevere rain.

The next morning they were brought back to the town, chained and ſuffering the ſcorching rays of a ſun intenſely hot. Then large and painful *boils** came out, and covered their whole body.

In this piteous condition they were embarked in an open boat for the capital of Bengal, and underwent ſuch cruel treatment and miſery in their paſſage, as would ſhock the humane reader ſhould he peruſe the particulars.

At length the ſoubah's mother interpoſed, and he replied, with an unexpected generoſity, "*their ſufferings have been great, and they ſhall have their liberty.*"

They were accordingly releaſed, but Mr. HOLWELL, whom I ſaw a few years ago at Southampton, informed me, that he had never ſince enjoyed any health †.

Another melancholy proof of the NECESSITY OF A DUE SUPPLY OF AIR, may be drawn from the teſtimony of Dr. TROTTER, delivered before a Select Com-

* Petechiæ. † Smollet.

mittee of the House of Commons, in the year 1790.

In July 1783, the ſlave-ſhip, in which he was, arrived at Cape La How, on the Gold Coaſt of Africa. In the ſpace of a week above *one hundred* prime ſlaves *,

* Dr. Trotter ſays, that the natives of theſe parts are *ſometimes* ſlaves from *crimes*, but the greater part of the ſlaves are, *what are called priſoners of war*. Of his whole cargo he recollects only *three criminals*; two ſold for *adultery*, and one for *witchcraft*, whoſe *whole family ſhared his fate*. One of the firſt ſaid he had been decoyed by a woman who had told her huſband, and he was ſentenced to *pay a ſlave*; but being *poor*, was *ſold himſelf*. The laſt ſaid he had had a quarrel with a *caboſheer* (or great man) who *in revenge* accuſed him of *witchcraft*, and ſold *him* and *his family for ſlaves*.

Dr. Trotter having often aſked Accra, a principal trader at Le Hou, what he meant by *priſoners of war*, found they were ſuch as were carried off by a ſet of *trepanners and kidnappers, who ravage the country for that purpoſe*. The buſh-men making war, *to make trade* (that is, *to make ſlaves*), was a common way of ſpeaking among the traders. Having aſked, What they did with their ſlaves when the nations, who traded for ſlaves with them, were at war with each other? was anſwered, That when ſhips ceaſed to come, *ſlaves ceaſed to be taken*. The practice was alſo confirmed by the ſlaves on board, who ſhewed by geſtures how the *robbers* had come upon them.

He once ſaw a black trader ſend his canoe to take *three fiſhermen* employed in the offing, who were immediately brought on board, and put in irons, and about a week afterwards he was paid for them. He remembers another man taken in the ſame way from on board a canoe along-ſide. The ſame trader very frequently ſent ſlaves on board in *the night*, which, from their own information, he found, were *every one of them* taken in the neighbourhood of Annamaboe. He remarked, that ſlaves ſent off in the *night*, were not paid for till they had been ſome time on board, leſt, he thinks, they ſhould be *claimed*; for *ſome were really reſtored*, one in particular, a boy, was demanded and carried off on ſhore by ſome near relations, which boy told him, he had lived in the neighbourhood of Annamaboe, and was *kidnapped*.

young, *ſtout*, and *healthy*, were purchaſed. The competition, however, of the purchaſers at ANNAMABOE, whither this ſhip afterwards ſailed, ran ſo high, that the captain could not obtain more than two thirds of the uſual compliment. The ſlaves were confined below ſixteen hours out of twenty-four, and permitted no exerciſe when upon deck. The rooms, where they were ſecured, are from five to ſix feet in height. Theſe rooms are imperfectly aired by gratings above, and ſmall ſcuttles in the ſide of the ſhip, which of courſe can be of little uſe at ſea. The gratings are alſo half covered, when it blows hard, to keep out the ſalt ſpray. The temperature of theſe rooms was often above 96 of Fahrenheit's ſcale. In the evidence, of which this is an abſtract, Dr. TROTTER affirms, he could never breathe there, unleſs under the hatchways. In ſuch circumſtances the ſufferings of theſe poor creatures muſt have been dreadful. I have often, ſays Dr. TROTTER, obſerved the ſlaves drawing their breath with all the laborious and anxious efforts for life, which are obſerved in expiring animals, ſubjected by experiment to foul air, or in the exhauſted receiver of an air-pump. I have often ſeen them, when the tarpawlings have been inadvertently thrown over the gratings, attempting to heave them up, crying out in their own language, "*We are ſuffocated.*" Many have I ſeen dead, who the night before have ſhewn no ſigns of the ſmalleſt indiſpoſition; ſome alſo in a dying ſtate, and if not brought up quickly upon the deck, irrecoverably loſt.

Hence, before the arrival of this veſſel at ANTIGUA, out of 650 ſlaves more than 50 had *died*, and about 300 were tainted with the SEA SCURVY *.

Mr. WILSON ſtates, that in his ſhip, and three others belonging to the ſame concern, they purchaſed among them 2064 ſlaves, and *loſt* 586. He adds, that he has known ſome ſhips in the ſlave trade bury a *quarter*, ſome *a third*, and others even *half* of their cargo †.

* Vide the Section on the SEA SCURVY.

† Even on the preſent regulated plan the ſituation of the ſlaves muſt be dreadful; for their bodies touch each other, and many of them have not room to ſit *upright*.

Ye bands of ſenators! whoſe ſuffrage ſways
BRITANNIA's realms, whom either IND obeys;
Who right the injured, and reward the brave,
Stretch your ſtrong arm, for *ye have power to ſave!*
Throned in the vaulted heart, his dread reſort,
Inexorable conſcience holds his court;
With ſtill ſmall voice the plots of guilt alarms,
Bares his maſked brow, his lifted hand diſarms;
But, wrapt in night with *terrors* all his own,
He ſpeaks in thunder, when the deed is done.
Hear him, ye ſenates! Hear *this truth* ſublime,
HE, WHO ALLOWS OPPRESSION, SHARES THE CRIME.

Dr. DARWIN.

To

To mention no other fact, a ſtrong proof of " THE NECESSITY OF A DUE SUPPLY OF AIR, may be found in the Hiſtory of the DUBLIN *Lying-in Hoſpital.*

In this hoſpital 2944 infants out of 7650 died in the years 1782, 1783, 1784, and 1785, within the firſt fortnight after their birth, that is nearly *one child* out of every *ſix.* They almoſt all died in convulſions, of what the nurſes called *nine-days fits*, becauſe they came on within nine days after their birth. Theſe children, many of them, foamed at their mouths, their thumbs were drawn into the palms of their hands, the jaws were locked, the face was ſwelled and looked *blue*, as *though they were choaked.*

This laſt circumſtance led the phyſicians to conclude that the rooms in the hoſpital were too *cloſe* and *crowded*, and hence that the infants had not a ſufficient quantity of *good air* to breathe. They contrived therefore *air-pipes*, 6 inches wide, which were placed in the ceiling of each room. Three holes, an inch wide, were bored through each window frame; and a number of holes were made in the doors at the bottom.

Thus the rooms were kept *ſweet* and *freſh*; and the *conſequence* has been, from the regiſter in that hoſpital, that,

In

Children.				
In 1786,	out of	1372	there died	51
1787,	——	1375	——	59
1788,	——	1496	——	55
		4243		165

So that ſince the alteration of the rooms as to airineſs, out of 4243 there died 165 children; whereas before, the average amount of deaths from the ſame number was 1632*.

* If out of 4243 children there periſh, *when the hoſpital was ventilated,* only 151 infants, how many may be expected to die out of 7650, the number of children born in the DUBLIN *Lying-in Hoſpital* in the years 1782, 1783, 1784, and 1785? The anſwer is, by the rule of proportion, 279. But how dreadful the account, there periſhed abſolutely 4243, deducting 279, ſolely *from the want of a due ſupply of air!* We have not only to deplore the number of innocent victims who were deſtroyed at this time and previous to it, but alſo to lament the wretched anguiſh of the diſconſolate parents, and the impoveriſhed ſtate of health in many of the poor babes who ſurvived this ſlaughter.

The great and good Dr. Hales, whoſe ſtudies and experiments were conſtantly directed to the benefit of mankind, recommended a trial of *ventilators* in the SAVOY and NEWGATE priſons, in both of which the *jail fever* was frequent, and commonly fatal: the good effects exceeded even his moſt ſanguine expectations; for a very ſmall proportion of the ſick died, when the ventilators came into uſe, and the contagion ſeemed in a manner arreſted. The benevolent Mr. HOWARD found the priſons on the continent perfectly free from *this peſtilential fever*; owing, as he thinks, to the apartments in which the priſoners were confined being ſpacious, and conſequently well aired.

SECT. III.

HAVING proved the connexion betwixt *life* and *air*, it it is neceffary now to fhew WHAT ARE THE CHEMICAL ALTERATIONS AIR UNDERGOES BY BEING RESPIRED.

Dr. PRIESTLEY having formed NITROUS AIR by the folution of various metallic bodies in *nitrous acid*, he difcovered that it poffeffed this fingular property, that when mixed with *common air*, a great *diminution* of the bulk of the 2 aerial fluids takes place, attended with a turbid red, or deep orange colour, and a confiderable heat.

I hardly know, fays this philofopher, any experiment, that is more adapted to amaze than this, which exhibits a quantity of *air*, which, as it were, devours a quantity of *another kind of air*, half as large as itfelf, and yet, inftead of acquiring *larger dimenfions*, becomes itfelf *confiderably contracted**.

This

* We are not fo much furprifed when we find an *aeriform body* ftarting out from a *folid fubftance*, as in the formation of *this* and *other factitious airs*; but we are more fenfibly affected, when, on the reverfe, *two invifible aerial* *bodies*

This diſcovery was a moſt agreeable one to me, adds this great experimentaliſt, as I hope it may be an *uſeful one* to the public. It is remarkable that *this air* occaſions no effervescence or diminution with *fixed* or *inflammable airs*, but only with AIR FIT FOR RESPIRATION *and* COMBUSTION, and, as far as I can judge, *exactly in proportion* to *its fitneſs for that purpoſe* *; ſo that by this means the *goodneſs* of any air may be diſtinguiſhed much more accurately, than by putting into it a mouſe, or any other animal, to try how long it can exiſt in any given quantity. By *this teſt* I was enabled to perceive a *real difference* in the air of my *ſtudy*, after a few perſons had been with me in it, and the air on the *outſide of my houſe*. A phial of air being ſent me from the neighbourhood of YORK, it appeared to be not *ſo good* as the air near LEEDS; that is, it was not *diminiſhed ſo much* by an *equal* mixture of NITROUS AIR.

The juſtly celebrated chemiſt LAVOISIER, aſcertains

bodies are converted into a *compact coloured fluid*, which, like ſteam, being condenſed, occupy, in *compariſon* with their former dimenſions, ſcarcely any perceptible *ſpace*. The NITROUS AIR here attracts to itſelf OXYGEN, CALORIC is given out, and *this combination* gives us *nitrous acid*.

* That is in proportion to the quantity of OXYGEN it contains, which will preſently appear to be the PABULUM VITA, or *principle of life*.

the

the proportion of *oxygen air* *, or *the vital principle* contained in any given quantity of common air by the means of PHOSPHORUS. His EUDIOMITER is thus conſtructed. Having filled a cylindrical glaſs tube with quickſilver, he immerſes it in a baſon of the ſame fluid. He then puts into it *the air*, the purity of which he propoſes to examine. He afterwards paſſes up the PHOSPHORUS, and having heated an iron wire at the extremity red hot, he applies the hot end to the PHOSPHORUS through the quickſilver, which quickly conſumes †, and the quickſilver *riſes* nearly 27 diviſions (if the tube has been accurately divided into 100 parts ‡); after which time, if any *phoſphorus* remains, it ceaſes to burn, there being no more OXYGEN in the tube to be attracted by the *phoſphorus* §.

By

* It was ſhewn in the former part of this work, that *atmoſpheric air* is a compound of *two diſtinct* and *ſolid ſubſtances*, OXYGEN and AZOT, rendered *aerial*, by the ſuſpenſive power of CALORIC, or FIRE. Vide p. 14.

† *Phoſphorus*, like other combuſtible bodies, attracts OXYGEN, the particles being once ſeparated beyond their ſphere of mutual attraction, or *the attraction of coheſion*. The *caloric*, which is diſengaged from the *attracted oxygen*, anſwers the ſame purpoſe as the *hot iron* which firſt kindled the *phoſphorus*. The *phoſphorus* becomes, in conſequence of this union with *oxygen*, PHOSPHORIC ACID.

‡ In 100 parts of atmoſpheric air, there is moſt commonly found 27 of *oxygen air*; or in other words, in 100 *gallons of air*, there would be found 27 *gallons* of OXYGEN AIR, and 73 of AZOTIC AIR.

§ This clearly evinces that *combuſtion* is the divorcement of OXYGEN

K from

By *this means* LAVOISIER aſcertained, that when the *air out of doors* conſiſted of

27 parts OXYGEN *air*,
and 73 —— AZOTIC air.

100 parts.

The air in the loweſt ward in the GENERAL HOSPITAL at *Paris*, contained

but 25 parts of OXYGEN AIR,
and 71 — of AZOTIC air,
and 4 — of *fixed air* *.

100 parts.

And when, before the play, the *air* in the THEATRE in the Thulieries contained

from CALORIC, which *being ſet at liberty*, aſſumes, as it is eſcaping, the character of *flame* or *fire*, for the PHOSPHORUS no longer burns, than while OXYGEN GAS is preſent, and the PHOSPHORIC ACID will have an *increaſe of weight* exactly correſponding to the *weight* of OXYGEN AIR *conſumed*; that is, 100 parts of PHOSPHORUS will abſorb 154 parts of OXYGEN or VITAL AIR.

* This proportion varied in different parts of the ſame room. At the top the air had ſuffered much more injury. It contained

but $18\frac{1}{2}$ parts of OXYGEN AIR,
and 79 —— of AZOTIC AIR,
and $2\frac{1}{2}$ —— of *fixed air*.

100 parts.

27 parts

27 parts of OXYGEN AIR,
and 73 — of AZOTIC air.

100 parts.

Towards the conclufion of the piece, which was acted before an unufual concourfe of fpectators, it contained

but 21 parts of OXYGEN AIR,
and $76\frac{1}{2}$ — of AZOTIC AIR,
and $2\frac{1}{2}$ — of *fixed air.*

100 parts.

Whence it is evident, that the *quantity* of OXYGEN, or VITAL, AIR had been diminifhed in the theatre in the proportion of 27 to 21, or nearly *one fourth*; that is, it was ONE FOURTH LESS FIT FOR RESPIRATION THAN BEFORE.

The air of the atmofphere, therefore, which is originally compofed of 2 *fluids*, is compofed of 3 *aerial fluids*, in all places which contain numerous affemblies of people. *Thefe* 3 aerial bodies, though blended together, arrange themfelves in fome degree according to their fpecific gravities; that is, the proportion of AZOT, which is the lighter body of the 3, will be found moft in the *upper part*, and the FIXED AIR will be found moſt in the *lower part* of the apartment.

This occaſions a circulation in the air, for, in ſpite of the architect, the *rarefied air* will aſcend, the *fixed air* ſink, and the *colder air* ruſh into the apartment through every crevice *.

Unleſs

* To render the CIRCULATION of the air *ſenſible*; if the air of a room be *heated* by a fire in it, whilſt the air of a contiguous room is *cold*; then let the door between theſe two rooms be opened, in which caſe the *hot air* of one room being *rarefied* will paſs through the *upper part* of the opening of the door into the cold room; and on the contrary the *cold air* of the other room being *heavier*, will paſs into the former through the *lower parts* of the opening. This may be proved by applying a candle at the *top* and *lower parts* of the opening between the two rooms. The direction of the flame of the candle will point out the *contrary currents of air*. It is for this reaſon that when a fire is lighted in a chimney, a *ſtrong current of air* enters the room, which may be felt by applying the hand near the key-hole or other ſmall openings, if the doors and windows are ſhut. It is in this way that a fire is ſaid to purify a room: but this effect is only becauſe the fire promotes the *circulation* of the air, and dries the dampneſs of the apartment: ſo that it is not the infected air that is purified, but a *new*, *freſh*, and *wholeſome air*, by the action of fire, that is made to take place of a bad and corrupt air. Hence it appears, that thoſe perſons are miſtaken who are over-anxious in keeping out the air from entering the apartments of convaleſcent perſons, by *accurately ſtopping, by liſt, linings*, and *ſand-bags, all the ſmalleſt openings that admit freſh air.*

I cannot forbear mentioning here, as it relates to health, the method for preventing *ſmoky chimneys*. The particles of air, which are expanded by the fire, being lighter than thoſe particles which are not heated, juſt as a cork riſes, if placed at the bottom of a tub of water, ſo muſt the *rarefied air* aſcend and paſs up the chimney, as being the lighter body of the two. If we conceive the figure of a FRENCH HORN, it is evident that *the volume of air* contained

in

Unlefs *this were the cafe*, and unlefs *the air was conftantly renewed*, the fpectators would be expofed to the moft fatal accidents long before the conclufion of the performance.

To convince ourfelves of this truth, nothing more is neceffary than to take the example of a room, let it be fuppofed 30 feet long by 25, and 30 feet high.

A room of thefe dimenfions would contain 100 fpectators. Now fince each perfon confumes about 5 cubic feet of air in an hour, that is, deprives fuch a quantity of air of its *oxygen* or *vital principle*, it would follow, that as fuch a room could contain only 22,500 cubic feet of air, that unlefs the air was conftantly renewed, it would be rendered completely mephitic or noxious in about *four hours and an half*, and it is probable that the greater part of the audience would be ferioufly incom-

in the mouth-piece, would be *fooner heated*, than *that at the bafe*, and therefore the *rarefaction of air* be more certain, were any given quantity of heat applied to the *fmaller* than the *larger portion of air*. It is thus with chimneys, the more they refemble the *French horn*, the more certain the afcent of the fmoke, for the *fmaller* the *portion of air* at the bottom, the *fooner* will it be heated, and the BALANCE at the *lower* and *upper parts* of the chimney being deftroyed, the *lighter air* cannot but afcend and carry with it the fmoke.—THE APERTURE at the *bottom* of chimneys fhould, therefore, be *fmall*.—Dr. FRANKLIN.

moded,

moded, or even perifh, long before the end of that period *.

The fame calculation applies to all confined places, where a number of perfons are affembled together; efpecially if the air circulates in them flowly, or with difficulty: *the oftener it is refpired the more it will become vitiated*; and it is eafy to obferve how the attention of the audience fails them in fuch places. They can no longer liften to the difcourfe. The irritating quality of the mephitic air excites a general coughing. The preacher now receives none of thofe marks of attention or refpect, which in more favourable circumftances he had a right to expect. They experience a drowfy head-ach. They exprefs even a phyfical anxiety to be gone, and the congregation feel themfelves on returning home jaded, and till revived by a *more wholefome or oxygenated air* they look wan, like perfons who are ready to faint away.

We therefore fully agree with Dr. THORNTON, who, in a letter to Dr. BEDDOES †, the celebrated Pro-

* The affecting narrative of the BLACK HOLE of CALCUTTA, and the DUBLIN LYING-IN HOSPITAL, are melancholy confirmations of the truth of this fuppofition of LAVOISIER's.

† Vide the communication of this phyfician, as publifhed by Dr. BEDDOES.

feffor

feſſor of Chemiſtry at Oxford, and inſtitutor of the *New Practice*, ſays, that he is perſuaded OXYGEN GAS would be found of great ſervice, if diffuſed at certain ſeaſons, in *mines*, in *churches*, in *crowded rooms**, in *hoſpitals*, and other

* A lively young lady, who came to BATH, to put herſelf under the care of Dr. MAKITTRICK ADAIR, gave a rout, and inſiſted, that he ſhould be of the party. The room was *ſmall*, and the company very *numerous*. He had not been long ſeated at the card-table, before a young gentleman, his partner, *fell into a ſwoon*. The doors were immediately thrown open to afford him freſh air, and the ſaſh lifted up, and both the gentleman who ſwooned, and the young lady, Dr. ADAIR's patient, who were invalids, were much injured by the ſudden expoſure to a current of cold air. How the reſt of the company were affected, ſays Dr. ADAIR, I had not an opportunity of knowing; but my own feelings and ſufferings for many hours after I retired from *this oven*, convinced me of the *dangerous conſequences* of *ſuch meetings*. On declaring a few days after, to one of my brethren, a man of humour, my reſolution of writing a bitter philippic againſt routs, he archly replied, "Let them alone, Doctor, how otherwiſe ſhould *twenty-ſix* phyſicians ſubſiſt in this place?"

If a ſmall tube, opening into the apartment deſigned for ROUTS, was to communicate with the outward air, the external orifice of the tube being made *ſomewhat* ABOVE THE LEVEL *of the room*, the fire and breath of the aſſembly would have no ſooner heated the air, than it would riſe immediately *upwards*, ſo as to fill more particularly the higher parts of the room; and as other particles would be ſucceſſively heated and rarefied in their turn, by their expanſive force they would preſs upon the upper ſtatum of air, ſo as to force the *lighteſt particles* through the opening left for that purpoſe in the ceiling of the room, by which contrivance the *foul and hot air* of the apartment would be *gradually drawn off*.

But in order *to admit freſh air* into the drawing-room, if another opening be made in the ceiling of the room, having a communication with a ſmall pipe that ſhould lead from thence to the outſide of the houſe, and extend *ſome way* BENEATH THE LEVEL *of the room*: in this ſituation the *cool external air* would be other public buildings, and efpecially in the bathing-rooms at BATH, where great *faintnefs* is often brought on the patients who are bathing by breathing a *reduced atmofphere* from the extrication of AZOTIC AIR, which is given out in a confiderable quantity by thofe waters *.

be forced in at the lower opening of the tube, and afcend into the apartment in proportion to the quantity that efcaped from the upper region by means of the other tube: and fince weighty air would no fooner enter the room than it would tend downwards by its own natural gravity, it would gradually be heated by the warm air in its defcent, and would thus be difperfed about the room, fo as *mildly* and *imperceptibly* to reach the company, and fupply them with a fufficient quantity of frefh and vivifying air, without any of thofe inconveniencies to which the company are fubjected by the ufual way of admitting *frefh air*. This fimple contrivance might be made as *elegant* as it muft be beneficial, and fuperfede in a great meafure the patent ftoves, which admit hot and cold air. Vide note p. 17.

* In every hundred weight of MINIUM or RED LEAD, there is combined about 12 *poands* weight of *oxygen*, or *pure*, *air*. Now as 60 pounds of water are about a cubic foot, and as oxygen air is eight hundred times lighter than water, 500 weight of MINIUM or RED LEAD fhould produce 800 *cubic feet of oxygen air*, or about 600 *gallons*. And, fince the fubftances, which contain *oxygen*, or *vital*, *air*, in immenfe quantities, are of little value, we have a right to expect, that a perfect, falubrious, *pure air*, may, as chemiftry advances, be obtained from fuch materials by a *cheap* and *eafy procefs*.—Dr. DARWIN.

Dr. BEDDOES, we are informed, has difcovered the method of feparating *watɩr* into its elementary principles, fo as to obtain from thence *oxygen air*. How great an advantage does this difcovery promife to the world!

SECT.

SECT. IV.

It was ſhewn in the laſt ſection, that if an animal be confined under a bell-glaſs, where all admiſſion of freſh air is denied, the air which before conſiſted of 2 *aerial fluids*,

1. OXYGEN AIR,

and 2. AZOTIC AIR,

will preſently conſiſt of 3 *aerial fluids.*

1. OXYGEN AIR, *in a diminiſhed quantity*,

2. AZOTIC AIR,

and 3. *fixed air.*

At length the OXYGEN AIR being conſumed, the animal will ceaſe to live, and the air in the bell-glaſs will be found to conſiſt now of 2 *aerial fluids*, that cannot maintain life, viz.

1. AZOTIC AIR,

and 2. *fixed air.*

A queſtion naturally ariſes, WHAT HAS BECOME OF THE OXYGEN, OR VITAL, AIR, deprived of *which* an animal *dies** ?

Anſwer. *This air* is abſorbed in part by the BLOOD.

* Vide Sect. VI. on RESPIRATION, which explains alſo the *deſtruction* of the OXYGEN AIR in the formation of *fixed air*, and *vapour.*

EXPERIMENTS TO PROVE THAT VENAL BLOOD ABSORBS OXYGEN AIR.

If blood be taken from a vein, it readily ſeparates into 2 parts, a thin ſemi-tranſparent fluid called *ſerum*, and the *craſſamentum*, floating on it.

This firm ſubſtance at firſt appears of a *dark purple colour inclining to black*, but ſoon it aſſumes on *its upper ſurface* a *bright ſcarlet appearance*, reſembling the blood contained within *an artery*.

To prove that *this florid colour* is owing to the abſorption of OXYGEN AIR, one of the principles of *common air*, the illuſtrious Dr. GOODWIN incloſed a quantity of OXYGEN AIR in a glaſs receiver inverted over quickſilver, and introduced into it 4 ounces of blood freſh drawn from the *jugular vein* of a ſheep: the blood became inſtantly *very florid*, and the quickſilver ſeemed to *aſcend* a little in the receiver. To aſcertain this latter circumſtance, I repeated, ſays he, the experiment three or four times: *the change of colour* in the blood was always *very ſudden*, and after ſeveral minutes the quickſilver *aſcended* two or three lines.

If OIL be ſpread on the ſurface of the blood, which will prevent the contact of air, no such alteration as to colour takes place.

GIRTANNER, who turned his thoughts much to this subject, discovered that *venal blood* not only assumed a *bright vermilion colour* when exposed to OXYGEN AIR, but gave out *carbon* and *hydrogen*, which uniting with the OXYGEN AIR, formed FIXED AIR * and WATER †, which was found on the surface of the quicksilver.

EXPERIMENTS TO PROVE THAT ARTERIAL BLOOD CONTAINS OXYGEN AIR.

The *arterial blood* from the carotid artery of a sheep was received into a bottle full of AZOTIC AIR. The blood from a *bright red* shortly assumed the *deep colour of venal blood*. On opening the bottle the next day, the

* *Charcoal* and *oxygen air*; for if *charcoal* be burnt in *oxygen air* it attracts the *oxygen*, and, suspended by *caloric*, forms CARBONIC ACID AIR, or FIXED AIR.

The presence of *fixed air* is ascertained by LIME WATER; for water dissolves LIME, and holds it suspended. The solution then appears perfectly clear and bright. If any FIXED AIR comes into contact with the water, the CARBONIC ACID seizes on the LIME, and makes with it a combination *insoluble* in WATER. The LIME, in that case, is *visible* in the water. LIME WATER is therefore a test of the presence of FIXED or CARBONIC ACID AIR.

† *Hydrogen* and *oxygen*. Vide p. 21, on the Composition of Water.

AZOTIC AIR which it before contained was found mixed with OXYGEN AIR, ſo that an animal could live in it, and a candle burnt in it for near two minutes.

This experiment proves deciſively that *arterial blood* contains OXYGEN AIR, and that as ſoon as it parts with *this air* it then reaſſumes the true *venal character*.

The *arterial blood* of the carotid artery of a ſheep was received into a bottle full of NITROUS AIR. The blood aſſumed a green colour * upon the ſurface. A ſmall quantity of greeniſh ſerum was ſeparated. The day after, on opening the bottle, the vapour of NITROUS ACID was obſerved by all who were preſent.

Here then is an experiment which alſo proves *the preſence* of OXYGEN AIR in the *arterial blood*; ſince it is from this circumſtance alone that it is capable of changing NITROUS AIR, into NITROUS ACID †.

* Dr. GIRTANNER having injected ſome *nitrous air* into the *vein* of a dog, when it came into contact with the common air admitted into the lungs, NITROUS ACID was formed, and the lungs aſſumed in conſequence a *greeniſh hue*. The blood returned by the veins to the heart was found *black*.

† Vide Dr. *Prieſtley*'s Teſt of the Purity of the Air, Sect. III.

SECT.

SECT. V.

THE CIRCULATION OF THE BLOOD.

THE CIRCULATION OF THE BLOOD was the fortunate diſcovery of the immortal HARVEY, and has paved the way for all the great improvements that have ſince been made in the ſcience of medicine.

I cannot help obſerving here, that *this doctrine* at firſt met with univerſal oppoſition, and that it was remarked, that no phyſician, paſt the age of 40, believed in it; and in conſequence the practice of this great and good man declined from the moment he publiſhed to the world his ever memorable diſcovery.

The new doctrine at length getting into vogue, the *ſenior* phyſicians, ſays MALPIGHI, were inflamed to ſuch a pitch at BONONIA, that in order to root out heretical innovations in philoſophy and phyſic, they endeavoured to get an act paſſed, whereby every graduate ſhould be obliged to take the following *additional clauſe* to his ſolemn oath on receiving his degree; "*You ſhall likewiſe ſwear,*

that

that you will, with all your might (PRO TOTO TUI POSSE) *preſerve and defend the doctrines of* HIPPOCRATES, ARISTOTLE, *and* GALEN, *which are taught in this univerſity, and have been approved of during a long ſeries of ages; and that you will not permit their principles and concluſions to be overturned by any perſon whatſoever.*"

Here it may be uſeful, adds the juſtly celebrated Dr. HUNTER, as well as entertaining, to remark, that *improvements* in medicine have always been among men an object of contention. A little reflection on human nature will ſhew that VANITY is the principle ſource of *this abſurdity*. All men wiſh to be reſpectable; and moſt of them to paſs in the world, *for what they are not*; for being *ſo very acute, judicious*, and *learned*, as to need *no new inſtructions*. Hence profeſſors aſſume a decided and dictatorial character, affecting to have gone to the *bottom of every thing*, and to have *overcome every difficulty*, either by the natural powers of their underſtandings, or by the ſeverity of their ſtudies, and perſeverance in the purſuit of knowledge. Old men, beſides, can ſeldom bear, what they think an inverſion of the natural order of things, that younger perſons ſhould inſtruct them. Of all men, *teachers* of every kind bear this with moſt impatience. For that reaſon we ſee, in fact, that the ſeniors

niors of schools, colleges, and public foundations, have generally been the most obstinate *in shutting out light*, and claiming a *birth-right* for *opinions*, as for *property*. It is easy to see that such men will resist *new doctrines* with more obstinacy than the rest of mankind, perhaps with INVETERACY, in proportion as the doctrines *are well founded* and *readily credited*. They will be sensible that many persons who embrace the *new opinion*, will call to mind *many looks of importance*, and *expressions of vanity*, which must *now* appear truly contemptible *.

But to return to the object of this section.

All the veins of the body falling into *two trunks*, viz. the ASCENDING (1), and DESCENDING, CAVAS (2), empty themselves into THE RIGHT AURICLE of the heart (3). *The right auricle* unloads into THE RIGHT VENTRICLE of the heart (4), *which* throws the blood through THE PULMONARY ARTERY (5) into THE LUNGS, by its *two branches* (6) (7) that go to the *right* and *left* LOBES.

From THE LUNGS the blood is brought back by THE

* Dr. HARVEY, before his death, had the happiness, however, to find the clamours of ignorance, envy, and prejudice, silenced; and *professional men* grew at last ashamed to own, that they had ever combated or disbelieved the CIRCULATION OF THE BLOOD.

four

four PULMONARY VEINS (8), (9), (10), (11), into THE LEFT AURICLE (12), and from thence it paffes into THE LEFT VENTRICLE (13), by *which* it is diftributed through THE BODY by means of THE AORTA (14), and its branches. *Thefe* terminate in THE VEINS of the body, which collect the blood and bring it back to the heart by the TWO CAVAS (1) (2). Or, in other words,

The HEART is divided into 2 *parts* by a *longitudinal* feparation. *Thefe* 2 *parts* are formed into 2 *cavities* by a *lateral* feparation.

The VEINS enter the 2 *upper cavities*, or AURICLES, and the ARTERIES go out from the 2 *lower cavities*, or VENTRICLES.

When the AURICLES contract, the blood is driven into the VENTRICLES; and when THESE contract, it is forced into the ARTERIES.

Then *commences*, in fact, THE DOUBLE CIRCULATION OF THE BLOOD.—The ARTERIES contract, and the blood flows from the *right divifion* of *the heart* THROUGH THE LUNGS to enter the *left divifion* of *the heart*:—and from the *left divifion* of *the heart*, the blood paffes THROUGH THE VARIOUS PARTS OF THE BODY to enter again the *right divifion* of *the heart*.

SECT.

SECT. VI.

THE OFFICE OF THE LUNGS.

Refpiration we cannot explain: we only know, fays Dr. HUNTER, that it is, *in fact*, effential and neceffary to life. Notwithftanding this, when we fee all the other parts of the body, and their functions, fo well accounted for; we cannot doubt but that *Refpiration* is fo likewife. And IF EVER we fhould be happy enough to find out clearly the object of this function, we fhall doubtlefs, as clearly fee, that this organ is as wifely contrived for *an important office*, as we now fee the purpofe and importance of the heart, and vafcular fyftem; which, till the circulation of the blood was difcovered, was wholly concealed from us.

If this learned teacher was to rife from the grave, I believe, no fubject would give him higher delight than to fee, iffuing from the furnaces of the chemift, a new and fimple philofophy, which has clearly developed the nature and neceffity of refpiration.

In the lungs the blood coming into contact with ATMOSPHERIC AIR * works many *chemical* alterations in it.

* Every chemift has learnt, from the difcoveries of LAVOISIER, "that "ATMOSPHERIC AIR confifts of *two parts*, viz. *oxygen air*, blended with "*azotic air*," which by chemical means may be feparated, and confined in dif-

 ferent

Here it is (in the LUNGS) that the dark blood, throwing off attenuated *charcoal*, forms with the *vital air* of the atmofphere,—FIXED AIR *.

Here it is, that the purple blood parts with its *hydrogen*, which uniting with the *vital air*, forms—the HUMID VAPOUR that iffues from the mouth †.

And here it is, that the purple blood (having thrown off *hydrogen* and *charcoal*) IMBIBES the *vital air*, which changes its *dark colour* to a *brilliant red*, rendering it—*the fpur to action* of the HEART and ARTERIES—the *fource* of ANIMAL HEAT—and *the caufe* of SENSIBILITY, IRRITABILITY, and MOTION ‡.

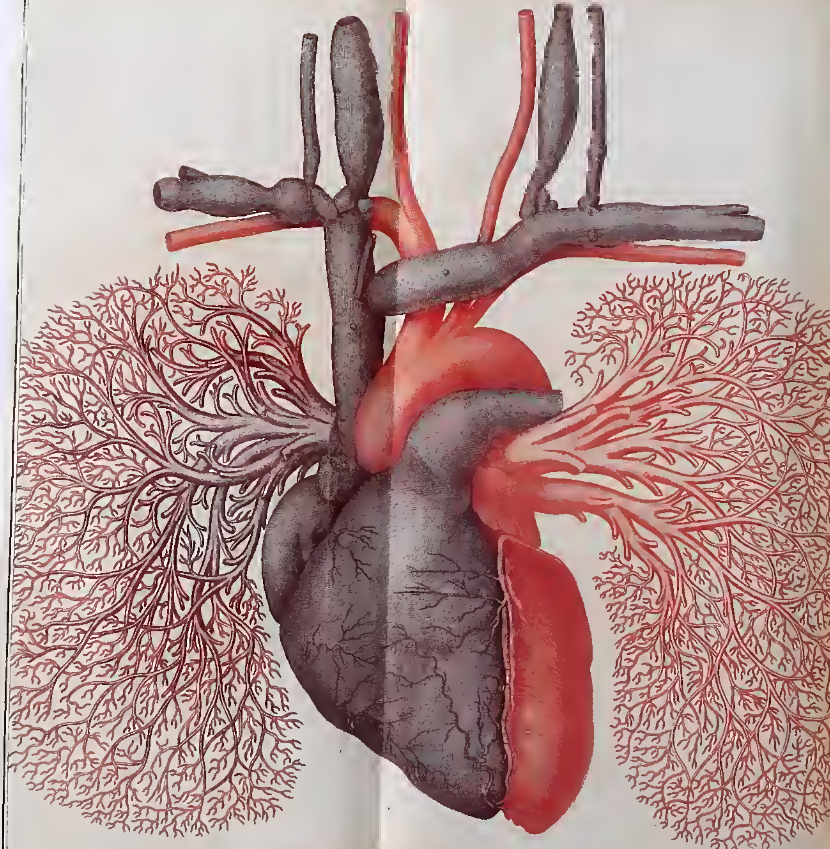
ferent jars, and that a moufe, or any other animal, will live a confiderable time in the *one*, being lively, brifk, and active; whilft, in *the other*, he foon languifhes and dies. *This part* of the air, therefore, as fo much contributing to *life*, is with the utmoft propriety denominated by phyficians, VITAL AIR.

* This is proved by making an expiration through a tube containing LIME WATER, which will become inftantly *turbid.*—Or if black blood be confined in a phial containing *vital air*, the whole of *that air* will be converted into FIXED AIR.

† This you may prove by placing venal blood in *vital air*, when the fides of the veffel will be covered with large drops of WATER.—Or if black blood be received into a phial containing *azotic air*, AMMONIAC will be formed, which was fhewn by BERTHOLET to be nothing more than *hydrogen* combined with *azot*. Vide Part I. p. 39.

‡ Hinc quoque apparet fanguinis *principalitas*, quod PULSUS *ex eo ortum ducat*. Nec fanguis folum pars primigenia et principalis dicendus eft, quod ab eo motus pulfufque principium orietur; fed etiam quia in eo primum CALOR

ANIMALIS



DR. GOODWIN'S CELEBRATED EXPERIMENT.

But that no poſſible doubt might exiſt, that OXYGEN AIR is imbibed *by the blood* in *the lungs*, Dr. GOODWIN opened the cheſt of a living dog.

The *lungs* and *heart* were then expoſed to view.

The blood, which was driven from the RIGHT VENTRICLE of the heart into the PULMONARY ARTERY, appeared of a *dark venous complexion.*

It certainly was a ſtriking ſpectacle to obſerve the *black blood* as it returned from the lungs by the four PULMONARY VEINS of the LUNGS, in its paſſage to the LEFT AURICLE of the heart, appear of a *bright vermilion colour.*

It was ſoon found neceſſary to inflate the lungs by artificial means.

If at any time this was intermitted, the blood in the

ANIMALIS INNASCITUR, SPIRITUS VITALIS ingeneratur, et ANIMA IPSA conſiſtit.

Hence alſo appears the *pre-eminence* of the blood, that the *pulſation* of the HEART and ARTERIES owes *its origin* to it. Nor is the blood to be called the *firſt mover* and *pre-eminent* for this alone, but *becauſe* from it ſprings the VITAL HEAT, the ANIMAL SPIRITS, and LIFE ITSELF.—HARV. Exercitat. 51.

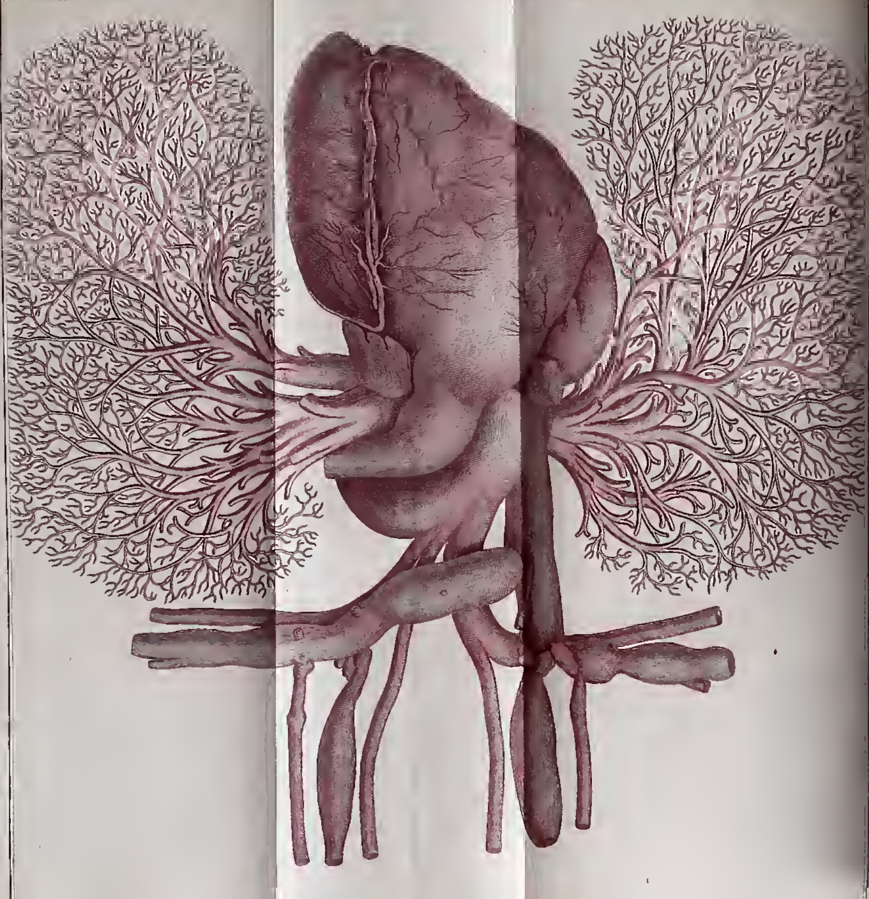
How infinitely near does the immortal HARVEY approach the truth, and yet he had not the moſt *diſtant conception*, that OXYGEN AIR was the *principle* from whoſe *benign influence* all THESE WONDERFUL PHENOMENA ariſe. Vide Sect. VII. &c. &c.

four PULMONARY VEINS appeared of a *dark purple colour*, and the LEFT DIVISION of the heart receiving *black blood*, a *diminution* of the pulſations of the HEART and ARTERIES took place, and in a little time all *their actions* ceaſed.

But if at this time the LUNGS were made by the *inflation* of common air alternately to collapſe and diſtend, the blood in the PULMONARY VESSELS regained its former *crimſon colour*, and *the action* of the HEART and ARTERIES was *excited anew* *.

* On this occaſion it is obvious to remark the *importance of the* LUNGS in the animal œconomy; we perceive that the blood, every time it is returned to the heart, is directly diſperſed throughout *the lungs*, and immediately *reconveyed to the heart, before it is permitted to begin a new circulation:* I may add, before it is CAPABLE of performing a *new circulation:* for had there been no real neceſſity, we may boldly aſſert, this operation of its *paſſing through the lungs* would never have taken place. In the ſtudy of nature, throughout all her works, however *complex* the machine, the *ſimplicity* of the moving cauſe claims the firſt attention of a ſpeculative mind: this obſervation is beautifully illuſtrated on the preſent occaſion; and I believe it will be admitted by every one, that the blood, after having performed *one round* throughout the animal œconomy, undergoes ſome new and important change, in its *tranſit through the lungs*, eſſentially requiſite to ſupport a *ſecond circulation.*—Dr. SMITH.

SECT.



SECT. VII.

ON ANIMAL HEAT.

It was ſhewn in the laſt ſection, that when the heart did not receive blood impregnated with OXYGEN AIR it ceaſed to beat; beſides *the circulation of the blood* we are indebted for our VITAL HEAT ALSO TO THE OXYGEN AIR CONTAINED WITHIN THE BLOOD.

The ingenious Dr. CRAWFORD appears to have been the firſt who attempted to aſcertain by direct experiments the cauſe of ANIMAL HEAT. In an elaborate work he maintains, that the blood, which is returned to the lungs, is highly charged with *phlogiſton*,—that the air having a greater affinity for *phlogiſton*, than the blood, attracts to itſelf *that principle*, and having in conſequence a leſs *capacity* for heat than before, it parts with a portion of its heat,—and as the *capacity* * of the blood for heat

* The meaning of this word may be eaſily underſtood, if we contemplate the CAPACITY of a *ſpunge* for containing water, and that of any other body; it muſt appear that bulk for bulk, its CAPACITY with regard to that fluid, is greater than the CAPACITY of any other known ſubſtance. Or, to give another illuſtration, *hot water* will diſſolve a greater quantity of *ſalt* than *cold*, and *hot air* will ſuſpend a greater quantity of *moiſture* than *cold air*. Hence *when theſe are changed into each other*, that is, the *hot water* containing ſalts is

heat is at the ſame time increaſed by the ſeparation of the *phlogiſton*, the *heat*, detached from the air, is fixed in a quieſcent or latent ſtate in the blood :—and that the blood in the courſe of the circulation abſorbing *phlogiſton*, and thereby having its *capacity* for *heat* diminiſhed, part of it (in proportion to the quantity of *phlogiſton* abſorbed) breaks out in the form of ſenſible or moving heat, and hence the cauſe of ANIMAL HEAT.

is *converted* into *cold water*, and the *hot air* of the day into the *cold air* of the evening: in the firſt inſtance, the *ſuperabundant ſalt* before held in ſolution will be depoſited at the bottom ; and in the ſecond, the moiſture, or the *dew* of evening, will deſcend on the ground. In the ſame manner the CAPACITY for *heat* being found greater in *arterial* than *venous blood*; hence when the arterial becomes venous blood (juſt as the *hot air* converted into *cold air* depoſited its *moiſture*, and *hot water* converted into *cold* depoſited *its ſalt*), ſo muſt *arterial* blood converted into *venous* depoſit its ſuperabundant *heat*.

Dr. CRAWFORD's opinion therefore, to ſtate it in a few words, is, that, in *reſpiration*, the blood is *diſcharging* PHLOGISTON and *abſorbing* HEAT ; and that, *in the courſe of the circulation*, it is continually *imbibing* PHLOGISTON and *emitting* HEAT. Perhaps this excellent phyſician is a convert to the NEW SYSTEM, and may hereafter, like the illuſtrious KIRWAN, formerly a ſupporter of the doctrine of phlogiſton, write a work to refute his *own book*.

It was certainly a great pleaſure to LAVOISIER to receive a letter from Dr. BLACK, the celebrated Profeſſor of Chemiſtry at Edinburgh, in which he ſays, " For thirty years I taught the doctrine of *phlogiſton*. Ten years of which time I combated *your diſcoveries*. That barrier againſt every improvement, PREJUDICE, required *ten whole years*, a ſecond ſiege of Troy, before it could be ſubdued. I now ſee, clear as the noon-day, the *truth* of the NEW SYSTEM. I have began to teach it, and the young ſtudents, having NO PREJUDICE to overcome, are every one of them delighted with its ſimplicity and truth. Your *new terms* are already familiar among them, &c."

It

It required a ſtrong philoſophic conviction in Dr. THORNTON to depart from a propoſition at that time ſo generally received. But having made many accurate experiments, when enquiring into that ſubject, he was confident, that the OXYGEN AIR which WAS ABSORBED BY THE BLOOD (as is proved here in Sect. VI. from the experiments of Dr. GOODWIN), was the true ſource of ANIMAL HEAT. Struck with the important *diſcovery*, he propoſed it as the ſubject of his *theſis* at CAMBRIDGE. The profeſſor of phyſic at firſt refuſed it, as being an opinion perfectly *novel.* He, however, at length very politely conſented to his diſputation on that queſtion, and, as Dr. THORNTON informs Dr. BEDDOES, he maintained at CAMBRIDGE, previous to his receiving his degree in phyſic in that univerſity, in oppoſition to the opinion of Dr. CRAWFORD, that the *venal* blood in the lungs abſorbs from the air not *fire*, but *oxygen*, in combination with *the matter of heat* (OXYGEN AIR), and that in the circuit of the blood through the body, the *oxygen*, meeting with ſome ſuperior attraction, is divorced from its *caloric* *, which becoming diſengaged (*juſt as an acid diſcovers its ſenſible properties, its alkaline baſis being withdrawn from it)*, ſo did it aſ-

* The matter of heat.

ſume

ſume its well known *active* character, and as *uncombined fire* ever tends to form an equilibrium, or equal temperature with the ſubſtances around, by pervading the body, it became the ſource of VITAL or ANIMAL HEAT.

Animal heat, therefore, to uſe the language of Dr. PEART *, in the opinion of Dr. THORNTON, appears to be *a gentle combuſtion*;—and *an animal* in many reſpects may be compared to *a burning lamp*; the HEAT produced in both caſes ariſing from the *ſame cauſe*.

If AN ANIMAL be placed in *an exhauſted receiver* of an air-pump it quickly expires; in ſimilar circumſtances A BURNING LAMP goes out. If AN ANIMAL be not ſupplied with *freſh air* it dies, and its heat is extinguiſhed; ſo it is with THE LAMP. The air breathed by ANIMALS is *diminiſhed in quantity*; ſo it is by the burning of THE LAMP. A *certain quantity* of air ſupports AN ANIMAL for a *certain time*, but no longer; ſo it will keep up THE FLAME OF THE LAMP, for a *certain* time only. The air in which a LAMP has burnt out *deſtroys* ANIMAL *life*; ſo the air that THE ANIMAL hath breathed, *puts out* THE LAMP. Fixed, azotic, and in-

* It is hoped Dr. PEART will not be offended to ſee his language changed from the *old* to the *new* chemiſtry.

 flammable

flammable airs, *destroy* ANIMALS; so likewise do they *extinguish* THE LAMP. A LIVING ANIMAL and a BURNING LAMP, therefore, exactly agree in requiring the *same kind of air* to support them, and in producing *the same effects* upon the air, to which they are exposed.

But they do not resemble each other only in *producing* HEAT, and *requiring the same kind* of AIR: for if AN ANIMAL hath not *fresh supplies* of FOOD, as well as AIR, after a *certain time* it dies, and becomes cold; just in the same manner as THE LAMP dies out, if not *duly supplied* with OIL.

Since then, *that part* of the air destroyed by RESPIRATION is the *same* as *that* destroyed by COMBUSTION: and since the *ultimate effect* is the *same* in both operations, that is, THE PRODUCTION OF HEAT, is it not reasonable to think, that the FOOD affords to the ANIMAL *principles alike attractive of* OXYGEN, *and disengaging heat*, as the OIL affords to THE LAMP? For since *the effects* are the same, *the cause* must be so too. OIL, therefore, *affords the principle attractive of oxygen* to THE LAMP: and, consequently, THE FOOD of animals *supports the generation of heat*, by *supplying to the* *animal body thofe principles which are attractive of* OXYGEN, *the bafe of vital air.*

The *chemical analyfis* of fuch fubftances as are to fupport animal life confirms this opinion; for no fubftance affords proper nourifhment, which contain not principles that readily combine with OXYGEN; and the inftantaneous fupport, and refrefhment, perceived by thofe, who are much exhaufted, upon taking into the ftomach certain inflammable fubftances, as diluted fpirits*, &c. depend, in Dr. THORNTON's opinion, on the fame principle. *Very different matters*, therefore, will fupport ANIMAL LIFE, if they contain principles, feparable by the animal procefs, that have an affinity with *oxygen*.

* A pleafing glow is firft perceived in the ftomach, which extends itfelf afterwards over the whole body.

Æther I conceive alfo acts in this way, rather than from the expanfive property of this volatile fluid in the ftomach If you take a phial and fill it with OXYGEN AIR, and pour into it a few drops of æther, and then apply to the entrance of the phial any ignited body, a violent explofion takes place, nearly as loud as a gun, the bottle is thrown down, but not broke, and you may collect from the phial rather more than a tea fpoonful of clear WATER. Here the *hydrogen* of the *æther* unites impetuoufly with the *oxygen* of the pure air, and WATER is formed, and *caloric* difengaged. You have here, en petit, a flafh of *lightning*, *thunder*, and the *thunder-fhower*.

ANIMAL

ANIMAL HEAT, THEREFORE, PROCEEDS FROM THE CHEMICAL UNION OF CERTAIN PARTS OF OUR FOOD AND OXYGEN, MODIFIED, AND COMBINED, BY THE PROPER EXERCISE OF THE NATURAL ANIMAL FUNCTIONS *.

* The faliva and a juice fecreted in the ftomach, called in us the *gaftric juice*, has a folvent power on *certain fubftances.* Our aliment is therefore broken down in the ftomach into its conftituent principles, and thefe comminuted parts then enter and pafs along the capillaries of the inteftines, which are incapable of admitting any fubftance, unlefs in an highly attenuated or aerial form. Vide the Section, on Mufcular Motion.

SECT. VIII.

ON THE BALANCE BETWIXT DIGESTION AND THE OXYGENATION OF THE BLOOD.

I HANE had, fays the celebrated Spanifh traveller, the Rev. Mr. TOWNSEND, frequent opportunities of remarking a beautiful balance betwixt RESPIRATION and DIGESTION.

During a putrid fever, which attacked me laft fummer, it was too evident to efcape the obfervation even of my nurfes. When the *ftomach* was oppreffed, *refpiration* laboured; and when the lungs were plentifully fupplied with *vital air*, the breathing became eafy, and the fuperabundant quantity of food was no longer a burthen.

I am happy to find my ideas on this fubject confirmed not only by Dr. THORNTON, to whom I firft practically noticed it, but alfo by the correfpondence between two of the moft ingenious medical practitioners and chemifts of the age, Dr. WITHERING and Dr. BEDDOES. The former

former writing to the latter ſays, the experiments you wiſh for on the ſubject have been in part made. The late Mr. SPALDING, who did ſo much in improving and uſing the diving-bell, was a man of nice obſervation, and had he not fallen a ſacrifice to the negligence of drunken attendants, would have thrown much additional light upon more than one branch of ſcience. He particularly informed me, that when he had eaten *animal food*, or drank *fermented liquors*, he *conſumed* the air in the bell much *faſter* than when he lived upon *vegetable food* and drank only water. Many repeated trials had ſo convinced him of this, that he conſtantly abſtained from the former diet whilſt engaged in diving.

In my putrid fever, whenever the air of my bed-chamber was artificially *oxygenated*, as my phyſician Dr. THORNTON often witneſſed, MY RESPIRATION WAS PLEASANT, MY OPPRESSION AT MY CHEST RELIEVED, AND I WAS ENABLED TO BREATHE FREELY THROUGH THE NOSTRILS WITHOUT THE ASSISTANCE OF MY MOUTH, WHICH I COULD NOT DO BEFORE THE ROOM WAS OXYGENATED. At the ſame time I am convinced THAT MY APPETITE WAS GREATLY INCREASED, MY OCCASIONAL SLEEPS

RENDERED SOUND AND UNDISTURBED, AND MY DIGESTION CONSIDERABLY QUICKENED.

We now fee the reafon why men who are oppreffed with food *pant*; and why in a clofe room, where they are confined within the curtains of a bed, where the air is vitiated by paffing frequently through their lungs, they open their mouths wide to breathe, and therefore why they *fnore*.

I have often had occafion to converfe with miners in Cornwall, who had been almoft deprived of life by breathing a mephitic air, and have been informed by them, that on reviving they have conftantly been feized with *naufea*, and that commonly the ftomach has rejected its contents quite *crude* *.

Whenever the imperfect tribe of animals, or fuch as fleep out the winter, are expofed to a cold fo great as, in a great meafure, to rob them of their *inbred heat*, their powers of *motion* are proportionably diminifhed, and as they cannot have, at that feafon, a very copious generation of caloric, but only enough to keep up the fpark of life (their animal oil, which is compofed of

* From the Rev. Mr. Townsend's Guide to Health. Obfervation V. on *Vital Air*.

principles

principles attractive of oxygen) being fufficient for that purpofe, they lofe alfo the power of *digeftion**.

At Bellifle, in the beginning of the winter 1761, I conveyed, fays JOHN HUNTER, worms, and pieces of meat, down the throats of lizards when they were going into winter quarters, keeping them afterwards in a cool place. On opening them at different periods, I always found the fubftances which I had introduced entire, and without *any the leaft alteration.*

A hedge-hog, while the heat of the body was at 30 degrees, had neither *defire for food*, nor *power of digefting it*; but when by artificial means it was increafed to 93 degrees, the animal feized a toad which happened to be in the room; and upon being offered fome bread and milk, it immediately eat it. The heat roufed up the actions of the animal œconomy; the breathing became quickened; and the blood, having imbibed a greater quantity of oxygen air, containing latent fire, to be extricated by the principles feparated by the ftomach:

* Obfervations on Digeftion, by John Hunter.

This accurate experimental philofopher has the *mufcular* ANIMAL HEAT, the *digeftive*, and the *procreative*, to mark the three intenfities; or rather the three effects produced by different degrees of *oxygenation* in the animated world.

hence

hence *the immediate call* on the digeſtive powers of that organ *.

SECT.

* The anatomical lecturer at Piſa, in the year 1597, happening to hold a lighted candle near the ſubject he was diſſecting, on a ſudden the vapours that iſſued from the ſtomach and inteſtines were ſet on fire. In the ſame year Dr. RUISCH was diſſecting a woman, and had no ſooner opened the ſtomach, than their iſſued out a yellow greeniſh flame, ſuppoſed to have ariſen from the vapours, which were kindled by a ſtudent's holding a lighted candle near him. Dr. VULPARE, the anatomical profeſſor at Bologna, affirms that any one may ſee, iſſuing from the ſtomach of an animal, a vapour that *burns like ſpirits of wine*, if the upper and lower orifices are bound faſt with a tight thread. The ſtomach thus tied, muſt be cut immediately under the upper ligature, the contents of the ſtomach being firſt preſſed with both hands, ſo as to paſs to one ſide. A candle being held about half an inch from the aperture, a flame will be obſerved immediately to iſſue from the ſtomach. BARTHOLINE relates the caſe of a perſon, who having drank much brandy for a wager, died, after an eruption of a flame of fire had firſt iſſued from his mouth. *The inflammable woman of Coventry*, as deſcribed by Mr. WILMER, appears alſo to have reduced herſelf by dram-drinking to ſuch a ſtate as to be capable of being ſet on fire, and burn like any very combuſtible matter; *ſo eager*, ſays the learned Dr. BEDDOES, *were the principles of which ſhe was compoſed to combine with oxygen.* In like manner the counteſs *Cornelia Bandi*, near Ceſena in Romagna, in 1731, in the ſixty-ſecond year of her age, was found in the middle of her bed-chamber reduced to aſhes. Theſe aſhes were light, and left in the hand a greaſy and ſtinking moiſture. The floor was ſmeared with a groſs unpleaſant moiſture, and the walls and furniture were covered with a moiſt ſoot.

An inſtance of the ſame kind occurred at Chriſt-Church in Hampſhire, June 26, 1613. One John HITCHELL, a carpenter of that pariſh, having ended his day's work, came home and went to bed. His wife found him dead before morning at her ſide. He felt ſo extremely hot, that it was impoſſible to touch him. *He lay burning for three days*; nor was there any appearance

SECT. IX.

In Section VII. it was proved, that *vital heat arofe from the decompofition of oxygen air in the blood.* In this it will appear, HOW LIFE DEPENDS ON A CERTAIN DEGREE OF HEAT IN THE BODY.

In the chick contained within an egg there are no powers capable of generating heat. Therefore until the chick receives heat from the mother it remains in a torpid and inactive ftate. The principles of life are then called into action. A gradual extenfion of the parts commence. During the time of incubation, the living principle every day increafes in quantity and power with the perfection of the animal, and the capacity of its organs for performing its functions, and *generating heat*, which laft does not happen till the time of its exclufion from the fhell: after which, the chick does not de-

pearance of flame outwardly, but only a fmoke or mift afcending from his carcafe till it was confumed.

GRACE PETT, a fifherman's wife, of the parifh of St. Clement's, Ipfwich, about fixty, was alfo confumed by an internal fire. She appeared like a heap of charcoal, covered with white afhes; the legs, arms, and thighs, were very much confumed. However it is remarkable that the deal floor on which fhe was extended had no appearance of being in the leaft finged.

Thefe remarkable inftances of the *quick combuftion* carried on in the body, if I may be allowed to continue the expreffion, is adduced only as exceptions to Dr. THORNTON's general rule, that within the body there is always carried on a *gentle combuftion*, productive of the VITAL FLAME.

pend *entirely* on the mother for the production of that heat, which muſt always accompany and ſupport the functions of life. When, by reſpiration, the firſt action after birth, *oxygen air* is abſorbed by the blood, the motion of the heart, the circulation, and other operations, are carried on with greater vigour than formerly, and the food being ſeparated into principles attractive of oxygen, the chick is capable, in a great meaſure, of generating a degree of heat equal to that of the parent. At firſt the mother, by a wonderful inſtinct, as if conſcious of the tender ſtate of her children, and of the impoſſibility of their being kept ſufficiently warm by their own powers, gathers them under her wings to cheriſh that vital warmth, which ſhe appears to judge them capable of creating, and *without which* they would neceſſarily periſh. In the ſame way, if, during incubation, the hen leaves her neſt ſo long as to cool the eggs a few degrees, from that period the powers of life are proportionably diminiſhed, and a ſtop is put to the growth of the chick; both of which, if the eggs have not been cooled too far, are recoverable on the return of the hen, or of that genial heat they receive from her body. The mother is ſo ſolicitous to preſerve *this heat*, that ſhe ſeldom leaves her neſt above five or ſix minutes in the day, to take a ſlender repaſt; and when ſhe diſcovers the motion of the chickens in the eggs, ſhe then ſits ſo cloſe, that even the ſight of food, though ever ſo much preſſed by hunger, can ſcarcely prevail with her to ſtir from the eggs for three or four days, or until they are completely hatched. But if ſhe abandons her neſt altogether, or is killed by accident, then, as the eggs cool, the powers of life gradually decline, till they are at laſt totally aboliſhed by the death of the chickens *.

* From Dr. GARDINER on the Animal Œconomy.

Though the *functions of life* are ſuſpended for want of a due quantity of animal heat, yet in ſome creatures, under theſe circumſtances, the *vital principle* ſtill remains entire. Thus flies, when the cold comes in, appear as if deprived of ſenſe, and in proportion to the degree of cold, the *moving mechaniſm* is retarded. But if the weather be intenſely cold, they then ſleep the ſleep of death. Hence the reaſon why we ſee toads burrowing, frogs living under large ſtones, ſnails ſeeking ſhelter in the hollows of trees, and fiſhes having recourſe to deep waters; the heat of all theſe places being generally *above* the freezing point, even in our froſts, which are however ſometimes ſo ſevere, as to kill many whoſe habitations are not well choſen. Nevertheleſs theſe torpid animals ſtill maintain a temperature of heat *ſomewhat higher* than the ſurrounding medium. In the *winter*, the atmoſphere at forty-four degrees, the heat of the torpid hedge-hog at the diaphragm was found, by Mr. JENNER, to be forty-eight degrees and a half. When the atmoſphere was at 26 degrees, the heat of a torpid hedge-hog was reduced ſo low as 30. In *ſummer*, the atmoſphere at 78 degrees, the heat of the hedge-hog at the diaphragm was found to be 97. The atmoſphere being at 30, that ingenious phyſician, and moſt accurate experimental philoſopher, Dr. HEIGHTON, the Lecturer on Phyſiology at GUY's and St. THOMAS's hoſpitals, found the animal heat of a torpid bat at 33; and when the atmoſphere was at 60, he found it ſo high as 63 degrees; that is, during life the vital heat was always found to exceed the ſurrounding medium. Vide JOHN HUNTER's *Obſervations on the Animal Economy.*

SECT. X.

In the laſt Section *the connection betwixt life and heat* was ſhewn; we ſhall ſlightly conſider here THE METHOD NATURE TAKES TO INCREASE, OR RID HERSELF, OF THIS SUBTLE AND PENETRATING FLUID.

As the heat of the living body always conſiderably *exceeds* that of the ſurrounding atmoſphere, it is obvious, ſo far from any heat being derived from it, on the contrary, the body muſt *communicate* heat to the external air; and if we conſider the great difference ſubſiſting between the temperature of the human body, and that of the atmoſphere in our climate, it is clear that a very large portion of heat muſt be always *eſcaping* from the body, and of courſe there muſt be *conſtant generation* of animal heat carried on in the body to balance this conſumption.

Every one who has paid attention to the temperature of the atmoſphere by means of the thermometer, muſt have obſerved how frequently our feelings, reſpecting heat and cold, *diſagree* with the indications of them, as expreſſed by that inſtrument; ſince it often happens, that

that when experiencing a very confiderable degree of cold, we are furprifed to find the mercury at a moderate temperature; and this may be obferved ufually to happen in *windy weather*, or when the air is particularly loaded with *wet particles*. This can be accounted for on no other principle than that of *the conftant production of heat within the animal, and of its tendency to pafs off by the furface:* for the thermometer very foon acquiring the temperature of the air, becomes at once ftationary, varying only with the real changes which take place in the atmofphere; whereas the conftant fucceffion of heat, which there is in the living animal, prevents its acquiring the temperature of the air, and it cannot, therefore, like the mercury, defcend to its temperature, and then become ftationary; and as the fenfe of cold felt by us, muft confequently be owing to the conftant efcape of heat which is thus promoted, the degree of cold felt muft obvioufly be in proportion to the celerity with which the air is enabled to carry off the warm atmofphere around us.

The effects produced by *fanning*, when perfons are very hot, may be underftood from the principles of the foregoing doctrine: when the furface is loaded with heat, and the air which is in immediate contact with it, has already taken up fo much, that it is either unable to carry off any more, or performs this office fo flowly, as to be unequal to the removal of the quantity which is conftantly arriving at the furface, the driving away fuch air by the fan, and permitting other colder air to approach, which not being fo loaded, is able to carry off the heat more quickly, the fkin muft in confequence feel cooled.

Moift air is, likewife, a better conductor of heat than when dry, becaufe *water*, though of the fame temperature with air, is well known to carry it off more quickly than air will do.

If, therefore, *thefe two caufes unite*, as is the cafe in *moift* and *windy* weather, we may eafily underftand why the heat from animals fhould be carried off more quickly, and the animals fhould experience a greater fenfe of cold, than when the air is *ftill* and *dry*, though the thermometer fhould, in both cafes, ftand at the fame point.

I. OF THE RETENTION OF HEAT.

It may be remarked, that all animals, when the heat is paffing off them in an *inconvenient degree*, endeavour

to

to CHECK IT by leffening the furface of their bodies, which is expofed to the furrounding medium; thus we fee why dogs, cats, &c. when lying on the ground, and not in a warm fituation, draw their limbs clofe to them, and endeavour to acquire fuch a pofture of the whole body, as fhall bring all the parts as much into contact as poffible; and when in a contrary fituation, as expofed to the warm rays of the fun, or near the fire, they ftretch out their limbs, and extend their whole furface as much as poffible: and we all know, that we ourfelves, when naked, or when entering a cold bed, do exactly the fame thing; and in bed we continue fuch a pofture until fuch a quantity of heat has been accumulated, and confined by the bed-clothes, as to remove all fenfation of cold, when, like the before-mentioned animals, we ftretch forth our limbs, and acquire our accuftomed pofture.

The univerfal cuftom of the inhabitants of all countries in which the temperature of the atmofphere is below the ftandard of the heat of the human body, making ufe of apparel, and this being thicker or thinner in proportion to the refpective differences of feafons or climates, is founded on the fame principle, " *to prevent fuch an*

efcape

eſcape of heat from the body as would be unpleaſant or injurious."

The ſame thing may be obſerved of the natural clothing of different animals; in *warm climates* their coats are ſhort, ſmooth, and lie cloſe to the ſkin; but in the *northern regions* their covering conſiſts of a rarer ſubſtance, as fur, wool, &c. In *birds* this circumſtance is peculiarly ſtriking; as they paſs freely through the air, and are often expoſed in the higher regions to a very cold medium, their natural heat would paſs off much too quickly, if they were not covered with a ſubſtance which conducts heat very ſlowly, which feathers are well known to do: and in thoſe birds which *live in water*, which withdraws heat much quicker than air, their covering is much more rare and compact than common feathers; the *down* upon the breaſt and under the bellies of thoſe birds, which in cold climates live principally in the water, being perhaps the ſloweſt conductors of heat in nature; modern luxury having, on this principle, ſet a great value on the down of the *eider duck*, and its uſe in retaining heat, to which it is applied, being well known in fits of the gout; to which caſes, on account of its extraordinary lightneſs, it is particularly

particularly well adapted, as the parts affected are usually fo exquifitely tender, as to fuffer pain from the contact of whatever has weight, or occafions preffure. The flow conducting powers of this down being evidently owing to its rare texture, it is obvious, that to retain this quality it fhould remain perfectly dry, as the plumage, when *wet* *, will very foon collapfe together, and form a body capable of carrying heat off, perhaps, too quickly. To guard againft this circumftance, nature has kindly furnifhed *thefe aquatic birds* with a peculiar kind of OIL, and has given them the power of occafionally opening the receptacle where it is depofited,

* Mr. HUNTER, having put a *dormoufe* in a freezing mixture, could not freeze the whole animal, but only the feet, the hair being fo bad a conductor of heat, that the *caloric* withdrawn from the animal was not more than its powers were capable of generating. Taught by the failure of this experiment, I took care, fays this great phyfiologift, that the hair fhould not a fecond time be an obftruction to our fuccefs. Having, therefore, firft made the animal *wet all over*, that its heat might be more expeditioufly carried off, it was put into a leaden veffel, and the whole placed in the cold mixture as before. The animal foon gave figns of feeling the cold, by coiling itfelf into a round form, and repeatedly attempting to make its efcape; and the breath and water evaporating from its body being foon frozen, appeared like a hoar-froft on the fides of the veffel, and on its whifkers; but as long as the vigour of life lafted, it feemed to defy the cold. However, from the hair being wet, and thereby rendered a good conductor, there was a much greater confumption of heat than in the firft experiment; which haftened on a diminution of the power of producing it. The animal foon became ftiff; and upon being thawed, was found quite dead.

and

and of ſpreading a ſufficient quantity of it over their outermoſt feathers, by which the contact of water is effectually prevented.

It may likewiſe be obſerved, that even in the *ſame animals* a difference, reſpecting the heat-conducting powers of their covering, takes place under different expoſures; that in *ſummer* it is leſs calculated to retain their heat than in *winter*, and when protected by the external cold, by living *within doors*, than when expoſed to it when living in the *open air*. The horſe may be conſidered as a very familiar inſtance of the truth of this remark, for every one knows how long and rough the coats of thoſe are which winter in the *ſtraw-yard*, and how ſhort and ſmooth are the coats of thoſe which are kept in warm *ſtables*; and that it is a common practice with ſuch as have the care of horſes, to cover them with woollen cloths, to render their coats fine and ſmooth.

2. OF THE ESCAPE OF ANIMAL HEAT.

When the air is of that particular temperature which, with the aſſiſtance of other operations in the œconomy, is juſt ſufficient to carry off ſuch a quantity of the heat generated in the body, that the remainder

 ſhall

ſhall exactly ſupport the animal body, we ſay ſuch an air is mild, or it is temperate; becauſe we are not ſenſible of any troubleſome degree of heat or of cold. This preciſe temperature varies in different people, according to the climate, age, and conſtitution of the individual; but at whatever point of the thermometer this temperature may be, if it riſes or falls a few degrees only, we then complain of heat or of cold, and employ various ways of obviating their effects. When we are ſurrounded with a *warm air*, a *freer perſpiration* ſucceeds; and if a further accumulation of heat takes place in the body, a *ſweat* is brought on proportioned to the ſtimulus, from the exceſs of heat. Nature is now employed in COUNTERACTING *the effects of an accumulation of heat* by the refrigerating proceſs of *ſweating*, and the conſequent expenditure of heat in the formation of vapour. How ſoon will the mercury and the thermometer cool by the ball being wet with æther, or valatile alkali: the degree of cold that may be produced in this way, has been ſufficiently ſhewn by the celebrated Dr. CULLEN. Witneſs the ice found in the morning on linen hung out to dry during the night, when the temperature of the air is even much above the freezing point: the practice in cooling wine in warm countries, by hanging up

 their

their bottles in wet cloths to the ſun *, to expedite the evaporation ; the cooling of the wine going on in proportion to the quickneſs with which its heat is abſtracted by the vapour. I ſhould not have inſiſted ſo much on the effects of evaporation, ſays Dr. GARDINER, Preſident of the Royal College of Phyſicians at Edinburgh, had I not conſidered it as a material circumſtance in examining the effects of hot air on the human body, which ſooner or later, according to the degree of heat it poſſeſſes, produces, in the manner above mentioned, a *ſweat*, and conſequently *evaporation* from every part of the body. Not that the whole of the matter perſpired is turned into vapour ; it is only ſuch a portion of it as can readily abſorb the neceſſary quantity of heat from the body and external air, which will be in proportion to the degree of heat they poſſeſs ; the reſt running in drops off the body, or it is abſorbed by the cloths, and is afterwards evaporated from them.

* The Arabians have this remarkable method of cooling their wines, which exhibits, in the moſt forcible manner, the truth of they above account. They dig a hole, and having filled it with ſtraw, they place the bottle of wine they mean to cool into the midſt of it, having previouſly ſurrounded it with *wet* ſtraw or clay. They then ſet fire to the ſtraw, and the bottle of wine is brought out (from the evaporation of the wet clay or ſtraw ſurrounding it) *quite cool*.

We will not fatigue our reader with noticing the manufacturers of *ice* in certain diſtricts of India, where the thermometer was never known to ſink ſo low as the freezing point. Vide Philoſ. Tranſ. Vol. LXV. p. 252.

The

The matter of heat, or caloric, finds, moreover, other outlets to efcape by, befides the furface of the body; as a confiderable quantity muft, evidently, pafs off from the *lungs* in breathing. Indeed the quantity which is carried off by the air and returned by the lungs, is found, by experience, to be much greater than one would at firft imagine, "for we know that the heat contained in one breath of air, will, if properly managed, raife Fahrenheit's thermometer *ten degrees* *." And provident nature feems to take advantage of this circumftance, when an extraordinary quantity of heat is fuddenly excited in thofe animals, which are but little able to carry off a fuperabundance: thus *dogs*, which do not fweat, and *fheep*, whofe cloathing is fo particularly unfavourable to the carrying off an unufual quantity of heat, always open their mouths very wide, that the whole furface of the fauces may be expofed, and move the tongue remarkably quick, to agitate the air in contact with it †.

When heat is accumulated in the fyftem, either by fever, by ftrong exercife, or by the fcorching heat of the fun, nature conftantly cries aloud for ACIDS, and a

* Vide Critical Review for January 1782, page 6.

† Vide Rigby's ingenious Differtation *on Animal Heat*.

cooling

cooling diet; and to thoſe who have turned their mind to chemiſtry, the reaſon for this ſtrong deſire is obvious. They know that *animal heat* originates in the decompoſition of OXYGEN AIR, after it is received into the blood by the lungs; and they obſerve, that the quantity of air which is decompoſed or vitiated, bears direct proportion (as before explained when mentioning the experience of the celebrated diver Mr. SPALDING) to the quantity of combuſtible matter, whether animal or vegetable, whether ſugar, oil, or ſpirit, received into the ſtomach. They obſerve, likewiſe, that *acids* taken into the ſtomach always check and reſtrain the generation of heat, and promote perſpiration *; or, in other words, that when the ſyſtem is ſaturated with OXYGEN only, leſs OXYGEN AIR is imbibed by the blood in the lungs, and conſequently leſs heat will be evolved in the body. It is upon theſe principles that the reapers in the ſouth of Spain covet their *guzpacho*, compoſed of bread, oil, and vinegar: the two firſt articles for nutriment, and the latter to moderate their vital heat. On the ſame

* The *hydrogen* uniting with the *oxygen* of the acid forms water, of which *perſpiration* is chiefly compoſed. In the caſe of Mr. HOLWELL, who ſurvived his impriſonment in Calcutta, he found the *perſpiration* from his ſhirt ſleeves relieved him, when water did not, which leads one to ſuppoſe, that the *oxygen* here is in a much leſs cloſe bond of union than in water.

principles

principles, obedient to the voice of nature, during the fultry heats of fummer, we equally defire our lettuce, oil, and vinegar, and we may remark, that in warm climates, and in fummer in the *more temperate regions* of the globe, the acefcent and watery fruits abound, but in the autumn *we* have chiefly thofe which produce oil and fugar *.

* That ACIDS only impart to the fyftem *oxygen*, and not *oxygen air*, and are therefore cooling, is the judicious obfervation of the celebrated Spanifh traveller, the Rev. Mr. TOWNSEND. It is mentioned in the chemical part of this work, in the note ‡, p. 25; and was fuggefted, alfo, fome years back, as probable, by Dr. BEDDOES, in his lectures on chemiftry at Oxford. A queftion here then naturally occurs, Why, in thefe fultry climates, do fugar, fpices, rum, &c. fo much abound? *Anf.* As exceffive heat drains the body, a fpeedy reparation may fometimes be required, and as the ftomach cannot quickly act upon a load, we may therefore have, perhaps for this reafon, thefe highly antifeptic perfpirable and nutritious aliments. People who drink at intervals much porter, and live in public houfes, in *colder climates*, are commonly obferved to be very *fat*.

SECT.

SECT. XI.

ON THE CAUSE OF MOTION IN THE VITAL, OR INVOLUNTARY, ORGANS.

It was obferved before, that the HEART was the center of motion, diftributing and receiving the blood from every part of the body; or, to ufe other language, the *arteries* and *veins* refemble diftinct trees, whofe *branches* inofculate at top, and whofe *trunks* are fixed in the heart, as the common bafis. The *nervous fyftem* may, in like manner, be compared to a tree, whofe root is from the BRAIN, and whofe *ftem* is confined within the fpine *.

From fome experiments that have been made on *nerves*, it appears, that they do not fhorten their dimen-

* The *brain* and *fpinal marrow*, improperly fo called, fend off fmall portions of their fubftance, furrounded by a part of their membranes. *Thefe portions* are called NERVES, of which 10 pair iffue from the *brain itfelf*, and 30 pair from the *fpinal marrow*; and thefe 80 nerves, divided and fubdivided into an almoft infinite number of fmall cords, are diftributed to every point of the body. Dr. ADAIR.

fions

ſions when excited by any ſtimulus, nor retract their divided parts when cut aſunder. They therefore eſſentially *differ* from that part of the animal fabric, which I muſt beg leave to call the CONTRACTILE LIVING FIBRE. *Theſe elaſtic threads* obey the impulſe of *different ſtimuli*. They are productive of motion in animals, as well as in the ſenſitive plant, and therefore act independent of nerves. They are diſpoſed, by the infinite wiſom of provident NATURE, in different directions, ſo that when excited into movement, they may perform ſome important action.

The contraction of the HEART and ARTERIES, for the purpoſe of circulating the fluids, nouriſhing the body, and diſtributing the animal heat, is performed by means of *theſe contractile living fibres*. Thus an ARTERY reſembles, in ſome meaſure, a tube of *elaſtic gum*, which when mechanically diſtended returns to its ordinary ſhape, and as *this elaſtic* and *irritable power* ſurvives * the life of the animal, arteries were believed by

* This *elaſtic principle* in the arteries acts ſo powerfully after death, that theſe tubes are conſtantly found void of blood. The ſame *elaſtic principle* in the muſcles renders the dead body, which was before pliant, tenſe and rigid. The barbarous cuſtom of hardening the fleſh of the cod, by *crimping* the fiſh alive, is another clear exhibition of the *great contractility* of the contractile living fibre.

the

the ancients to be *air-carriers*, from which ſuppoſed office they derive their preſent name.

The moving fibres of the HEART and ARTERIES are excited into action by the *quantity* of the blood, and the *ſtimulus* of OXYGEN AIR *. The contractile fibres of the STOMACH are excited into action by the *quantity* and *quality* of the food, or, in defect of theſe, by its own *gaſtric juice*; and the INTESTINES perform their periſtaltic or vermiform motion, by the excitement of the *bile* and their *natural contents* †.

* This poſition was before proved in page 79, from the celebrated experiment of Dr GOODWIN. Another ſtrong proof *that oxygen air imbibed by the blood is an excitement to the heart and arterial ſyſtem*, may be ſeen among the records of the experiments of the Philoſophic Society at Dr. HIGGINS's. A YOUNG GENTLEMAN HAVING BREATHED PURE UNDILUTED OXYGEN AIR FOR SEVERAL MINUTES, HIS PULSE, WHICH BEFORE THE EXPERIMENT WAS AT 64, SOON ROSE TO 120 BEATS IN A MINUTE.

The above-mentioned experiment was certainly attended with much riſk; as OXYGEN AIR, like gold, to paſs current always requires *ſome alloy*.

What advantage may be derived to the ſick by increaſing or diminiſhing at pleaſure this *natural ſtimulus* in the blood may be eaſily conceived! See Dr. THORNTON's Communication to Dr. BEDDOES

† The ſenſibility of the contractile fibres varies greatly. Thus the *bile*, which is the natural purge or ſtimulus to the fibres of the bowels, when thrown back into the vaſcular ſyſtem, has very little effect upon it. Thus what paſſes *quietly* through th ſtomach is often a cauſe of great *irritation* in the inteſtinal canal. Thus the *gentle ſtimulus* of light is a *very powerful* operator in contracting the dimenſions of the pupil of the eye: i. e. occaſioning the reaction of its fibres.

Theſe

These moving fibres are alfo affected by *other* than their *natural ftimuli*, which ftimuli often appear to have a peculiar determination or action on a particular organ. Thus if *ipecacuanha* be injected into a vein, it excites the ftomach, equally as though it had been taken by the mouth; and the fame is the effect of *jalap*, or any other purgative, it will be conftantly found to ruffle the inteftines *. Thus, if *mercury* be oxydated, that is, combined with oxygen, the abforbents † will convey it into the

* A plaifter of Arfenic applied to a fcald head, has been known to kill fuddenly; I have feen convulfions and death from a quickfilver girdle applied to cure the itch. A decoction of tobacco ufed in wafhing the head, brought on vomiting, delirium, and convulfions: a poultice of this plant applied to the region of the ftomach, produced vomiting, purging, and delirium: white lead applied to cure a fcurfy eruption, brought on fhortnefs of breath, vomiting, and fainting. In all thefe inftances the mifchief was done by *uninftructed old women*, and equally ignorant and *impudent quacks*; for when fuch applications are made with *learning* and *judgment*, they are equally fafe and effectual. Thus a bitter poultice applied to the belly deftroys worms; flannels dipped in hot brandy allay vomiting; and opium applied externally mitigates pain; in one cafe, however, it produced, from the ignorance of the advifer, convulfions and death. Thus feveral children have had their agues cured by a waiftcoat of bark. At Guadaloupe, a phyfician, not long ago, by infufing certain remedies into the veins, is faid to have cured feveral perfons labouring under inveterate difeafes, and the expedient feems to merit the attention of practitioners, efpecially as we are affured that alarming fymptoms from the bite of a viper were removed by injecting the diluted fpirit of hartfhorn into the blood.—Dr. ADAIR.

† I think I have proved, fays the illuftrious Dr. HUNTER, that the lymphatic veffels are the abforbing veffels, all over the body; that they are the

the blood, and a decompofition taking place, the metal will be *revived*, and the METALLIC BASIS (the learned Dr. GIRTANNER thinks it is folely the *feparated oxygen)*

the fame as the lacteals; and that thefe altogether, with the thoracic duct, conftitute *one great* and *general fyftem*, difperfed through the whole body for abforption; that this fyftem *only* does abforb; that it ferves to take up, and convey, whatever is *to make*, or *to be again mixed with the blood*, from the inteftinal canal, from the fkin, and from all the internal cavities and furfaces whatever. In our times, after fchools of anatomy have long flourifhed in all the civilized nations of Europe, and when, from the number of men who have been employed in fuch refearches, it might have been imagined that difcoveries were exhaufted, PROVIDENCE has allowed me a greater fhare of that fort of honour, than at firft I could have expected. My difcovery of the ABSORBENT SYSTEM gains credit daily, both at home and abroad, to fuch a degree, that I believe we may now fay, that it is almoft univerfally adopted: and, if we miftake not, in *a proper time*, it will be allowed to be the *greateft difcovery*, both in *phyfiology* and in *pathology*, that anatomy has fuggefted, fince the difcovery of the circulation of the blood.

Having ventured to throw out, continues Dr. HUNTER, fo bold a propofition, that my reputation may not fuffer through want of a little reflection upon the fubject, I muft beg leave to explain my opinion. The difcovery of a duct of a gland, an undefcribed mufcle, an artery, or a concealed vein, all fuch difcoveries certainly are trifling, when compared with the introduction of a *new* and *general fyftem*, which is interwoven with, and performs a peculiar and important function in, every part of the body; fo *important*, indeed, that it was neceffary, and accordingly has fince been actually found out in brutes, likewife in birds, and in fifh. *Such is the difcovery* of the ABSORBENT SYSTEM: and every perfon, who is really an anatomift, or phyfiologift, will, upon a little reflection, admit what has been here advanced; and, looking over the whole progrefs of anatomy, he will allow, that fince the time of Ariftotle to the prefent day, there have been only *two great difcoveries* with regard to the phyfiology of our bodies; to wit, the CIRCULATION OF THE BLOOD, and the ABSORBENT SYSTEM. Vide Dr. HUNTER's Second Lecture.

will

will become a powerful ſtimulus to the ſecreting organs, the abſorbents, and to the heart and arterial ſyſtem, but more eſpecially the ſalivary glands *.

The vital organs, the heart, the lungs, the ſtomach, and inteſtines, which feel and react on their own peculiar ſtimuli, have, however, their appropriate and diſtinct NERVES †; ſo that our *mechanical ſyſtem* is not wholly unconnected with the *ſentient*; and hence the digeſtion, the action of the heart, the breathing, the vermiform motion of the inteſtines, are " languid and depreſſed," or fly into " angry and perturbed motions," whenever we are rouſed by violent and inordinate paſſions ‡.

* This ſubject deſerves a full inveſtigation, or undoubtedly more attention than has been hitherto given it. Vide Vol. III. p. 342.

† The *phrenic nerve* goes to the diaphragm, or great muſcle of reſpiration, the *par vagum* to the ſtomach and bowels, and the *ſympathetic* nerve to the heart. Theſe nerves are much ſmaller and fewer than what go to the organs of voluntary motion.

‡ If a nerve be cut, leading to any of the vital organs, death enſues from the defective energy of that organ. The connection is therefore intimate between the *nerves* and the actions of the *contractile fibre*; but this is no argument that theſe are one and the ſame thing, as the *latter* appears to be governed by the ſame laws as act the fibres of the *ſenſitive plant*, &c. Vide Vol. III. p. 365.

SECT.

SECT. XII.

ON THE CAUSE OF MOTION IN THE VOLUNTARY ORGANS, OR MUSCLES.

Does there appear any principle in all nature, ſays our Engliſh hiſtorian*, more myſterious than the union of ſoul and body, by which the ſpiritual part poſſeſſes ſuch an influence over the material, that it is able to direct the motion of any muſcle, or even ſometimes a part of a muſcle. Were we empowered by a ſecret wiſh to diſplace mountains, or control the planets in their orbit; this extenſive authority would not ſeem more extraordinary or more unaccountable. An accident fortunate for philoſophy has thrown, however, ſome light on this hitherto myſterious ſubject.

Whilſt Profeſſor Galvani, at *Bologna*, was diſſecting a frog, in a room where ſome of his friends were amuſing themſelves with an electrical machine, one of them happened to draw a ſpark from the conductor, as the profeſſor touched one of the nerves of the animal.

* Hume.

In

In an inftant the whole body of the frog was fhook by a violent convulfion.

The profeffor was aftonifhed at the phenomenon, and believing it to be owing to his having wounded the nerve; to affure himfelf, whether this was really the cafe, he pricked it with the point of his knife, without any motion being produced: he now touched the nerve with the inftrument as at firft, and defired a fpark to be taken from the machine, on which the contractions were renewed.

The experiment was repeated a third time, but the animal remained motionlefs; however, as the ivory handle of the diffecting knife was a bad conductor of electricity, he changed it for a metallic one, and re-excited the movements, which he conftantly failed in doing whilft ufing an electric fubftance.

After having made a great number of experiments with the electrical machine, he refolved next to make trial of atmofpheric electricity. To this end he raifed a conductor upon the roof of his houfe, from which he brought an iron wire into his room, and to this attached metal conductors, connected with the nerves of the animals deftined to be the fubject of his experiments, and to their legs he tied wires, which reached the floor.

Confiderable

Confiderable movements were obferved in the animals, whenever it lightened. Thefe preceded the claps of thunder, and always correfponded with their intenfity and repetition; and even when it did not lighten, the movements took place, whenever any thunder cloud paffed over his houfe.

Having next laid bare the nerve leading to the wing of a duck, the fciffars of the operator being under it, whenever any of the company prefent applied a fhilling, or a half crown, to the nerve fo difpofed, the nerve was agitated by a violent movement, which occurred as often as the fhilling or half-crown was employed, till the nerve was exhaufted of its power, which happened commonly in about 15 minutes.

It was afterwards found, that if an half crown be placed in contact with the under part of the tongue, and a plate of zinc be applied to the upper part, on bringing the two metals into contact with each other, a pungent difagreeable feel, which it is difficult to defcribe, is produced at the point of the tongue.

And if a plate of zinc be placed between the gums and the upper lip, and a plate of gold be placed in the upper part of the tongue, when the gold is brought into con-

tact

tact with the zinc, the perfon fees immediately a flafh of lightning.

After performing this experiment repeatedly, I conftantly felt, fays Dr. MONRO, the Profeffor of Medicine at Edinburgh, a pain in my upper jaw, which continued for more than an hour. And in one experiment, after I had applied a blunt probe of zinc to the partition which divides the nofe into two noftrils, and repeatedly touched it with a crown piece of filver applied to the tongue, I thereby produced the appearance of a flafh of lightning, and feveral drops of blood fell from that noftril. Dr. FOWLER, after making a fimilar experiment on his ears, obferved a fimilar effect.

The experiment of producing fparks by ftroking the back of a cat in frofty weather, readily fhews that the electric fluid naturally exifts in a very active ftate in the bodies of fome animals. Poffibly, fays the celebrated Dr. PRIESTLEY, the *light* which is faid to proceed from animals, as from wild beafts, when they are in purfuit of their prey in the night, may not only arife, as it has hitherto been fuppofed to do, from the mere friction of their hairs or briftles, but violent *mufcular exertion* may alfo contribute to it. *This light* may, with the electric flashes from their eyes, affift them occafionally to catch their prey; as glow-worms and other infects are provided with a conftant electric light for that purpofe.

Mr. HARTMAN having neglected to fupply his paroquet with water to wafh himfelf, he obferved that its feathers, in a ftate of drynefs, were endued with a proper electrical virtue, repelling one another, and retaining their electricity even a long time after they were plucked from the body of the bird, juft as they would have done if they had received electricity from an excited glafs tube.

The following is a very remarkable inftance of the exiftence of this fluid in the human frame, and of the eafe with which it is put into action. BRIDONE, in his travels, mentions the ftory of a lady, who, on combing her hair in frofty weather in the dark, had fometimes obferved fparks of fire to iffue from it; this made him think of attempting to collect the electrical fire from the hair, without the affiftance of any other electrical apparatus. To this end he defired a young lady to ftand on wax, and comb her fifter's hair, who was

fitting

ſitting in a chair before her; ſoon after ſhe had begun to comb, the young lady on the wax darted out ſparks of fire againſt every object that approached her. Her hair was ſtrongly electrical, and affected an electrometer at a conſiderable diſtance. He charged a metallic conductor from it, and in the ſpace of a few minutes collected a ſufficient quantity of electric fire ſo as to kindle common ſpirits, and, by means of a ſmall jar, gave many ſmart ſhocks to all the company preſent.

Monſ. CAVALLO alſo mentions, that he obtained, by means of a ſmall condenſing plate, very ſenſible ſigns of electricity from various parts of his own body, and from the head of almoſt every other perſon on whom he made the experiment.

The celebrated JOHN WESLEY relates, that Mrs. Suſanna Sewall, wife to Major Sewall, in New England, at a certain time of the year, never changed her apparel without obſerving a ſtrange flaſhing of ſparks. In the company of ſeveral perſons, having taken off ſome of her wearing apparel, and ſhaking it, ſparks flew forth, making a noiſe much like bay leaves thrown into the fire. They deſired Mrs. Sewall one day to put on her ſiſter's garment; and when ſhe put it off, in the evening, it ſparkled as her own uſed to do.

 It

It has often been obſerved, that when we wear worſted under-ſtockings, and ſilk over them, if we chance to draw off the ſilk ſtocking in the dark, the bright electric fluid is often ſeen flaſhing from every part of the under-ſtocking.

A variety of other curious facts clearly evince, that the electric fire is eſſentially connected with the animal body, and is continually exerting its influence in it.

The electric fluid, however, is far more conſpicuous in the body of the GYMNOTUS, which has the remarkable property of generating and throwing out its electricity much beyond the limits of its own ſyſtem. I have often, ſays Dr. GARDEN, when I have taken hold of the *gymnotus* with one hand, and put the other into the water over its body, without touching it, received a *ſmart ſhock*; and I have obſerved the ſame effect to follow, when a number of perſons joined hands, the perſon at one extremity of the circle taking hold of, or touching the electric fiſh, and the perſon at the other extremity putting his hand into the water over the body of the fiſh. The ſhock was communicated through the whole circle as ſmartly as if both the extreme perſons had touched the fiſh. I am told, continues Dr. GARDEN, that ſome of theſe fiſh, in Surinam river, are upward of 12 feet long, whofe ftroke or fhock proved *inftant death* to any perfon who had the misfortune to touch it.

Monf. FERMINS, in his Natural Hiftory of *Surinam*, publifhed in 1765, alfo tells us, that making 14 perfons grafp each other by the hands, while he grafped the hand of the laft with one of his, and with the other touched the GYMNOTUS with a ftick, the whole number felt the fhock, and he could not prevail on any of them to repeat the experiment *.

Dr. PRIESTLEY relates, that the fenfation is ftrongeft when the fifh is in motion, and is tranfmitted to a great diftance, fo that if perfons in a fhip happen to dip their fingers or feet in the fea, when the fifh is fwimming at the diftance of 15 feet from them, they are effected by the fhock.

Mr. WALSE gives us the following beautiful experiment, to prove that the *gymnotus* is very fenfible whether the fubftances brought near him are proper or not for receiving the electric fhock.

The ends of two wires were put into the water of the

* VANDELOTT makes two fpecies of the *electric eel*, the black and reddifh; though he acknowledges that, excepting the difference of colour and degree of ftrength, they are not materially different.

vessel,

veſſel, which contained the animal; theſe wires were of ſome length, ſtretched to their extent, and terminated in two glaſſes of water placed at a conſiderable diſtance from each other. Whilſt the apparatus remained in this ſtate, and the circulation was of courſe *interrupted*, the animal did not prepare to exerciſe his power, but the inſtant a ſpectator, or any conducting ſubſtance, filled the interval, and rendered the circle complete, it inſtantly approached the wires, arranged itſelf, and gave the ſhock.

The ſurpriſing property of the TORPEDO, in giving violent ſhocks to the perſon who takes it in his hands, or who treads upon it, was long an object of wonder. For ſome time it was generally reckoned to be a fabulous hiſtory; but at laſt the matter of fact being aſcertained beyond a doubt, philoſophers have endeavoured to find out the cauſe.

As an inſulated perſon cannot receive a ſhock from either of theſe extraordinary fiſhes, the identity of this fluid, and the electric fluid, is clearly aſcertained.

Mr. HUNTER has well obſerved, ſays Sir JOHN PRINGLE, that the magnitude and number of the nerves beſtowed on the electric organs of the *torpedo* and *gymnotus*, muſt appear as extraordinary as their effects; for if if we except the important organs of our ſenſes, there is no part, even of the moſt perfect animal, which, for its ſize, is more liberally ſupplied with nerves than the *torpedo*: nor yet do theſe nerves of the electric organs ſeem neceſſary for any *ſenſation* that can belong to them: and with reſpect to *actions*, there is no part of any animal, however ſtrong and conſtant its actions may be, which enjoys ſo large a portion of them. If then it be probable, that *theſe nerves* are *unneceſſary* for the purpoſe either of *ſenſation* or *action*, may we not conclude, that they are ſubſervient to the management of the *electric fluid*.

Monſ. REAUMUR has alſo reſolved it into the action of a vaſt number of *minute nerves*, ſituated in a line under the ſkin, which by their accumulated force gives a ſudden and violent ſhock. He obſerves, alſo, that when theſe animals have exhauſted their electric powers, they ſubmit quietly to every inſult; but having by a little reſt and time recovered their former force, they then haſtily repay the offence *.

The

* May not animals have a power, is the conjecture of the celebrated Dr. PRIESTLEY, of extracting from the blood the *electrical fluid*; the BRAIN then would be the great laboratory for that purpoſe; and by means of the NERVES,

The ingenious Monf. VALLI obferves, alfo, that the fize and number of the nerves, which are beftowed upon the *electrical organs* of the torpedo and gymnotus are truly extraordinary and aftonifhing.

The nerves of the *mufcles* in animals are likewife very large, and their minute ramifications fo great, that feveral phyfiologifts have been led to believe that mufcular contractile fibres are the fame thing as nervous fibrils.

The blood-veffels of the *electrical organs* are very numerous, follow the courfe of the nerves, and diftribute the fmaller branches along with them.

The quantity of veffels expended upon the *mufcles* is alfo prodigious, and they likewife are found to accompany the courfe and diftribution of the nerves.

There exifts in *mufcles* as well as in the *electrical organs* of the torpedo and gymnotus, cylinders, partitions, and a great fubdivifion of parts.

Have we not therefore every reafon to believe that our *mufcles* are fo many *electrical organs*, each mufcle being as it were a battery, and mufcular intumefcence and contraction, in confequence of a fort of explofion

NERVES, that great principle, thus exalted, would be directed into the *mufcles*, and force them to act, in the fame manner as they are forced into action when the electric fluid is thrown into them *ab extra.*

produced

produced by the animal or nervous electricity *. According to this hypothesis our nervous and muscular systems may be considered, says Dr. Beddoes, as a beautiful machinery, and muscular motion, at least that of animals analogous to man, would be a chemical operation combining *hydrogen* and *azot* with OXYGEN. This hypothesis, though not perhaps capable at present of the strictest proof, appears highly probable. It accounts for the perpetual necessity of imbibing OXYGEN AIR, and enables us to trace the changes undergone by this substance, from the moment it is received, till the

* I once happened, says Dr. Priestley, to lay a chain near my electric batteries, so as to make it return at a sharp angle, in order to impress the form of the letter *b* upon the table; and observed, that on the discharge, the part of the chain that had been *doubled* was displaced, *and pulled about two inches towards the rest of the chain.* At this I was surprised, as I thought it lay so that it could not slide by its own weight. Upon this I repeated the experiment with more accuracy. I stretched the whole chain along the table, laying it double all the way, and making it return by a very sharp angle. The consequence always was, that the chain was SHORTENED about *two inches*, and sometimes more, *as if a sudden pull had been given it.*

The contraction of a muscular fibre may be *compared*, says the illustrious Dr. Darwin, to the following electric experiment. Let twenty very small Leyden phials, properly coated, be hung in a row by fine silk threads at a small distance from each other; let the internal charge of one phial be positive, and of the other negative, alternately; if a communication be made from the internal surface of the first to the external surface of the last in the row, they will all of them instantly *approach* each other, and thus SHORTEN a line that *might connect them together like a muscular fibre.* Vide Zoonomia, p. 61.

moment it is expelled. During the contraction of the muscles, OXYGEN combines with the elements above mentioned into *water*, and *various salts*, among which the *marine* and *phosphoric acids* deserve particular notice. *In this state* it is taken up by the *absorbents*, and afterwards *exhaled* or *excreted*. Hence the necessity for OXYGEN AIR in the blood for muscular action, and hence the reason why motion languishes, whenever this principle is scantily supplied by the lungs *.

* A very delicate experiment was made by Dr. MAYOW, in the last century. A dog that was *panting* and *breathing* deeply, on receiving arterial, that is, *oxygenated* blood into one of his veins, instantly began to breathe so *calmly* that his respiration was scarce *sensible*. The animal receiving from an *unusual source* the sustenance which is probably expended by violent muscular action; it was *therefore* no longer necessary to inhale it rapidly. From Dr. BEDDOES's Observations on the Nature and Cure of *Calculus, Sea Scurvy, Consumption, Catarrh, Fever*, &c. Vide also page 89, line 14.

SECT.

SECT. XIII.

ON TONE.

The elaſtic and vibratory nature of catgut, formed from the inteſtines of animals, led the phyſicians of old to conceive, that the *moving fibres* in living animals were influenced by the ſame well known properties. They remarked, therefore, with pleaſure, that a like ſentiment prevailed, even in common life; hence the untutored expreſſions, *I feel braced*, *wound up*, *nerved*; and their oppoſite terms, *relaxed*, *unſtrung*, and *unnerved*.

In ſupport of the doctrine of *tone* or *tenſion*, the celebrated Dr. Cullen has given us the following very ingenious arguments.

Moſt muſcles have *antagoniſt muſcles*; that is, the fibres of each muſcle are always drawn into *tenſion* when in a ſtate of reſt, by the oppoſite power of ſome other muſcle. Thus if one of the *flexor muſcles* be cut in two, the *extenſor*, or oppoſite muſcle, will be found in a ſtate of ſpaſm, or contraction, and vice verſa; and this may be ſeen even in a body recently dead †: and

† Vide note *, page 109.

thus the mufcles of a diflocated fhoulder bone are, from lofing their antagonift power, in a conftant ftate of fpafm or action *.

They are alfo kept in a proper ftate of *tenfion* by ligaments, by tendinous bands, by the natural weight of depending parts; and laftly, by the fulnefs of the blood veffels which traverfe the mufcular fibres.

The *effects* of the *vafcular fyftem* on *mufcular parts* have not as yet been properly fcrutinized. If we confider the numerous veffels that every where fpread themfelves on mufcular fibres, and, as they are more or lefs replete with blood, muft give them a greater or lefs degree of *tenfion*, it can fcarcely be doubted but that they muft have fome effect this way: which obfervation will appear more ftriking if we obferve the peculiar manner of the diftribution of the trunks of blood veffels, which are feen running parallel to the mufcular fibres, and all their branches entering them at right angles. Hence, if

* This proves that in *mufcular fibres* fuch a contractile power always *during life* exifts. Thus a plant ftands erect, and all its leaves are beautifully difpofed around it. Only tranfplant this flower, how will it droop; but a *frefh life* is poured into it, it then reaffumes its erect pofition. This *perpetual action* in the moving fibres arifes, therefore, from their *vis vitæ*, or *living powers*; or, as phyfiologifts darkly exprefs it, on their *vis infita*. The fphincters, or circular mufcles, confining the contents of certain parts, have no antagonift powers, and therefore are in a conftant ftate of action from their *vis infita*, which alone is overcome by diftention.

 we

we forcibly inject the veins or arteries of a dead animal, it will cause *a sudden contraction of those muscles through which they pass*. As a further proof of this, considerable hæmorrhages are found to weaken the *whole muscular system*; and certainly the phænomena of *blood-letting* may be better explained by this doctrine of TENSION, than by the notion of *derivation* and *revulsion* *, which made so much noise thirty years back: for it is hardly probable, if we consider the impetuosity of the circulation, that by drawing off a slight quantity of blood from any particular part, any very considerable change either in the distribution or quantity of the blood can be produced in that part. But seeing that *tension* admits of great variety, and that a very slight alteration, with respect to *tension* †, makes a great alteration throughout the system, who can hesitate a moment in accepting this doctrine of TENSION, in preference to that of derivation and revulsion?

* Stimulant applications, as bathing of the feet, blisters, vesicatories, aloetic cathartics, pressure on the carotids, &c. as inviting the blood from the *ascending* to the *descending* AORTIC system, better elucidate this celebrated doctrine of derivation and revulsion.

† Thus a small quantity of flatus in the stomach or intestines will produce various commotions in the system. We shall not attempt now to explain the nature of these flatulencies, but only observe, that evident spasms of the muscular system are often induced by them, and particularly in the extremities, which are as quickly relieved by the discharge of that wind.

The

The effects of *certain remedies* is another proof of the importance of the consideration of the doctrine of TENSION.

Astringents are such substances, as applied to the human body, produce a condensation of the moving fibres*, and thereby increase their density and force of cohesion. If they be applied to longitudinal fibres, the contraction is made in the length of these; and if applied to circular fibres, they diminish the diameters of the vessels or cavities which these fibres surround. The operation of astringents in condensing the solids, appears chiefly from their use in tanning or making of leather. The same operation also appears in what is called their antiseptic power, which seems to depend upon their preserving the firmness and cohesion of the animal substances to which they are applied, for a much longer time than the firmness would have continued in these substances without such application. As they therefore consolidate the moving fibres, they must therefore in-

* On examining the muscular fibres of a hawk's wing with a very fine microscope, these seemed (like the proboscis of a butterfly, or the tendril of the passion flower) of a spiral form, and if so, to the human comprehension of the best possible shape for repeated elongations and contractions. I was astonished, says the learned Dr. MONRO, to discover from the microscope that the fibrils of vegetables were also convoluted. A doubt, however, still exists, whether these were not deceptions of the microscope.

crease

creafe their *tone* or *tenfion* *, and are therefore properly called *tonics*; and upon the fame ground may be called, alfo, *corroborants*, or *ftrengtheners*.

The moft obvious operation of bark, and other tonics, is, that being taken into the ftomach, they increafe the appetite for food, and promote the digeftion of it. But we are led to believe, that thefe functions depend in a great meafure on the *tone* of the mufcular fibres of the ftomach; and therefore may fuppofe, that the improvements of thefe functions depends upon an increafe of *tone* of thofe fibres. And farther, as the lofs of appetite and indigeftion are fuppofed to occur from a lofs of *tone* in the ftomach; fo bitters, as they are often effectual in curing thefe diforders, may be prefumed to do it by reftoring *tone* to this organ. There is then hardly any doubt but that aftringent remedies are powerful *tonics* with refpect to the ftomach; and there is as little doubt, that the ftate of the ftomach is as commonly communicated to the other parts of the fyftem: fo it is fufficiently probable, that by an improvement of digeftion, the vigour of the fyftem may be in general amended; and that with the *tone*, the activity of the whole *moving fibres* may be increafed. That the tonic power of aftringent

* Or *fpring*. Vide note *, page 130.

remedies

remedies in the ſtomach and the inteſtines is communicated to other, and even the moſt diſtant, parts of the ſyſtem*, appears ſtrongly, from their being a ſpecial means of preventing the return of the paroxyſms of an ague, and a powerful remedy for the recovering of ſtrength after a long illneſs.

* To remove a prejudice, ſays Dr. BROWN, that has often been inſiſted on, of the GOUT not depending upon *debility*, becauſe *inflammation* accompanied it; little doubting that the *inflammation itſelf* depended on *debility*, I ſubjected the queſtion to actual experiment. During a fit of the gout I invited Dr. JONES and other friends to dinner, and by the uſe of certain ſtimulants uſed in their preſence, I recovered the moſt perfect uſe of that foot, which before dinner I could not put to the ground for pain. How can opium, and other ſtimulants, at once relieve the gout of the ſtomach, and in the remoteſt extremity of the ſurface, unleſs the muſcular parts be cloſely connected together, and the excitement of one part be *extended* throughout the whole body? Thus, if a man be accuſtomed to take a dram at any certain hour, when that hour returns he feels a feebleneſs over the whole ſyſtem. The palpitation of the heart ſhews the ſanguiferous ſyſtem to be affected, as the *tremor* of the muſcles does the muſcular ſyſtem; but by applying the uſual ſtimulus, all theſe ſymptoms diſappear, and the TENSION is reſtored to the whole ſyſtem. That this depends on *tenſion* may be argued from hence, ſays the celebrated Dr. CULLEN, as theſe *tremors* may be taken off by applying an external weight, to ſupply the *want of tenſion* in the fibres: for a perſon who cannot take up a ſmall glaſs without exceſſive trembling, will be able to manage a *large bowl* with tolerable ſteadineſs.

This doctrine alſo explains the reaſon why *tonic* remedies, if long continued, are debilitating; for the muſcular fibres, as a bow kept on the *conſtant ſtretch*, loſe, like it, their *contractile principle*, and become *lax*. Vide CULLEN on the Gout, Sect. 557, page 113. Alſo Law II. of Organic Life.

The pneumatic phyficians believe that the TONE of the fibres depends not fo much on a due tenfion, as on the *oxygen* imparted to them from the *arterial blood*.

It is not from the fleek countenance, not from the plump habit, as indicating *diftended voffels*, that we are to form our judgment of ftrength, for HYPOCRATES has well obferved, " otium humectat et corpus reddit debile; labor ficcat et corpus robuftum efficit." To fee, therefore, vigour in perfection, we muft look at the hardy and laborious ruftic, whofe turgid mufcles, as in the ftatue of the Farnefian HERCULES, can be readily diftinguifhed through the fkin.

In fatting poultry we feed them to the full, but we endeavour to keep them perfectly at reft. In confequence of this treatment the veffels are *diftended*, but the fibres are relaxed, tender, and weak, in their cohefion. To fatten our ducks, we not only confine them in a place of fmall dimenfions, but keep them from the water, becaufe we obferve that their cold bath and exercife render the fkin and all their fibres tough.

It may be received as an axiom, fays the learned author of the Guide to Health, " *that the living power or energy of an organ is in proportion to the quantity of oxygenated blood that circulates through it.*" For it is not *merely* the *quantity* of fluids feebly creeping through the veſſels, nor *fat* ſtagnant in every part of the ſyſtem, but the *quick ſucceſſion* and *ſtrong impulſe* of *well oxygenated blood* that produces TONE and VIGOUR.

This may be more clearly comprehended, if we attend to the manner in which horſes are fed and worked upon the road. When firſt taken up from graſs they abound in fat, but are not fit for labour, becauſe, on moderate exertion, they are bathed in ſweat, and are ſoon exhauſted with fatigue. If, when taken into work, with ſixteen buſhels of oats, beſides beans, per month, and a ſmall quantity of hay, they are employed in proportion to their food, they know not what it is to feel fatigue. Their veſſels, filled with *well oxygenated blood*, contract with vital energy, the action and reaction are great, all is activity, all is vigour.

END OF THE FIRST VOLUME.

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