

Medical extracts : on the nature of health, with practical observations, and the laws of the nervous and fibrous systems / by a friend to improvements.

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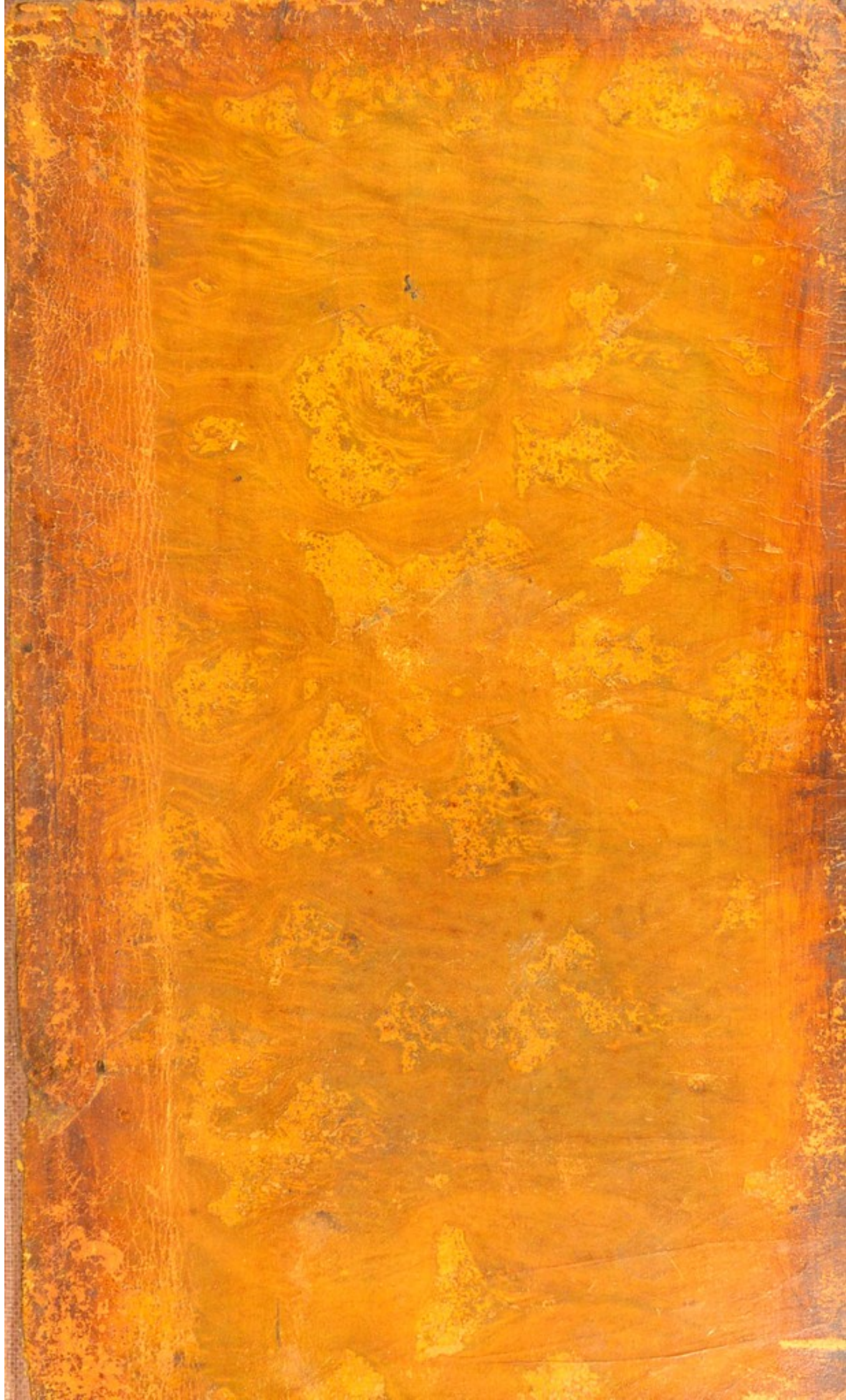
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Author

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MEDICAL EXTRACTS:

ON THE

NATURE OF HEALTH,

WITH

PRACTICAL OBSERVATIONS:

AND

THE LAWS

OF THE

NERVOUS AND FIBROUS SYSTEMS,

BY

A FRIEND TO IMPROVEMENTS.

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.

L O N D O N,

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.

MEDICAL EXAMINER

OF THE

NATURE OF HEALTH

AND

THE CAUSES OF DISEASE

AND

THE LAWS

OF THE

ARTS AND MANUFACTURES

AND THE

ARTS

AND

THE

THESE LECTURES WERE DELIVERED AT THE
ROYAL INSTITUTION, LONDON, IN THE
YEAR 1841, BY
J. D. BARNARD, ESQ., F.R.S.

LONDON,

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

1841.

ALSO, BY THE SAME AUTHOR, A TREATISE ON THE
NATURE OF HEALTH, AND THE CAUSES OF DISEASE,
IN TWO VOLUMES.

1841.

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.

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

SIR,

As a Patron of the Liberal Sciences, and more especially, from the native benevolence of your disposition, 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 Chemistry, and those important discoveries respecting the animal œconomy, which these have suggested.

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

VOL. I.

A

The

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 physick 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

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 tribute of respect and esteem,

I have the honour to subscribe myself,

SIR,

Yours, &c. &c.

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Yours, &c. &c.

ANALYTICAL CONTENTS
OF
VOLUME I.

PART I.

SUMMARY

OF
PNEUMATIC CHEMISTRY.

	PAGE
The DEDICATION to SIR JOSEPH BANKS, Bart.	
APOLOGY.	
The PROGRESS OF CHEMISTRY.	

{ PARACELSUS, - - - - -	i
{ SENNERTUS, - - - - -	ii

VOL. I.

* 2

Sir

CONTENTS.

	PAGE
{ Sir THEODORE MAYENCE, - - - - -	iv
{ VAN HELMONT, - - - - -	v
{ BACON, - - - - -	vii
{ BOYLE, - - - - -	viii
{ MAYOW, - - - - -	x
{ HALES, - - - - -	xiii
{ BOERHAAVE, - - - - -	xv
{ BECHER, - - - - -	xvii
{ STAHL, - - - - -	ib.
{ The <i>Doctrine</i> of PHLOGISTON, - - - - -	xviii
{ Of <i>Flame</i> according to THIS DOCTRINE, -	ib.
{ The <i>Burning</i> of SULPHUR, - - - - -	xix
{ ————— CHARCOAL, - - - - -	xx
{ ————— SPIRITS of WINE, - - - - -	ib.
{ ————— METALLIC SUBSTANCES, -	xxi
{ The <i>Products</i> of these several Substances, -	ib.
{ Farther Proofs that Sulphur contains PHLO- GISTON, - - - - -	ib.

The

CONTENTS.

	PAGE
{ The DOCTRINES of the <i>Pneumatic</i> , or <i>Anti-phlogistic</i> , THEORY, - - - - -	xxv
{ The <i>Discoveries</i> of Dr. BLACK, - - - - -	xxvi
{ ————— of Dr. MACKBRIDE, - - - - -	ib.
{ The Honourable Mr. CAVENDISH, - - - - -	xxvii
{ Mr. LANE, - - - - -	xxviii
{ Dr. PRIESTLEY, - - - - -	ib.
{ His <i>Discovery</i> of VITAL AIR, - - - - -	xxix
{ BERGMAN, - - - - -	xxzii
{ SCHEELE, - - - - -	ib.
{ This <i>last Chemist</i> also <i>discovered</i> VITAL AIR, - - - - -	ib.
{ KIRWAN, - - - - -	xxxiii
{ LAVOISIER, - - - - -	ib.
{ LAVAOSIER is joined by BERLOLLET, MOREAU ADET, HAZENFRATZ, DE LA PLACE, MONGE, CHAPTAL, FOURCROY, and other <i>eminent Chemists</i> , who <i>establish</i> the NEW SYSTEM, - - - - -	ib.
{ A SUMMARY OF THIS NEW SYSTEM.	
{ <i>Atmospheric Air</i> supports RESPIRATION and COMBUSTION, - - - - -	ib.
{ <i>Proof</i> of THIS, - - - - -	xxxiv

CONTENTS.

	PAGE
{ <i>Combustion is limited by the quantity of AIR,</i>	xxxiv
{ <i>Combustion gives the Analysis of COMMON</i>	
<i>AIR, - - - - -</i>	ib.
{ <i>VITAL AIR unites with the combustible</i>	
<i>Body, - - - - -</i>	xxxv
{ <i>The Quality of the RESIDUARY AIR, - -</i>	ib.
{ <i>The true Definition of COMBUSTION, - -</i>	ib.
{ <i>The QUALITIES of the combustible Bodies</i>	
<i>when burnt, - - - - -</i>	ib.
{ <i>The Derivation and Origin of the Term OXY-</i>	
<i>GEN AIR, - - - - -</i>	ib.
{ <i>Of the Disengagement of HEAT and LIGHT,</i>	xxxvi
{ <i>Light and Heat are component Parts of VITAL</i>	
<i>AIR, - - - - -</i>	ib.
{ <i>How the Goodness of ATMOSPHERIC AIR</i>	
<i>may be ascertained, - - - - -</i>	xxxvii
{ <i>Of the Importance of the Consideration of</i>	
<i>COMBUSTIBLE BODIES, - - - - -</i>	ib.
{ <i>The DIAMOND is a combustible Body, - -</i>	ib.
{ <i>Metals unite with OXYGEN the Base of Vi-</i>	
<i>TAL AIR, - - - - -</i>	xxxviii
{ <i>Metals are to be esteemed combustible Bodies,</i>	ib.

CONTENTS.

	PAGE
{ <i>Metals during combustion increase in weight</i>	
<i>by absorbing OXYGEN, - - - - -</i>	xxxix
{ <i>Heat increases this Absorption, - - - - -</i>	ib.
{ <i>Metals differ in this Respect, - - - - -</i>	ib.
{ <i>Metals absorb different Quantities of VITAL</i>	
<i>AIR, - - - - -</i>	ib.
{ <i>The Reason why Metals exhibit different-</i>	
<i>coloured Flames, - - - - -</i>	xl
{ <i>Combustible Bodies decompose WATER, de-</i>	
<i>priving it of its OXYGEN, - - - - -</i>	xli
{ <i>Hence the Evolution of its other Principle HY-</i>	
<i>DROGEN, - - - - -</i>	ib.
{ <i>The Composition of WATER proved by Syn-</i>	
<i>thesis, - - - - -</i>	ib.
{ <i>HYDROGEN AIR arises always from the De-</i>	
<i>composition of WATER, - - - - -</i>	xlii
{ <i>Heat assists the Decomposition of WATER, -</i>	ib.
{ <i>The different Species of INFLAMMABLE</i>	
<i>AIR, - - - - -</i>	xliii
{ <i>The Properties of HYDROGEN, - - - - -</i>	ib.
{ <i>The Cause of the AURORA BOREALIS, -</i>	xliv
{ <i>The Cause of DETONATIONS, - - - - -</i>	ib.
{ <i>Of THUNDER and RAIN, - - - - -</i>	ib.
{ <i>Sudden Appearance of STORM, - - - - -</i>	ib.

The

CONTENTS.

	PAGE
{ The <i>Origin</i> of ACIDS, - - - - -	xl v
{ Why ACIDS have <i>common Properties</i> , - -	ib.
{ <i>Method</i> of <i>Investigation</i> , - - - - -	ib.
{ The <i>Advance</i> made with respect to our Know- lege of <i>different Acids</i> , - - - - -	xlvi
{ Why ACIDS are <i>differently characterised</i> , -	ib.
{ Of the COMMON PRINCIPLE and BASE, - -	ib.
{ These are <i>discriminated</i> by <i>different Terms</i> in the NEW SYSTEM, - - - - -	xlvi
{ <i>Metals</i> decompose WATER, - - - - -	ib.
{ <i>Sulphurous Acid</i> promotes the <i>Decomposition</i> of WATER, - - - - -	ib.
{ Sometimes <i>Acids</i> are also <i>decomposed</i> , - - -	ib.
{ The <i>different Affinities</i> which <i>Metals</i> have for OXYGEN, - - - - -	xlvi i i
{ The <i>Reduction</i> of METALS, - - - - -	ib.
{ The <i>Progress</i> of the NEW or ANTIPHLOGIS- TIC CHEMISTRY, - - - - -	xl ix
{ The <i>Confutation</i> of the OLD, or PHLOGISTIC, DOCTRINE, - - - - -	ib.
{ The <i>Conversion</i> of Drs. BLACK and KIR- WAN to the <i>New System</i> of <i>Chemistry</i> , - -	li
	Dr.

CONTENTS.

	PAGE
{ Dr. PRIESTLEY acknowledges himself <i>nearly</i> a <i>Convert</i> to the NEW DOCTRINE, - -	li
{ The <i>Difference</i> between the <i>mineral</i> and <i>ve-</i> <i>getable Kingdoms</i> , - - - - -	liii
{ <i>Plants</i> are <i>distinguished</i> by possessing a LIVING PRINCIPLE, - - - - -	ib.
{ They <i>reproduce</i> their <i>Species</i> , - - - - -	liv
{ Their <i>Relation</i> to AIR, - - - - -	ib.
{ They have <i>no locomotive Power</i> , - - - - -	ib.
{ Dr. PRIESTLEY's and Dr. INGENHOUSZ's <i>Dis-</i> <i>coveries</i> respecting <i>Plants</i> , - - - - -	lv
{ <i>These Philosophers</i> were the first who <i>inhaled</i> the VITAL AIR, - - - - -	lviii
{ The <i>benign Effects</i> which THIS AIR produced, -	ib.
{ The FORMER <i>recommended</i> the Trial of the Vital and other <i>Airs</i> in <i>Diseases</i> , - - -	lix
{ The LATTER <i>actually made</i> the <i>first Experi-</i> <i>ence</i> , - - - - -	lviii
{ Dr. INGENHOUSZ and Mr. CRUIKSHANK at the same Time <i>discover</i> the Nature of PERSPIRATION, - - - - -	ib.
{ The Trial of FIXED AIR in <i>Pulmonary, Can-</i> <i>cerous</i> , and <i>other Complaints</i> , - - - - -	lx

Dr.

CONTENTS.

	PAGE
{ Dr. PERCIVAL's <i>Experience</i> , - - - - -	lx
{ Dr. SMITH's <i>important Discovery</i> that the OXY- GENOUS NITROUS ACID VAPOUR arrests the Progress of <i>contagious Fever</i> , - - - - -	ib.
{ He is <i>seized himself</i> with the <i>same Malady</i> , -	lxi
{ His <i>Memorial</i> , - - - - -	ib.
{ He is appointed, on account of this Disco- very, <i>Physician in Ordinary to the KING</i> , -	lxii
{ <i>Other Trials</i> are made by order of the <i>Lords</i> <i>Commissioners of the Admiralty</i> , which are attended with the <i>same happy Success</i> , -	ib.
{ De MORVEAU at the same time also disco- vered the Efficacy of MARINE ACID VA- POUR in <i>Putrid Fevers</i> , and different Mi- litary Hospitals were ordered to be puri- fied by this Process by a <i>Decree</i> of the <i>National Assembly</i> , - - - - -	ib.
{ Dr. CRAWFORD's <i>Discovery</i> that <i>Mercury</i> is a Specific in <i>Putrid Fever</i> , - - - - -	lxiii
{ <i>Cases</i> to prove this, - - - - -	ib.
{ Dr. WADE and Dr. CHISHOLM <i>confirm the</i> <i>same</i> , by a very <i>extensive Experience</i> , -	lxvi
{ Dr. RUSH's <i>Description</i> of the <i>Putrid Fever</i> which raged at PHILADELPHIA, - - -	lxvii

His

CONTENTS.

	PAGE
{ His <i>Embarrassment</i> at first, - - - - -	lxviii
{ He possesses a MS. Account of the <i>Yellow Fever</i> as it prevailed in <i>Virginia</i> in the Year 1741, which was given him by Dr. FRANKLIN, - - - - -	ib.
{ EVACUATIONS are strongly <i>recommended</i> in this MS. - - - - -	lxix
{ Their <i>salutary Effects</i> , - - - - -	lxx
{ Where SALIVATION was excited, the <i>Cure</i> was always very <i>striking</i> and <i>speedy</i> , - - -	lxxiii
{ Dr. WOOD's Discovery of NITRE as a Specific in <i>Putrid Fever</i> , - - - - -	lxxiv
{ His <i>Reasoning</i> as to its <i>chemical Properties</i> , and <i>physical Operation</i> , - - - - -	lxxv
{ His <i>Success</i> , - - - - -	lxxvi
{ The Rev. Mr. CARTWRIGHT's Discovery of YEAST as a Cure of <i>Putrid Fever</i> , - - -	lxxvii
{ Its <i>chemical Action</i> , - - - - -	ib.
{ His <i>Success</i> , - - - - -	lxxviii
{ Dr. THORNTON's Practice in <i>Putrid Fever</i> , - - -	lxxxii
{ His <i>Success</i> , - - - - -	lxxxiii
{ Of SCURVY, - - - - -	lxxxvii

CONTENTS.

	PAGE
{ Dr. BEDDOES's <i>Hypothesis</i> , that it depended upon a <i>Deficiency</i> of OXYGEN in the Blood, - - - - -	ib.
{ This <i>Theory</i> was first realized by Dr. TROTTER, - - - - -	ib.
{ His <i>Success</i> with LIME-JUICE, - - - -	lxxxix
{ Mr. PATTERSON's Discovery that NITRE DISSOLVED IN VINEGAR cures the <i>Sea-Scurvy</i> , - - - - -	xciii
{ Its <i>Effects</i> , - - - - -	xciv
{ Of the Application of the <i>Pneumatic Remedies</i> previous to the Revolution in France, - - - - -	xcv
{ FOURCROY's <i>judicious Observation</i> , - -	ib.
{ Dr. BEDDOES, - - - - -	lxiv
{ An <i>Account</i> of his <i>Writings</i> and their <i>Reception</i> , - - - - -	ib.
{ Dr. DARWIN's Sentiment respecting the <i>Pneumatic Practice</i> , - - - - -	xcix
{ This Physician supposes that the OXYGEN in the Blood not only stimulates the Heart to action, but probably affords the <i>Material</i> for the <i>Production</i> of the IRRITABLE and SENTIENT PRINCIPLES, - -	ib.

The

CONTENTS.

	PAGE
{ The Rev. Mr. TOWNSEND's Observations on the <i>Factitious Airs</i> , - - - - -	c
{ These promise, under the skilful Manage- ment of Dr. BEDDOES at the Hot-wells Bristol, and Dr. THORNTON in London, to be a Remedy well worthy the Atten- tion of the medical Practitioner, - - -	ib.
{ The VITAL AIR properly diluted with com- mon air, is,	
1. A STIMULUS the most <i>natural</i> and <i>diffusive</i> ,	
2. It <i>promotes</i> the INSENSIBLE PERSPI- RATION,	
3. <i>Aids</i> DIGESTION,	
4. <i>Favours</i> SLEEP,	
5. <i>Exhilarates</i> the SPIRITS,	
6. <i>Relieves</i> DIFFICULT RESPIRATION, -	ib.
{ The AZOTIC, and HYDROGEN, AIRS,	
1. <i>Abate</i> INFLAMMATION,	
2. <i>Arrest</i> CONSUMPTION, - - - - -	ib.
{ And the CARBONIC ACID AIR, or FIXED AIR, is,	
1. A <i>most powerful</i> ANTISEPTIC, - -	ib.

CONTENTS.

PAGE

According to the *Opinion of different Writers,*

VITAL AIR,

1. *Raises* the PULSE,
2. *Alters* the MASS of BLOOD,
3. *Opens* OBSTRUCTED VESSELS,
4. *Promotes* the INSENSIBLE PERSPIRATION,
5. *Quickens* DIGESTION,
6. *Increases* the ANIMAL HEAT,
7. *Strengthens* the MUSCULAR POWERS,
8. *Raises* the SPIRITS,
9. *Renders* the RESPIRATION EASY,
10. *Gives* BLOOM to the Complexion, - ' ci

The DISEASES in which the VITAL AIR has been successfully employed,

1. PUTRID FEVER,
2. DROPSY of the HEAD,
3. ——— of the CHEST,
4. ——— of the ABDOMEN,
5. ASTHMA,
6. DYSPNŒA,
7. CHLOROSIS,
8. HEAD-ACHE,
9. HYSTERIC FITS,
10. WANT of APPETITE,
11. DEJECTION

CONTENTS.

PAGE

11. DEJECTION of SPIRITS,	
12. MELANCHOLY MADNESS,	
13. ULCERS,	
14. SYPHILIS,	
15. PALSY,	
16. EPILEPSY,	
17. LOSS of SIGHT, - - - - -	ciii

The DISEASES in which the MEPHITIC AIRS
have been employed, viz. AZOTIC, IN-
FLAMMABLE, and HYDROCARBONATE,
AIRS,

1. CONSUMPTION,	
2. CANCER,	
3. SPITTING of BLOOD,	
4. CATARRH,	
5. CROUP, - - - - -	civ

The PROGRESS of *Pneumatic Medicine*, in

1. <i>America</i> ,	
2. <i>India</i> ,	
3. <i>Germany</i> ,	
4. <i>Spain</i> ,	
5. <i>Prussia</i> ,	
6. <i>France</i> , - - - - -	cv

{ The *Character* of the ANTI-PNEUMATISTS, - cvii

Of

CONTENTS.

	PAGE
{ Of the <i>Advantage</i> which results from an <i>Introductory Discourse</i> , - - - - -	cvii

PART I.

A SUMMARY

OF THE

PNEUMATIC CHEMISTRY.

The *Characteristic* of the PRESENT AGE.

INTRODUCTION, - - - - -	cxii
-------------------------	------

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

{ Of the <i>Attraction</i> of GRAVITATION, - -	cxiii
------------------------------------------------	-------

{ How this differs from the <i>Attraction</i> of Co- HESION, - - - - -	cxiv
---------------------------------------------------------------------------	------

{ The <i>Causes</i> of THESE PHÆNOMENA are <i>inex- plicable</i> , - - - - -	ib.
----------------------------------------------------------------------------------	-----

CONTENTS.

	PAGE
{ The <i>Attraction</i> of COHESION is of <i>three</i> <i>Kinds</i> , forming,	
1. The <i>hard</i> , or <i>solid</i> , <i>Aggregate</i> ;	
2. The <i>pliant</i> , <i>soft</i> , or <i>solid Aggregate</i> ;	
3. The <i>aeriform</i> , or <i>gaseous Aggregate</i> ,	cxv
{ Though each depends upon the <i>same Power</i> , they owe their <i>respective Differences</i> to CA- LORIC, or the <i>Matter of Heat</i> , which per- vades all Bodies, - - - - -	ib.
{ This is illustrated by a double HYPOTHESIS,	cxvi
{ GENERAL LAW RESPECTING HEAT.	
ALL BODIES ARE EXPANDED BY HEAT, -	cxvii
1 st <i>State of Expansion</i> .	
{ This is illustrated by putting <i>porous Bodies</i> into WATER, which occasions them to swell, - - - - -	cxvii
{ It is exemplified,	
1. By <i>heating a Bar of Iron</i> ,	
2. By <i>Rings</i> dropping off the <i>Fingers</i> in the <i>cold Fits</i> of an <i>Ague</i> , and being <i>immoveable</i> during the <i>hot</i> .	
3. By the <i>Method</i> of putting <i>Iron Hoops</i> round <i>Barrels</i> and <i>Wheels</i> , - -	cxviii
4. By the <i>Construction</i> of the <i>Thermo-</i> <i>meters</i> .	
5. By the <i>Glass Pulse</i> , - - - - -	cxix
6. By the <i>breaking of Glass</i> es upon pour- ing into them <i>hot Water</i> , - - -	cxxi

CONTENTS.

PAGE

2d State of Expansion, or that of Fluidity.

{ The *first Expansion* carried a little further
produces the *State of Fluidity*, - - - cxxii

{ Until the *whole be melted* Ice always continues
of the *same Degree of Coldness*, viz. 32°, - ib.

{ The *sensible Heat*, therefore, which passes
into the Ice becomes *latent*, - - - cxxii

{ This arises upon a Change of *Capacity* in the
Body for heat, - - - - - ib.

{ An *Explanation* of the Word CAPACITY, cxxiii

{ The Formation of a FRIGORIFIC MIXTURE
depends upon *this Principle*, - - - cxxiv

3d State of Expansion, or the Aeriform State.

{ This is *exemplified* by an Experiment with
Æther, which being put into the ex-
hausted Receiver of an Air-pump became
gazeous, and the *Water* which surrounded
it was converted into *Ice*, - - - - - cxxv

{ WATER *boils* at *different Degrees* of Heat, ac-
cording to the *Pressure* of the *Atmosphere*, cxxvi

{ PAPIN'S *Digester*, - - - - - ib.

{ How the *Air* becomes *Elastic*, - - - - - ib.

{ The *Phænomenon* of GLASS-BOOMS, - - cxxvii

The

CONTENTS.

	PAGE
{ The <i>Procefs</i> of DISTILLATION, - - -	cxxviii
{ The <i>Improvement</i> that was likely to accrue in this Branch of Science, from the Study of LAVOISIER, - - - - -	ib.
{ The <i>Discovery</i> of the Steam Engine, - -	cxxx
{ Its <i>subsequent Improvement</i> by Mr. WATT, -	ib.
{ As the CENTRIPETAL and CENTRIFUGAL FORCES, or the <i>Powers</i> of GRAVITY and PROJECTION, are in <i>continued Opposition</i> to each other; so all the beautiful Phæno- mena of Chemistry depend on the <i>Oppo- sition</i> of COHESIVE ATTRACTION and the REPULSION of HEAT, - - - - -	cxxxix
{ <i>Modes</i> by which COHESIVE ATTRACTION is <i>diminished</i> , - - - - -	ib.

SECT. I. THE MECHANICAL PROPERTIES OF AIR.

{ Though we cannot <i>see</i> the AIR, we are fen- sible it <i>exists</i> , - - - - -	1
{ 1. From its <i>filling out</i> a Bladder, - -	ib.
{ 2. By reason of <i>Winds</i> and <i>Hurricanes</i> , -	ib.

CONTENTS.

PAGE

{	That AIR has <i>Weight</i> is proved by ACTUAL EXPERIMENT, - - - - -	1
{	1. A <i>Cubic Foot</i> of AIR is found to weigh rather more than <i>an Ounce</i> , - -	ib.
{	2. If a Vessel be <i>exhausted</i> of AIR, and suspended over Water, the <i>Water</i> will rise into the Vessel, - - -	ib.
{	Thus <i>Water</i> will rise above its Level 32 Feet, and <i>no higher</i> , - - - - -	2
{	PUMPS and SPRINGS depend upon <i>this Principle</i> , - -	ib.
{	They cannot raise Water above 32 Feet, - - - - -	ib.
{	<i>Experiments</i> have been made to ascertain THIS FACT, -	ib.
{	Hence we acquire an exact Knowledge of the <i>Weight</i> of the ATMOSPHERE, - - - -	ib.
{	It equals a <i>Flood</i> of <i>Water</i> covering the Earth 34 Feet, - - - - -	ib.
{	Or as much <i>Quicksilver</i> as would be 29½ <i>Inches</i> , - - - - -	ib.
{	BAROMETERS are founded upon <i>this Principle</i> , - - -	ib.
{	A Column of <i>Quicksilver</i> cannot be raised by the <i>Pressure</i> of the AIR more than 29½ <i>Inches</i> , which though occupying less space, equals the Weight of 32 Feet of <i>Water</i> , - -	ib.
{	To raise <i>Water</i> 32 Feet, or <i>Quicksilver</i> 29½ <i>Inches</i> , will require 15 Pounds upon every <i>square Inch</i> , - - - - -	ib.

If

CONTENTS.

	PAGE
{ If we compute the <i>square Inches</i> upon the Surface of an ordinary Body, allowing every Inch to sustain 15 <i>Pounds</i> , we shall find that our <i>ordinary Load</i> is 20,000 <i>Pounds</i> , -	3
{ There is some <i>Variation</i> in this, as is shewn by the BAROMETER, where the <i>Mercury</i> is not always at the same Height, - - -	ib.
{ Sometimes we have 4000 <i>Pounds less Weight</i> of AIR than at other Times, - - -	ib.
{ The Reason why the <i>Sinking</i> of the <i>Mercury</i> in the BAROMETER denotes <i>Rain</i> , - - -	ib.
{ As a man 20 <i>Feet</i> under Water, supports more <i>Water</i> than another at the Depth of 10 <i>Feet</i> , so a Man at the Bottom of a <i>Valley</i> has more <i>Air</i> pressing on him, than at the Top of a <i>high Mountain</i> , - - -	4
{ The BAROMETER also confirms this, - - -	ib.
{ The <i>Quicksilver</i> as we <i>ascend</i> , having <i>less Air</i> to press on it, <i>sinks</i> at the Rate of a <i>tenth Part</i> of an <i>Inch</i> every 90 <i>Feet</i> , - - -	ib.
{ Our <i>Frames</i> are <i>sensible</i> of THESE CHANGES, -	ib.
{ They are <i>braced</i> , <i>vigorous</i> , and <i>strong</i> , with a large <i>Body</i> of AIR upon them, - - -	ib.
{ <i>Weak</i> , <i>languid</i> , and <i>relaxed</i> , when the AIR is <i>light</i> , - - -	ib.

CONTENTS.

SECT. II. THE CHEMICAL PROPERTIES OF AIR.

	PAGE
{ The Discoveries made on <i>this Subject</i> are the most beautiful of MODERN CHEMISTRY, -	5
{ They have immortalized the Names of PRIESTLEY, LAVOISIER, FOURCROY, and CAVENDISH, - - - - -	ib.
{ The Honourable Mr. BOYLE considered our Atmosphere as a large chemical Vessel, in which an infinite Number of Operations were carried on, - - - - -	ib.
{ The AIR, therefore, in his Estimation, far from being a simple elementary Body, was composed from all the Bodies of the Earth, -	ib.
{ MODERN CHEMISTRY has made great Advances in this curious Research, - - - -	6
{ CHEMISTRY affords two Methods, that of	
1. ANALYSIS, and	
2. SYNTHESIS, - - - - -	ib.
{ The Method of ANALYSIS explained, - -	ib.
{ The Method of SYNTHESIS explained, - -	ib.
{ The Derivation of THESE TERMS, - - - - -	ib.

SECT.

CONTENTS.

SECT. III. THE MODERN ANALYSIS OF ATMOSPHERIC AIR,

PAGE

- { 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.

CONTENTS.

PAGE

{	LAVOISIER then examined the 86 <i>cubical Inches</i> of AIR remaining in the Glafs after the <i>Calcination</i> was ended, and	
{	1. It <i>destroyed an Animal</i> which was put into it, - - - - -	8
{	2. It <i>extinguished</i> , like Water, the <i>Flame</i> of a Candle, - - - - -	ib.
{	Being found <i>adverse</i> to <i>Life</i> , it was called AZOTIC GAS, from α , <i>privitive</i> ; and $\xi\omega\nu$, <i>life</i> , - - - - -	ib.
{	Of its <i>other Appellations</i> , - - - - -	ib.
{	1. <i>Phlogisticated Air</i> ,	
{	2. <i>Non-respirable Air</i> ,	
{	3. <i>Noxious Air</i> ,	
{	4. <i>Mephitic Air</i> ,	
{	5. <i>Impure Air</i> .	

LAVOISIER'S 2D EXPERIMENT.

{	He took the 90 <i>Grains</i> of the RED CALX of MERCURY, and put it into a Vessel void of AIR, - - - - -	9
{	A <i>greater Heat</i> than in the last Experiment being applied, the MERCURY was <i>reduced back to its metallic State</i> , - - - - -	ib.

The

CONTENTS.

	PAGE
{ The CALX in this Process lost 7 Grains (only 83 Grains of RUNNING QUICKSILVER being procured), - - - - -	9
{ Now 14 cubical Inches of AIR was found in the Vessel, 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 so very favourable to Life was called therefore VITAL AIR, -	ib.
{ Of its other Appellations, - - - - -	ib.
1. Dephlogistified Air.	
2. Pure Air.	
3. Empyreal Air.	
4. Highly respirable Air.	
5. Oxygen Gas (Acid making Air), from the Greek Words οξυς, <i>sour</i> ; and γεννομαι, <i>to beget</i> .	
{ The Reasons for this last Term OXYGEN GAS, - - -	11
1. Sulphur combining with Vital Air forms an Acid Air, which being absorbed by Water, is denominated VITRIOLIC ACID.	
2. Charcoal,	

CONTENTS.

PAGE

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

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

{ Of the Discovery of the VITAL, or OXYGEN, GAS, - - - - - 11

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

{ Dr. PRIESTLEY is believed to have been the *First* who discovered *this aerial Gas*, which is justly denominated the *Pride* of MODERN PHILOSOPHY, - - - - - 10

{ LAVOISIER however is undoubtedly 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*, - - - - - ib.

{ And HE was undoubtedly the *First* who proved, that ATMOSPHERIC AIR consists of *two distinct aerial Fluids*, viz.
1. *Azotic Air*, and
2. *Vital Air*, - - - - - ib.

SECT.

CONTENTS.

SECT. IV. THE SYNTHESIS, OR COMBINATION, OF

1. AZOTIC AIR, and
2. VITAL AIR.

PAGE

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

CONTENTS.

PAGE

{ 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 en-
tering into the Composition of *Ammoniac* or *Alkali*, - ib.

{ That CALORIC, or Matter of Heat, should render OXY-
GEN 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 LA-
VOISIER 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 *Calci-*
nation 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

In

CONTENTS.

PAGE

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, - - - - - 15

The true *Proportion* of
1. AZOTIC AIR, and
2. VITAL AIR,
is usually,
In a Gallon of ATMO- { 3 Quarts of AZOTIC AIR, and
SPHERIC AIR, - { 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, over-
coming 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 Mag-*
nets of different Powers,
which would represent,
the OXYGEN in union with the *Azotic Gas*
and its own *Caloric*.

CONTENTS.

PAGE

{	As a LOADSTONE would draw the NEEDLE from the <i>two Magnets</i> ; so the MERCURY draws to itself the OXYGEN from the <i>Azot</i> and <i>Caloric</i> :	
{	Hence 1. Its Conversion into a <i>Calx</i> or <i>Oxyd</i> . 2. Its <i>Increase</i> of <i>Weight</i> . 3. The <i>Azotic Gas</i> remaining when the Calcination is complete, - - -	13
{	The Term <i>Affinity</i> 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 <i>Attraction of Cohesion</i> , -	12
{	If a Grain of <i>Sand</i> interpose, or any roughness exist, the Particles being beyond the <i>Sphere of mutual Attraction</i> , they are no longer actuated by this law, - - - -	13
{	The <i>Attraction of Cohesion</i> in MERCURY at the <i>common</i> <i>Temperature</i> , hinders the Admission of <i>Oxygen</i> for which it has an <i>elective Attraction</i> , - - - - -	ib.
{	But when exposed to a <i>strong Heat</i> , the <i>Caloric</i> expands this Fluid ; that is, insinuates itself through the Body, and <i>separates</i> its Particles, and, like the Pieces in the Bullet where <i>Sand</i> interposed, the divided Particles are no longer subject to the <i>Law of Cohesion</i> ; then it is they obey the <i>Law of Attraction</i> , and each Atom of MER- CURY <i>attracts to itself</i> a Particle of <i>Oxygen</i> , just as a Loadstone would draw to itself a Particle of Iron, - -	ib.
{	The LOADSTONE only attracts <i>Iron</i> . This represents the Term <i>Affinity</i> . As the LOADSTONE does not attract <i>Tin</i> , so the MERCURY did not attract the <i>Azot</i> , be- cause, as Chemists would say, it had <i>no Affinity</i> for it, -	ib.

CONTENTS.

PAGE

{	The Temperature being increased,	
	The Affinity of CALORIC for Oxygen	
	is rendered superior to	
	The Affinity of MERCURY for Oxygen:	
{	Hence the Oxygen is withdrawn from the	
	MERCURY, and hence,	
	1. Its Decrease in Weight.	
	2. Its Restoration from a Calx to a Metal-	
	lic Body, and	
	3. The Vital Air (Oxygen and Caloric)	
	obtained by this Process, - - -	14

SECT. IV. THE ANALYSIS OF OXYGEN AIR, Or its Separation into its three Constituent Parts,

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

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

{ He took the Steel-chain of a Watch, and heat-
ed one Extremity red hot;

{ He then thrust the heated End into a Phial
containing OXYGEN AIR, - - - - - ib.

CONTENTS.

	PAGE
{ It <i>burnt away</i> like a Match, exhibiting the <i>brightest light</i> , - - - - -	16
{ As it burnt, it cast off brilliant Sparks, like a Firework, which fell to the Bottom in <i>Globules</i> , - - - - -	ib.
{ Soon a <i>rapid diminution</i> of the OXYGEN AIR took place, - - - - -	17
{ If the OXYGEN AIR be <i>pure</i> , and the IRON <i>sufficient</i> , the <i>whole</i> of the AIR will be <i>ab-</i> <i>sorbed</i> by the Iron, - - - - -	ib.
{ And if the Quantity of the Iron be <i>insuffici-</i> <i>ent</i> , the <i>remaining</i> AIR <i>unabsorbed</i> will be found <i>perfectly pure</i> , - - - - -	ib.
{ That is, if 100 Grains of Iron be consumed in 70 cubic Inches of OXYGEN AIR, the <i>whole Volume</i> of Air will <i>disappear</i> , - - - - -	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 <i>not sufficient</i> to absorb all the OX- YGEN AIR employed, the <i>remaining</i> OXYGEN AIR is nevertheless found <i>pure</i> , the AZOTIC AIR left us, af- ter the Calcination of the Mercury in the first Experi- ment, page 8, could arise from <i>no other Cause</i> than its Separation from the OXYGEN AIR :	
{ This Experiment also shews that AZOTIC AIR <i>retards</i> the Union of OXYGEN with Bodies <i>attracting</i> it, and in some Cases <i>altogether prevents</i> it, - - - - -	16

How

CONTENTS.

	PAGE
{ How much <i>flower</i> is the <i>Calcination</i> or <i>Rusting</i> of IRON under <i>other Circumstances</i> ! - - -	16
{ The ROUND GLOBULES thrown off, as the Iron was <i>burning</i> , being collected, was found to be <i>martial Æthiops</i> , and equalled the <i>Weights</i> of IRON and of the OXYGEN AIR employed and consumed, - - -	ib.
{ A more <i>philosophic Account</i> of THIS EXPERIMENT.	
{ At a certain <i>Temperature</i> IRON has a <i>stronger Affinity</i> for the OXYGEN than CALORIC and LIGHT have, - - -	17
{ The IRON therefore <i>attracts to itself</i> the OXYGEN, with which it <i>combines</i> , - - -	ib.
{ And the CALORIC and LIGHT becoming <i>disengaged</i> are rendered <i>active</i> , and <i>evident to the Senses</i> , - - -	ib.
{ As the <i>Calcination</i> of MERCURY in LAVOISIER's Experiment lasted <i>several Days</i> , the <i>Disengagement</i> of CALORIC and LIGHT was <i>extremely small</i> for each particular Moment of Time, and therefore not <i>perceptible</i> 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 <i>Combustion</i> of the METAL was <i>more rapid</i> , or, more justly speaking, the <i>Decomposition</i> of the OXYGEN AIR, - - -	ib.

When

CONTENTS.

	PAGE
{ When we are sailing on the Water in a still Day, distant Objects appear to meet us, but <i>our Reason</i> corrects the Delusion, - - - - -	ib.
{ When we behold the Sun, moving from East to West, <i>Philosophy</i> again assumes its Empire, and we are convinced it is stationary, - - - - -	ib.
{ If we take a Prism, it displays to us a Variety of Colours; <i>our Reason</i> tells us here also, that these colours arise from the Rays of Light, and are not in the Prism, - - -	18
{ So of the Combustion of Bodies, the CALORIC and LIGHT are not from the <i>Wax</i> of our Candles, but from the <i>Oxygen Air</i> , which, as we saw in the last Experiment, becomes, under certain Circumstances, decomposed, - - - - -	ib.

SECT. V. THE SYNTHESIS OF WATER,

Or *its Composition* from its two Principles,

1. HYDROGEN, and
2. OXYGEN.

{ WATER is neither that *compound* or *simple Element* formerly supposed, - - - - - 18

DR. PRIESTLEY'S CELEBRATED EXPERIMENT.

{ In the Middle of a Glass Tube he put some calcined Lead, - - - - - ib.

To

CONTENTS.

	PAGE
{ To the two Ends, he affixed Bladders filled with <i>inflammable Air</i> , - - - - -	18
{ Having applied a strong Heat to the Middle of the Tube, he pressed the Bladders, - -	ib.
{ The INFLAMMABLE AIR soon <i>disappeared</i> , -	19
{ The RED LEAD re-assumed its <i>original metallic Splendour</i> , - - - - -	ib.
{ No OXYGEN GAS was <i>evolved</i> , - - - - -	ib.
{ A Question then arose, whence <i>this Property</i> in INFLAMMABLE AIR, which the <i>Anti- phlogistians</i> would ascribe to the Evolution of OXYGEN GAS? - - - - -	ib.
{ The INFLAMMABLE AIR which had appeared was said to have been <i>absorbed</i> , and was now called <i>Phlogiston</i> , - - - - -	19
{ But <i>this</i> must have occasioned an <i>Increase</i> of <i>Weight</i> , if INFLAMMABLE AIR or PHLO- GISTON be Matter, whereas on the con- trary the <i>metallic Lead</i> weighed <i>lighter</i> than in its State of <i>Calx</i> , - - - - -	ib.
{ Fortunately for the <i>new Doctrines</i> of <i>Chemis- try</i> , the Honourable Mr. CAVENDISH re- solved this <i>Difficulty</i> , - - - - -	ib.

He

CONTENTS.

	PAGE.
He passed the <i>electric Shock</i> 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 IN- FLAMMABLE Air, produce exactly 100 Grains weight of WATER, - - - - -	ib.
{ The Properties of INFLAMMABLE Air, - - - - -	19
1. It <i>destroys Life</i> .	
2. It is 15 Times <i>lighter</i> than common Air.	
3. It <i>explodes</i> with common Air, provided any Body in actual Inflammation be present.	
DR. PRIESTLEY'S EXPERIMENT.	
{ Of the <i>Production</i> of INFLAMMABLE Air from Iron and <i>diluted vitriolic Acid</i> , - - - - -	ib.
{ This arises from the <i>Decomposition</i> of the WATER, and not from the Iron or vitriolic Acid, - - - - -	ib.

SECT.

CONTENTS.

SECT. VI. THE ANALYSIS OF WATER ;

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

1. HYDROGEN, and

2. OXYGEN.

PAGE

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 re-
ceiving any aerial Body, and - - ib.

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

CONTENTS.

PAGE

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

{ The HYDROGEN AIR here proceeded from the Combination of the <i>Hydrogen</i> of the WATER to the <i>Caloric</i> of the Furnace, - - - - -	ib.
--------------------------------------------------------------------------------------------------------------------------------------------	-----

{ INFLAMMABLE AIR the <i>French Chemists</i> call HYDROGEN GAS, from the Greek Words <i>υδωρ</i> , <i>water</i> ; and <i>γεινομαι</i> to produce, - - - - -	ib.
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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

CONTENTS.

PAGE

{ 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 *cal-*
careous 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.

CONTENTS.

PAGE

{	The PHOSPHORUS having then no more Oxygen to convert it to an Acid, we have,	
	2dly. <i>Phosphorus</i> combined with the <i>same</i> <i>Earth</i> , and	
	3dly. The <i>Carbon</i> 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. OXYGEN AIR.

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

The

CONTENTS.

	PAGE
{ The CARBONIC ACID AIR, or Fixed Air, obtained, equalled the <i>Weights</i> of the CHARCOAL and the OXYGEN AIR employed, -	26
{ FIXED AIR is composed of 28 <i>Parts</i> of CHARCOAL to 72 of OXYGEN AIR, - - - -	ib.
{ Or in other Words, 144 <i>cubic Inches</i> of THAT AIR will saturate or take up 28 <i>Grains</i> of CHARCOAL, - - - - -	ib.
{ The Properties of FIXED AIR are,	
1. It is specifically <i>heavier</i> than common Air.	
2. It is adverse to both <i>Flame</i> and <i>Life</i> , -	ib.

SECT. IX. THE ANALYSIS OF ADEPS, OR ANIMAL FAT;

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

1. HYDROGEN, and
2. CHARCOAL.

{ Of the <i>Distillation</i> of <i>animal</i> and <i>vegetable Substances</i> , - - - - -	27
-------------------------------------------------------------------------------------------	----

{ Vegetable OIL is proved to be composed of <i>Hydrogen</i> and <i>Carbon</i> or Charcoal, - - -	28
--------------------------------------------------------------------------------------------------	----

That

CONTENTS.

PAGE

{	That animal OIL, or Adeps, is composed of <i>Hydrogen</i> and <i>Carbon</i> we have the follow- ing proof,	
{	In the first <i>Rectification</i> of ANIMAL OIL a small quantity of WATER is formed by the Union of the <i>Oxygen</i> contained in the AIR of the distilling Vessel, and the <i>Hydrogen</i> of the OIL, - - - - -	29
{	We at length, by frequent Distillations, can decompose the whole OIL, and convert it into <i>Water</i> and <i>Charcoal</i> , and the <i>Weights</i> of the <i>Charcoal</i> and <i>Water</i> will be found <i>exactly corresponding</i> with <i>those</i> of the OIL and the OXYGEN AIR consumed, - - -	ib.
{	Of the Burying-ground called the <i>Innocents</i> , at PARIS, the common Receptacle of the Dead of that City, - - - - -	30
{	The Bodies were converted into a Substance resembling <i>Fat</i> or <i>Spermaceti</i> , - - - -	ib.
{	The Rev. MR. TOWNSEND'S CELEBRATED EXPERIMENT, - - - - -	35
{	The Conversion of <i>animal Substances</i> into <i>Sper-</i> <i>maceti</i> must arise, says Monf. LAVOISIER, from the Disengagement of <i>Azot</i> , leaving behind the <i>Hydrogen</i> and <i>Carbon</i> which are the true Elements of <i>Fat</i> , - - - - -	34

SECT.

CONTENTS.

SECT. X. ON PUTREFACTION;

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

1. HYDROGEN,

2. OXYGEN,

3. CARBON, and

4. AZOT.

PAGE

{ 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 *Hy-*
drogen, Oxygen, and Carbon, maintain for
a long while their organized Structure and
putrefy with difficulty, - - - - - 37

{ The *first Effect* produced on VEGETABLE SUB-
STANCES which have lost their vital Prin-
ciple is the Destruction of the Equili-
brium, 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.

CONTENTS.

PAGE

{ 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

CONTENTS.

PAGE

{ 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 *Hy-*
drogen 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 con-
sequence disengaged, - - - - - ib.

CONTENTS.

	PAGE
{ Of the <i>poisonous Vapour</i> which issues from <i>putrefying Substances</i> , - - - - -	40
{ The <i>late</i> PLAGUE in <i>Philadelphia</i> , which swept off 4000 Persons in a few Months, originated from <i>this Source</i> . (This will be treated on at large under the Article <i>Fever</i> .)	
{ The ABSURD CUSTOM of <i>burying</i> the <i>Dead</i> in <i>Churches</i> .	

PART. II. THE AGENCY OF OXYGEN AIR IN THE ANIMAL BODY, AND THE CAUSE OF VITAL AND VOLUN- TARY ACTION.

Introduction.

{ A CONCISE VIEW OF THE WHOLE ANIMAL ŒCONOMY.	
--------------------------------------------------	--

{ <i>General Observations</i> respecting the BONES, -	vi
The FEET, - - - - -	ib.
The LEGS and THIGHS, - - - - -	vii
The RIBS, - - - - -	ib.
The BACK-BONE, - - - - -	ib.
The ARMS, - - - - -	viii
The	

CONTENTS.

	PAGE
The HANDS, - - - - -	viii
The NAILS, - - - - -	ix
The HEAD, - - - - -	x
The COUNTENANCE, - - - - -	ib.
The ARTERIES, - - - - -	xi
The VEINS, - - - - -	xii
{ The <i>Distinction</i> betwixt a VEIN and an ARTERY, - - - - -	ib.
The VALVES, - - - - -	xiii
The HEART, - - - - -	ib.
The LUNGS, - - - - -	ib.
{ <i>General Observations</i> on the ORGANS perform- ing the <i>Circulation</i> of the <i>Blood</i> , - - -	xiv
The GLANDS, - - - - -	xv
The NERVES, - - - - -	xvi
The MEMBRANES, - - - - -	ib.
The MUSCLES, - - - - -	ib.
The SKIN, - - - - -	xviii
The TEETH, - - - - -	xix
The LIPS, - - - - -	ib.
The CHEEKS, - - - - -	ib.
The SALIVARY GLANDS, - - - - -	ib.

CONTENTS.

	PAGE
The GULLET, - - - - -	xx
The WIND-PIPE, - - - - -	ib.
The STOMACH, - - - - -	ib.
The PANCREAS, - - - - -	xxi
The GALL-BLADDER, - - - - -	ib.
The LIVER, - - - - -	ib.
The PLAITS of the <i>Intestines</i> , - - - - -	xxii
The VILLOUS COAT of the <i>Intestines</i> , - - - - -	ib.
The MUCOUS GLANDS of the <i>Intestines</i> , - - - - -	ib.
The LACTEALS, - - - - -	ib.
The MESENTERIC GLANDS, - - - - -	xxiii
The RECEPTACULUM CHYLI, - - - - -	ib.
The THORACIC DUCT, - - - - -	ib.
The left SUBCLAVIAN VEIN, - - - - -	ib.
The VENA CAVA SUPERIOR, - - - - -	ib.
The right AURICLE of the <i>Heart</i> , - - - - -	ib.
The right VENTRICLE of the <i>Heart</i> , - - - - -	ib.
The PULMONARY ARTERY, - - - - -	xxiv
The AIR-CELLS of the <i>Lungs</i> , - - - - -	ib.
The left AURICLE of the <i>Heart</i> , - - - - -	ib.
The four PULMONARY VEINS, - - - - -	ib.
The	

CONTENTS.

	PAGE
The left VENTRICLE, - - - - -	xxv
The AORTA, - - - - -	ib.
{ <i>Two peculiar distinguishing Excellencies in</i> the ANIMAL MACHINE,	
1. <i>Self-restoration</i> , - - - - -	xxvii
2. <i>The Continuation of the Species</i> , -	xxix
The EYE, - - - - -	xxxii
The EYE LIDS, - - - - -	ib.
The EYE-LASH, - - - - -	xxxiii
The MUSCLES of the <i>Eye</i> , - - - - -	ib.
The EAR, - - - - -	ib.
The SMELL, - - - - -	xxxv
The TASTE, - - - - -	ib.
The TOUCH, - - - - -	xxxvi
{ Of the <i>Superiority of MAN</i> above <i>other Ani-</i> <i>mals</i> , - - - - -	ib.

SECT. I. AIR IS ABSOLUTELY NECESSARY FOR THE PRESERVATION OF LIFE.

{ This is proved by an Experiment with an <i>Air Pump</i> , - - - - -	45
--------------------------------------------------------------------------	----

SECT.

CONTENTS.

SECT. II. A DUE SUPPLY OF AIR IS INDISPENSABLE.

	PAGE
{ The Treachery of SUR RAJA AL DOWLA, Soubah of Bengal, - - - - -	46
{ He invests Calcutta, - - - - -	ib.
{ The gallant Resistance made by the Governor, Mr. HOLWELL, - - - - -	47
{ He is obliged at length to surrender to the Soubah; after being promised, upon the Honour of a Soldier, "That no Injury should be offered him or his Garrison," -	ib.
{ He is conducted with 146 other Prisoners to a Place called the BLACK-HOLE Prison, -	ib.
{ The Symptoms that arose in consequence of this confined Place, were	
1. A profuse Sweat,	
2. An insatiable Thirst,	
3. Difficulty of breathing, - - - - -	ib.
{ They attempt to relieve themselves by stripping off their Clothes, - - - - -	48
{ Mr. HOLWELL promises the Serjeant of the Guard a thousand Rupees, provided he could find Means to remove some of his People into another Place of Confinement, -	ib.

CONTENTS.

PAGE

{ The Offer was accepted: But *the Tyrant*, by
whose Order alone such a Step could be
taken, *was asleep, and no One durst disturb*
his Repose! - - - - - 48

{ The *Despair* and *Confusion* amongst the *Pri-*
soners, - - - - - 49

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

{ The *extraordinary Respect* which was paid HIM, ib.

{ He is seized with strong 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 himself still more
thirsty after drinking, he abstained from
Water, and moistened his Mouth from
Time to Time by sucking the PERSPIRA-
TION from his Shirt-sleeves, which tasted
soft, pleasant, and refreshing, - - - ° ib.

{ Here the OXYGEN of the Animal Oil might
perhaps supply in some Degree the want
of *that Principle*, which was held here in
a less close Bond of Union than in Water, ib.

{ They drop fast now on all Sides, and a *pun-*
gent Steam like HARTSHORN (Hydrogen and
Azot) arose from the Bodies of the Dead, ib.

Out

CONTENTS.

	PAGE
{ Out of 146, who entered this Prison, only 23 were found <i>alive</i> in the Morning, - - -	52
{ All these were seized with a <i>putrid Fever</i> , -	ib.
{ Mr. HOLWELL suffers <i>further Hardships</i> , -	53
{ At length the Soubah's Mother interposed, and with unexpected Generosity he replied, " <i>their Sufferings have been great, and they shall have their Liberty;</i> " and they were accordingly released, - - - - -	ib.
{ Another melancholy Proof of THE NECESSITY OF A DUE SUPPLY OF AIR may be drawn from the Evidence of Dr. TROTTER de- livered before the House of Commons, -	ib.
{ A Note shewing the <i>Manner</i> Slaves are procured, - - -	54
{ The <i>Treatment</i> of Slaves on their Passage, -	55
{ A Description of the <i>Places</i> in the Ship where the Slaves are stowed, - - - -	ib.
{ The <i>Temperature</i> of these Rooms is generally <i>above</i> 96 of Fahrenheit's Scale, - - - -	ib.
{ 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 <i>foul Air</i> , or in the exhausted Receiver of an <i>Air-pump</i> , -	ib.

I have

CONTENTS.

PAGE

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

{ *Many* have I seen DEAD, who the Night be-
fore 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.

{ Another strong Proof of the NECESSITY of a
DUE SUPPLY of AIR may be found in the
History of the DUBLIN *Lying-in Hospital*, 57

{ In this Hospital out of 7650 Infants there
died 2944 Infants within the *first Fortnight*
after their Birth, - - - - ib.

CONTENTS.

	PAGE
{ That is nearly <i>one Child</i> out of <i>every Six</i> , -	57
{ These Children, many of them, foamed at their Mouths, and the Face looked <i>blue</i> , as though they were <i>choaked</i> , - - - - -	ib.
{ This last Circumstance led the Physicians to conclude that the Room in the Hospital was <i>too close</i> and <i>crowded</i> , and hence that the Infants had not a <i>sufficient Quantity</i> of GOOD AIR to breathe, - - - - -	ib.
{ The Contrivances that were devised to let in <i>fresh Air</i> and remove the <i>Bad</i> , - - -	ib.
{ The CONSEQUENCE was that out of 7650 Children born, there died <i>only</i> 279, - ..	58
{ That is not even <i>one Child</i> in <i>Twenty</i> , - -	ib.
{ Mr. HOWARD's Opinion respecting the Cause of <i>Jail-Fevers</i> , - - - - -	ib.

SECT. III. THE CHEMICAL ALTERATIONS AIR UNDERGOES BY BEING RE- SPIRED.

{ Dr. PRIESTLEY's <i>Eudiometer</i> , - - - - -	59
{ His Discovery of NITROUS AIR, - - - - -	ib.
{ The MANNER <i>this Air</i> is produced, - - -	ib.

Its .

CONTENTS.

	PAGE
{ Its PROPERTY of <i>consuming Vital Air</i> , - -	59
{ The Union of <i>Nitrous Air</i> with <i>Vital Air</i> forms NITROUS ACID, - - - - -	60
{ Hence the <i>Decrease</i> of the <i>Bulk</i> of the <i>two mixed Airs</i> ; as NITROUS ACID occupies but a <i>small Space</i> in compari- son with these <i>two Airs</i> , - - - - -	ib.
{ This <i>Decrease</i> marks the QUANTITY of <i>Vital</i> <i>Air</i> in any given Portion of <i>Common Air</i> , -	ib.
{ By THIS TEST, Dr. PRIESTLEY perceived, that there was less <i>Vital Air</i> in his Study than on the Outside of his House, - - - -	ib.
{ And that the Air in the Neighbourhood of <i>York</i> was not so good as the Air near <i>Leeds</i> , - - - - -	ib.
{ That is, the Bulk of the Air in the first Trials was not <i>diminished</i> equally by the NITROUS AIR, as in the latter Trials, - - - -	ib.
{ LAVOISIER'S <i>Eudiometer</i> , - - - - -	61
{ He places a cylindrical glass Tube inverted over Quicksilver, - - - - -	ib.
{ He then passes into it some <i>Phosphorus</i> , - -	ib.
{ This being set on fire consumes all the <i>Vital</i> , or <i>Oxygen</i> , Part of the Air, - - - - -	ib.

CONTENTS.

PAGE

{ 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.

The

CONTENTS.

	PAGE
{ The different <i>specific Gravities</i> of FIXED, OXYGEN, and AZOTIC AIRS, - - - -	63
{ Of the <i>Circulation</i> of the Air, - - - - -	64
{ The Cure of <i>smoaky Chimneys</i> , - - - - -	ib.
{ The <i>Quantity of Air</i> vitiated by a <i>Man</i> in an Hour, - - - - -	65
{ The Air of a Room 30 Feet long, 25 broad, and 30 Feet high, containing 100 Specta- tors, would be rendered perfectly <i>mephitic</i> in four Hours and a Half, were it not for the <i>Circulation of the Air</i> , - - - - -	65
{ The <i>Effects</i> of <i>impure Air</i> on the <i>Mind</i> and <i>Body</i> , - - - - -	66
{ DR. THORNTON'S <i>Proposal</i> to <i>diffuse VITAL</i> <i>AIR</i> in <i>Mines</i> , <i>Churches</i> , <i>crowded Rooms</i> , and <i>Hospitals</i> , - - - - -	67
{ His <i>Observations</i> , and <i>Proposal</i> , for rendering the <i>Bathing Rooms</i> at BATH more <i>salubrious</i> , ib.	ib.
{ Of the <i>Production</i> of OXYGEN, or VITAL, AIR, and the Prospect, as Chemistry advances, of obtaining this at a <i>very moderate Rate</i> , -	68
{ Of VENTILATION, - - - - -	67
{ An easy and cheap Process for removing the <i>foul Air</i> of a Room, and throwing in <i>good Air</i> , - - - - -	ib.

SECT.

CONTENTS.

SECT. IV. AN ANSWER TO THIS QUESTION, “ WHAT HAS BECOME OF THE OXYGEN, OR VITAL, PORTION OF THE AIR, WHICH DISAP- PEARS AFTER AN ANIMAL HAS BEEN FOR SOME TIME CONFINED IN A CERTAIN PORTION OF COMMON AIR ?”

PAGE

Common Air is composed of <i>two Principles</i> , viz.	
1st. <i>Oxygen, or Vital, Air</i> , and	
2d. <i>Azotic Air</i> , - - - - -	69
Soon by Respiration we have,	
3dly. <i>Fixed Air</i> , - - - - -	ib.
At length the <i>Oxygen Air</i> is wholly ABSORBED, and the <i>remaining Air</i> is composed of,	
1. <i>Azotic Air</i> , and	
2. <i>Fixed Air</i> .	
Both which <i>Airs</i> are adverse to Life, - -	ib.
A <i>Question</i> here naturally arises, WHAT HAS BECOME OF THE OXYGEN, OR VITAL, AIR, DEPRIVED OF WHICH AN ANIMAL DIES? - - - - -	ib.

THIS

CONTENTS.

PAGE

{ THIS AIR is absorbed *in part* by the Blood, - 69

{ A Note to shew that some Part of the OXYGEN, or VITAL, AIR is also expended in the *Formation* of FIXED AIR and VAPOUR, - - - - - ib.

{ *Experiments* to prove that *venal Blood* absorbs OXYGEN AIR, - - - - - 70

{ *Experiments* to prove that *arterial Blood* contains OXYGEN AIR, - - - - - 71

{ The Reason why *Lime-water* detects the presence of FIXED AIR, - - - - - ib.

SECT. V. THE CIRCULATION OF THE BLOOD.

{ 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.

CONTENTS.

PAGE

{ Dr. HUNTER attempts to account for the Reason why PREJUDICE almost constantly attends new Discoveries, - - - - -	74
--------------------------------------------------------------------------------------------------------------------	----

{ The CIRCUIT OF THE BLOOD through

1. The <i>ascending Cava</i> , - - - - -	75
2. The <i>descending Cava</i> , - - - - -	ib.
3. The <i>right Auricle of the Heart</i> , - - -	ib.
4. The <i>right Ventricle</i> , - - - - -	ib.
5. The <i>pulmonary Artery</i> , - - - - -	ib.
6, 7. The <i>right and left Lobes of the Lungs</i> , - - - - -	ib.
8, 9, 10, 11. The <i>four Pulmonary Veins</i> , -	76
12. The <i>left Auricle</i> , - - - - -	ib.
13. The <i>left Ventricle</i> , - - - - -	ib.
14. The <i>Aorta and its Branches</i> , - - -	ib.

{ Of the CIRCULATION,

1st. From the <i>right Cavities of the Heart</i> THROUGH THE LUNGS to the <i>left Cavity of the Heart</i> , - -	ib.
2d. From the <i>left Cavities of the Heart</i> THROUGH THE VARIOUS PARTS OF THE BODY to the <i>right Cavities of the Heart</i> , - -	ib.

SECT.

CONTENTS.

SECT. VI. THE OFFICE OF THE LUNGS.

	PAGE
{ The Office of <i>Respiration</i> was unknown to the late Dr. HUNTER, - - - - -	77
{ A valuable <i>Quotation</i> from that learned Teacher, - - - - -	ib.
{ IF EVER we should be happy enough, says he, to discover clearly the Object of <i>Re- spiration</i> , we shall doubtless, as clearly see, that <i>this Organ</i> is as wisely contrived for an <i>important Office</i> , as we now see the Pur- pose and Importance of the Heart, and vascular System; which, till the Circula- tion of the Blood was discovered, was wholly concealed from us, - - - - -	ib.
{ The <i>Blood</i> , as it comes in contact with the AIR, expanding the Lungs, works many <i>chemical Alterations</i> in it, - - - - -	78
{ 1st. The <i>Charcoal</i> of the Blood forms with the <i>Vital Air</i> , FIXED AIR, - - - - -	ib.
{ This is proved by making an Expiration through a Tube containing <i>Lime-water</i> , which will become instantly TURBID, - - - - -	ib.
{ Or if <i>Venal Blood</i> be confined in a Phial containing <i>Vital Air</i> , the whole of <i>that Air</i> will be converted into FIXED AIR, - - - - -	ib.

CONTENTS.

	PAGE
{ 2d. The <i>Hydrogen</i> of the Blood forms with the <i>Vital Air</i> the HUMID VAPOUR, that issues from the Mouth, - - -	78
{ This you may prove by placing <i>venal Blood</i> in <i>Vital Air</i> 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 <i>Azotic</i> <i>Air</i> , AMMONIAC will be formed (which was proved Page 39 to be <i>Hydrogen</i> combined with <i>Azot</i>), - - -	ib.
{ 3d. The <i>Blood</i> also <i>absorbs</i> within itself the <i>Vital Air</i> , which changes its <i>dark</i> <i>Colour</i> to a <i>brilliant Red</i> , - - -	ib.
{ Thus <i>changed</i> , it becomes	
1. The SPUR TO ACTION of the <i>Heart</i> and <i>Arteries</i> ,	
2. The <i>Source</i> of ANIMAL HEAT,	
3. The Cause of SENSIBILITY,	
4. IRRITABILITY, and	
3. MOTION, - - - - -	ib.
{ A Quotation from Dr. HARVEY, - - -	79
{ Dr. GOODWIN's celebrated <i>Experiment</i> , which proves the Dependance of the CIRCULA- TION ON RESPIRATION,—or rather on the Condensation, or Fixation, of OXYGEN AIR in the Blood, - - - - -	ib.
{ A valuable Quotation from Dr. SMITH, - -	ib.

SECT.

CONTENTS.

SECT. VII. ON ANIMAL HEAT.

	PAGE
{ Dr. CRAWFORD was the first who ascertained by direct Experiments that <i>Animal Heat</i> was derived from the <i>Air</i> ; but he knew not that <i>Vital Air</i> was <i>imbibed</i> by the <i>Blood</i> in the <i>Lungs</i> , - - - - -	81
{ Dr. THORNTON next <i>improved</i> upon <i>this im-</i> <i>portant Discovery</i> , - - - - -	83
{ This last Physician first publicly taught, at <i>Cambridge</i> , that the OXYGEN AIR imbibed by the <i>Blood</i> in the <i>Lungs</i> underwent a <i>De-</i> <i>composition</i> by THE OTHER PRINCIPLES in the animal Body, - - - - -	ib.
{ ANIMAL HEAT is therefore a Species of <i>gentle</i> <i>Combustion</i> , - - - - -	84
{ The <i>Analogy</i> betwixt an ANIMAL and a BURNING LAMP, 1st. They require the same kind of <i>Air</i> , and 2d. A Supply of <i>Principles</i> attractive of <i>Oxygen</i> , disengages <i>Caloric</i> , - -	ib.

CONTENTS.

SECT. VIII. ON THE BALANCE BETWIXT DIGESTION AND THE OXYGE- NATION OF THE BLOOD.

PAGE

{ MR. SPADDING'S CELEBRATED EXPERIMENT, - 89

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

{ In my putrid fever, says the Rev. MR. TOWNSEND, whenever I breathed *superoxygenated Air*, as my Physician Dr. THORNTON often witnessed,
1. My *Respiration* was *pleasant*,
2. My *Oppression* at my Chest *relieved*,
3. My *Appetite* was greatly *increased*, and
4. My *Digestion* was considerably *quickened*, - - - - - ib.

{ The *Reason* why people who are *oppressed* with *Food PANT*, - - - - - 90

{ The *Cause* of SNORING, - - - - - ib.

{ Miners, when recovering from *Asphyxia* arising from breathing *impure Air*, are constantly seized with *Nausea*, and the *Stomach* rejects its *Contents* quite *crude*, - - - - ib.

JOHN

CONTENTS.

PAGE

{ 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 Economy; the *Breathing* became
*quicken*ed; and the *Blood*, having imbibed
a greater quantity of OXYGEN AIR, con-
taining *latent Fire*, to be *extricated* by
Principles separated by the Stomach, hence
the *immediate Call* on the *digestive Powers*
of that Organ, - - " - - - - - ib.

SECT. IX. HOW LIFE DEPENDS ON A CERTAIN DEGREE OF HEAT IN THE BODY.

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

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

All

CONTENTS.

	PAGE
{ All Animals, even <i>torpid Animals</i> , maintain their <i>Heat</i> higher than that of the <i>surrounding Atmosphere</i> , - -	95
{ John HUNTER's and Dr. HAIGHTON's <i>Experiments</i> on <i>this Subject</i> , - - - - -	ib.

SECT. X. THE METHOD NATURE TAKES TO INCREASE, OR RID HER- SELF, OF THIS SUBTLE AND PENETRATING FLUID.

{ The <i>Heat</i> of the <i>Body</i> is always <i>greater</i> than that of the <i>external Air</i> , - - - - -	96
-------------------------------------------------------------------------------------------------------------------	----

{ This is proved,	
1. By the <i>Effects</i> of <i>moist Air</i> ,	
2. By the <i>Coldness</i> occasioned by a <i>brisk</i> <i>Wind</i> , - - - - -	97

{ For <i>these Effects</i> can only <i>arise</i> by withdraw- ing a <i>superior Heat</i> , as no such Alteration is shewn by the <i>Thermometer</i> , which in both these Cases stands at the same Point, - -	98
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----

1st. OF THE RETENTION OF HEAT, 98

{ The Reason why Animals in cold Situations <i>coil</i> themselves up, - - - - -	99
-------------------------------------------------------------------------------------	----

{ <i>Man clothes himself</i> according to the <i>Difference</i> of <i>Climate</i> , - - - - -	ib.
--------------------------------------------------------------------------------------------------	-----

CONTENTS.

	PAGE
{ Of the <i>transmissive Power</i> of <i>different Clothing</i> ,	
1. With respect to <i>Hair</i> and <i>Fur</i> ,	
2. To <i>Feathers</i> and <i>Down</i> , - - - -	100
{ JOHN HUNTER'S EXPERIMENTS, - - - -	ib.
2d. OF THE ESCAPE OF ANIMAL	
HEAT, - - - - -	102
{ <i>Nature obviates the Effects</i> of <i>too much Heat</i>	
by PERSPIRATION, - - - - -	103
{ The <i>superabundant Heat</i> is <i>expended</i> in VA-	
POUR, - - - - -	ib.
{ The <i>cooling Effect</i> of EVAPORATION is shewn,	
1. From the <i>Fall</i> of the <i>Thermometer</i> by	
putting on it a <i>few Drops</i> of <i>Æther</i>	
or <i>Volatile Alkali</i> ,	
2. By the <i>Manufacture</i> of <i>Ice</i> in <i>warm</i>	
<i>Climates</i> , - - - - -	ib.
{ <i>Evaporation</i> , or the <i>frigorific Process</i> , takes	
place also in our <i>breathing</i> , - - - -	105
{ The <i>Quantity</i> of <i>Heat</i> thrown off by the	
<i>Lungs</i> , - - - - -	ib.
{ Why ACIDS are <i>cooling</i> ? - - - - -	106
{ How they produce this <i>salutary Effect</i> on the human Body	
according to the Rev. Mr. TOWNSEND and Dr. BED-	
DOES, - - - - -	107
	Some

CONTENTS.

	PAGE
{ Some <i>general Observations</i> elucidating this Subject, - - - - -	107
{ An <i>Objection</i> answered, - - - - -	ib.

SECT. XI. OF THE CAUSE OF MOTION IN THE VITAL OR INVOLUNTARY ORGANS.

{ NERVES do <i>not contract</i> their <i>Dimensions</i> when stimulated, - - - - -	108
{ The FIBRE alone has <i>this Property</i> , - - -	109
{ The <i>Contraction</i> of the HEART and ARTERIES depends upon <i>this Property</i> in the Fibre, -	ib.
{ The <i>Fibres</i> of DIFFERENT ORGANS have APPROPRIATED STIMULI, viz.	
1. OXYGEN AIR excites the <i>Heart</i> ,	
2. The GASTRIC JUICE the <i>Stomach</i> ,	
3. The BILE the <i>intestinal Canal</i> , and	
4. LIGHT the <i>Pupil</i> of the <i>Eye</i> , - - -	110
{ A very striking Experiment, which shews that VITAL AIR gives activity to the <i>Heart</i> and <i>Arteries</i> , - - -	ib.
{ These <i>moving Fibres</i> are affected by other than their <i>natural Stimuli</i> , thus	
1. <i>Ipecacuanha</i> , though injected into a Vein, affects the <i>Stomach</i> ,	

2. *Jalap*

CONTENTS.

PAGE

{	2. <i>Jalap</i> the <i>Intestines</i> , and	
{	3. <i>Mercury</i> the <i>salivary Glands</i> , - -	111
{	A Note more particularly to illustrate <i>these Effects</i> , - -	111
{	DR. HUNTER'S CELEBRATED DISCOVERY OF THE ABSORBENT SYSTEM, - - - - -	112
{	Why <i>those Organs</i> , whose <i>Actions</i> depend on the <i>contractile Fibre</i> , and the <i>Stimuli</i> adapt- ed to them, have NERVES, - - - -	113

SECT. XII. ON THE CAUSE OF MOTION IN THE VOLUNTARY ORGANS OR MUSCLES.

{	GALVANI'S DISCOVERY OF THE ANIMAL OR NERVOUS ELECTRICITY, - - - -	114
{	HIS CELEBRATED EXPERIMENTS on the <i>Nerves</i> ,	
{	1. With an <i>electrical Machine</i> , - - -	114
{	2. With <i>electric Clouds</i> , - - - -	115
{	3. With <i>two different Metals</i> , as <i>Iron</i> and <i>Silver</i> , - - - - -	116
{	The Experiments of Dr. FOWLER and Dr. MONRO,	
{	1. With <i>Silver</i> and <i>Zinc</i> , - - - -	116
{	2. With <i>Zinc</i> and <i>Gold</i> , - - - -	117

CONTENTS.

	PAGE
{ The ELECTRIC FLASH which <i>these produced</i> when applied to the <i>Tongue</i> or <i>Ear</i> , - -	117
{ <i>Wild and savage Animals</i> have a great <i>Quantity</i> of <i>electric Matter</i> , as is shewn,	
1. By <i>stroking</i> the <i>Back</i> of a <i>Cat</i> in a frosty Night,	
2. By the <i>Erection</i> of their <i>Bristles</i> ,	
3. By the <i>electric Flashes</i> that dart from their <i>Eye</i> , - - - - -	ib.
{ Instances of the ELECTRIC FLUID in <i>various Animals</i> ,	
1. In a <i>Paroquet</i> , - - - - -	118
2. In <i>Men</i> and <i>Women</i> , - - - - -	119
3. In the <i>GYMNOTUS</i> , or <i>electric Eel</i> , -	120
{ The <i>Observations</i> of Dr. GARDEN, Monf. FERMIN, and Dr. PRIESTLEY, respecting <i>this Fish</i> , - - - - -	121
{ Mr. WALSE'S BEAUTIFUL EXPERIMENT, -	ib.
4. In the <i>Torpedo</i> , - - - - -	122
{ JOHN HUNTER'S <i>Observations</i> on the <i>electric</i> <i>Organs</i> of <i>these Fish</i> , - - - - -	ib.
{ Monf. REAUMUR'S <i>Observations</i> , - - - - -	123
{ A <i>Conjecture</i> respecting the <i>BRAIN</i> and <i>NERVES</i> by Dr. PRIESTLEY, - - - - -	123
	Monf.

CONTENTS.

	PAGE
MONS. VALLIS' beautiful Comparison of the electric Organs of this Fish with the Muscles of our Body, - - - - -	114
{ Of VITAL, or OXYGEN, AIR, as related to Motion, and the nervous Electricity, - - -	125
{ An elegant Experiment made by Dr. MAYOW, a Philosopher of the last Century, - - -	126

SECT. XIII. ON TONE.

{ This Doctrine is supported by Dr. CULLEN,	
1. By observing that Muscles have antagonist Muscles, and if one of these be cut, the other which is opposed to it will be in continued Action or Spasm, - - - - -	127
2. By the Effects of topical Bleeding, -	128
3. By the Operation of astringent or tonic Remedies, - - - - -	130
{ Tone, or Strength, is believed by the pneumatic Physicians to depend more upon the VITAL AIR in the Blood than upon TENSION, - - - - -	133

It

CONTENTS.

	PAGE
It may be received as an Axiom, says 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," - - - - -	138
Some Facts are adduced in support of this Doctrine, - - - - -	ib.

SECT. XIII. ON TONSILS.

The Doctrine is supported by Dr. Cullen, 1. By observing that Abscesses have been seen in the Tonsils, and in one of these be seen the matter which is expelled so it will be in continued Action or Inflammation - - - - -	137
2. By the Effects of topical Bleeding - - - - -	138
3. By the Operation of Spasms or Tonic Medicines - - - - -	139
Tonsils or Stomachs is believed by the same author to depend more upon the State of the Blood than upon Tonic Medicines - - - - -	139

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

VOL. I.

* A

was

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!

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

LUCRET.

THE
P R O G R E S S
OF
CHEMISTRY.

WE will not tire the reader with tracing the progress of chemistry from the earliest antiquity: but commence at that time when alchemists gave up their golden dreams, and turned their attention to improve by this art the science of medicine.

The doctrines of Galen, which were spread over Europe, had taken such firm root in the 16th century, that they seemed to defy all opposition. The remedies invented by chemical operations were at that time only administered by men in the lowest condition of life, men without science, without industry, and without honour. At length, however, PARACELSUS appeared. He does not seem to have studied physic in any of the established schools; but while he travelled in different countries he picked up remedies from all sorts of people, and particularly from the chemists of those

those days. From these he learned the use of mercury and antimony, and from some hardy empirics the use of opium. When returning home from his travels he determined upon following his father's profession, which was that of physic, and by these remedies he was able to cure many diseases that baffled the inert remedies of the Galenists; and being of a bold and boastful disposition, he made the most of these cures; while, at the same time, the partiality of mankind to novelty soon contributed to give him fame. He was so far more fortunate than other chemical practitioners, that he obtained the professor's chair at the university of Basil. In this new situation he attempted a system of physic, blended with the most extravagant and visionary doctrines, supported 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 most outrageous manner against the regular practitioners. He went even so far as publicly to burn the works of the Greek physicians; and he insolently told the physicians of Basil, that the very down of his bald pate had more knowledge than all their writers, the buckles of his shoes

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

These at last finding their throne totter, called in the aid of the secular power, and employed it to crush their adversaries. In France antimony was prohibited: but in Germany the chemists prevailed, and the Galenists were obliged sometimes to have recourse to the remedies of the chemists, when SENNERTUS, one of the most eminent of the Galenists in Germany, endeavoured to reconcile the two opposing parties.

Sennertus.

*Sir Theodore
Mayerne.*

Very early in the seventeenth century, Sir THEODORE MAYERNE, who as a chemical physician had been much opposed and oppressed by the Galenists of France, was called over into England, where he was appointed first physician to the king, and continued to hold that office for more than thirty years after. His theory and his prescriptions were like those of the Galenists; but he was at the same time a great favourer of chemical medicines, and particularly of antimony; the medicine, with regard to which the two sects were most especially divided. It does not however appear, that he met with any violent opposition from the physicians 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. *VanHelmont.*

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 use and the ornament of life; but I think it natural that the mechanical department, where palpable masses of matter are brought into action, and motion is visible in its progress, should sooner advance towards perfection than the chemical, where effects are produced by the insensible movements of imperceptible particles. It seems therefore to have its foundation in the order of things, that the philosophers of the preceding age should have been employed chiefly by astronomers and mechanics, and those of the present by chemistry. Yet if the rule be at all just, what a violent exception,—suffer me to repeat it, have we in the instance of JOHN BAPTIST VAN HELMONT, who silently, and unperceived, discovered, if not the whole sum and substance, yet certainly many of those splendid facts which adorn the writings of PRIESTLEY, CAVENDISH, SCHEELE, LAVOISIER, and other philosophers of the present day.

Not long after, the illustrious BACON formed *Bacon.* plans for promoting the sciences in general, and particularly the study of nature. In his comprehensive view of things, he felt that chemistry might turn out one of the most curious and useful branches of na-

tional philosophy. He advised the collecting of facts, and to compare these very maturely and cautiously, in order to discover, if possible, the causes and circumstances upon which they depend, and declares that in this way only could any satisfactory system be produced. Theories, he thought, were only useful so far as they arose from experiments already made, or as they might lead to new ones: for reasoning may be considered as the eye of the philosopher; but experience is his feeling; and this latter sense ought constantly 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 vision.—It was thus that this sagacious philosopher directed men in the true path of science, and banished that dark and abstruse philosophy, which was built upon the absurdest conjectures.

Boyle.

On the day in which this great promoter of the sciences died, BOYLE was born. He was in opulent circumstances, and by the agreeableness of his manners, and goodness of his heart, he was peculiarly turned to the study of nature, which pleased him most,

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

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, 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,*

Mayow.

“ air, or what has been since called oxygen, or the acidifying 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 breathing 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 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 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 *Dr. Hales:* 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, 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

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 *Boerhaave.* 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-

ter resides in them, but in such 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 resumes its former nature, and becomes *true air*, disposed to reunite with other substances again, and remain quiet, but without losing its real nature; for whenever it is freed from the bonds which retain it, it shews itself to be the same body. Nothing can be more certain than this *resolution* and *composition*; and I would have given many examples of it, had I not lately read Dr. HALES' celebrated treatise on Vegetable Statics; in the sixth chapter of which book, the author has collected with so much labour and justness, and has related in the best possible order, the experiments which have been made on this subject, so that he has exhausted the subject. To these I refer my readers, and they will see how ART has arrived at the power of *unveiling* NATURE.

Hitherto chemistry, though it was much advanced, had been treated in a desultory manner. A great number of facts were discovered; but none had attempted to generalize them, and form a system; and though many particulars were known, yet the science itself was not in existence.

The illustrious BECHER first began to collate, *Becher,* 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 phenomena. 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.

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
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 φλογος, flame, or fire.

fluence

fluence of circumstances. In bodies liable to burn, it exists in a latent state:—place them in circumstances in which combustion 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 discover this principle by the alteration of their properties. Hence it is *,

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

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

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 footy 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 sufficiently heated, with a flame more bright than that of spirits of wine or charcoal; others burn or smother away like rotten wood; and most of them, when they have been kept in the open air in a proper degree of heat, lose their metallic appearance, and are converted into earth. Thus red lead or minium is the earth procured from the burning of lead; and putty, such as the polishers of glass and marble use, is the earth procured from tin. The principle effecting the combustion of metallic substances, and dispersed in the act of combustion, is PHLOGISTON.

The *acid* of sulphur;—the *ashes* of charcoal;—the *water* of the spirit of wine;—the *earths* of metallic substances, are utterly incapable of combustion: their respective differences from SULPHUR, CHARCOAL, SPIRITS OF WINE, and METALLIC SUBSTANCES, with respect not only to *inflammability*, but to *smell*, *colour*, and *other properties*, are attributed to the PHLOGISTON which is dispersed during the combustion of each of them.

From the ANALYSIS or decomposition of SULPHUR, we conclude that the constituent parts of sulphur are

two—an *acid* which may be collected; and an INFLAMMABLE PRINCIPLE which is dispersed. The reader will wish to see this ANALYSIS confirmed by synthesis, that is, in common language, he will wish to see sulphur actually made by combining its *acid* with the *inflammable principle*.

As this *inflammable principle* cannot be obtained in a palpable form separate from all other bodies, the only method by which we can attempt to unite it with the acid of sulphur, must be by presenting to that acid some substance in which it is contained.—Charcoal is such a substance, and by distilling powdered charcoal and the acid of sulphur together, we can produce undoubted sulphur. This sulphur is formed from the union of the acid with the PHLOGISTON; and the charcoal may be by this means so entirely robbed of its PHLOGISTON, that it be reduced to the state it is found after complete combustion in the open air.

Spirits of wine, we have said, consists of PHLOGISTON united with *water*:—and if we distil spirits of wine and the acid of sulphur mixed together we shall obtain a pure yellow sulphur, in no way to be distinguished from common sulphur.

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 *glafs*, 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 *glafs*;—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 *glafs* 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 *glafs*; 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

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

It had long been observed, that certain substances, such as *marble, chalk, and limestone*, effervesced with acids;—that these substances were insoluble in water; they were soft to the touch and inoffensive:—But when treated with fire they assumed directly contrary properties, not effervescing with acids;—being easily dissolved by water so as to form a transparent liquor;—and lastly, they were rendered so caustic as to corrode all animal and vegetable substances. These curious phænomena had not escaped the notice of attentive observers of former times; but the honour of first satisfactorily explaining the true cause of these events seemed reserved for the illustrious professor of chemistry at Edinburgh, Dr. BLACK. He discovered,

*The doctrines
of pneumatic
chemistry.*

Dr. Black.

vered, that by the process of fire, these substances lost half their former weight, and when treated with acids the compound weighed lighter than before. *Something* therefore was lost. In a treatise, which indeed is a fine specimen of the best method of investigating and demonstrating chemical truths, he ascertained, “*what this SOMETHING was,*” and proved it to be a permanently elastic fluid, which he therefore denominated FIXED AIR, deprived of which, the residue was caustic or *quick-lime*—having those properties first enumerated.

Macbride.

Hitherto the existence of FIXED AIR, and its combination with bodies was a physical opinion, and no physiologist since VAN HELMONT had adopted it, when the amiable and learned MACBRIDE, professor of physic at Dublin, examined into the medicinal properties of THIS AIR, and established by the most decisive experiments its *antiseptic properties*. He ascertained, that flesh, which is half putrid, having lost a portion of the FIXED AIR which enters into its composition, may recover its former sweetness, by restoring to it its FIXED AIR; to produce which effect, it will be sufficient to expose it to the vapours
of

of any fermenting substance, or rather to a current of
FIXED AIR from an effervescing mixture.

Soon after the publication of Dr. MACBRIDE'S
treatise, the Hon. Mr. CAVENDISH communicated
to the Royal Society some new experiments confirm-
ing the doctrines of these two eminent professors.
He further shewed that water is capable of absorbing
a volume of FIXED AIR more than equal to itself;
that this quantity is proportionably greater as the
water is colder, and is compressed by a heavier atmo-
sphere; that water thus impregnated with fixed air has
all the acidulous and spirituous taste of Seltzar water.
Mr. CAVENDISH added to BOYLE'S and HALES'
method of obtaining the permanently elastic fluids,
the modes of confining and transfusing them from
one vessel to another, so that they might be examin-
ed and managed with pleasure, and thus he gave
“*to airy nothing a local habitation and a name:*” he
determined the quantities of fixed and inflammable
gases obtained from different substances: he ascertain-
ed their specific gravities: and introduced, or at least
set the example, by his accurate mode of experiment-
ing

*The honour-
able Mr.
Cavendish.*

ing, of establishing a complete system of *pneumatic chemistry*.

Mr. Lane. Mr. LANE discovered* that water impregnated with *fixed air* has the property of dissolving almost all metals, and especially iron and zinc; a very small quantity of these metals being sufficient to communicate to water their taste and virtues.

Dr. Priestley. Soon after Dr. PRIESTLEY entered upon his career, and proceeded with such rapidity of success, that he attracted the attention of philosophers of all nations to these and similar objects, and excited their emulation in the same pursuit; and thereby he has given rise to such auspicious consequences in chemistry, that his entry into this branch of experimental philosophy will be ever considered as an æra in the annals of chemistry.

It is impossible to compress his numerous discoveries in the limits of a few pages. They fill up six volumes; and as the knowledge of the *permanently elastic fluids* is the most important part of chemistry, and has

* This honour is usually attributed to Dr. PRIESTLEY, as he took the most active part in diffusing this knowledge.

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.

On the 1st of August, 1774, I endeavoured, says *Of the discovery of vital air.* 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
 VOL. I. * E 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 phenomena 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 flumbered 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.*"

It

It is singularly curious, that two philosophers of the present day should both, and at the same time, and by different processes, discover 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 whose book they certainly knew nothing. Dr. PRIESTLEY and Mr. SCHEELÉ however paid the debt to humanity, being biaſſed by the prevailing opinion of *phlogiston*, in which they were seconded by the ingenious and laborious KIRWAN, who wrote a book expressly *Kirwan.* to support the *old theory*, as it is called.

At this time the *new*, or *antiphlogistic theory* sprang up in France. It derived its chief origin from LAVOISIER, who had soon the felicity of being *Lavoisier.* joined by BERTHOLLET, MORVEAU, ADET, HAZENFRATZ, DE LA PLACE, MONGE, CHAPTAL, FOURCROY, and others, who have united their labours in establishing this *new system*; which, from such a combination of talents, could not fail of being exhibited with every advantage, and of fixing the attention of the philosophic world.

I. They contend, that although the atmosphere *Atmospheric air supports respiration* is a vast laboratory, in which nature operates im-
menſe

and combustion.

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 is 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 dis-
engagement
of heat and
light.*

X. There is another interesting phænomenon in combustion, which modern chemistry is able to explain; namely, that of the disengagement of *heat* and *light*.

*Combustion
also decom-
poses the vital
air.*

XI. Combustion is not confined to the decomposition of atmospheric air by absorbing one of its principles; for it also *decomposes* the VITAL AIR, by absorbing, fixing, and rendering more or less solid, in the combustible body, the *oxygen*, or base of the vital air, and disengaging the solvent of this base, *caloric*, or *heat*, in greater or less quantity.

*Light and
heat compo-
nent parts of
vital air.*

XII. It is demonstrated, that the light which constitutes *flame* is contained in the VITAL AIR, of which it is one of the principles; for combustible bodies afford much more flame when they burn in vital air, than in atmospheric air.

A corollary.

XIII. Hence it follows, that when we burn a combustible body, in order to procure *heat* or *light*, as we do to mitigate the rigours of winter, or to chase away the darkness of the evening, we obtain these from the AIR itself 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.

VOL. I.

* F

XVII. Though

*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 com-
bustion 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.*

faturate them in their combustion by the contact of air, but each metal considered separately absorbs different proportions, and stops at various points of *oxydation*, according to the degree of temperature to which it is raised. Thus tin, lead, copper, iron, change colour and assume the tints of the rainbow, at the first degree of fire to which they are exposed in contact with the air: lead first becomes a grey oxyd, next yellow, and lastly red; mercury passes from black to white, from white to yellow, and from yellow to red; iron, at first a black oxyd, becomes next green, then brown, and ultimately white: copper is at first a brown oxyd, from which it changes to blue, and its last degree of oxydation imparts to it a green colour.

The reason why metals exhibit different coloured flames.

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

Before we consider the oxydation of metals in *water* and *acids*, it may be proper first to notice the composition of these bodies.

XXIV. WATER

XXIV. WATER is not a simple element, as was formerly supposed. By burning with rapidity a number of combustible bodies, more or less heated, as charcoal, red-hot iron, oil, &c. water is decomposed, yielding to these combustible bodies the OXYGEN it contained.

Combustible bodies decompose water, depriving it of its oxygen.

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

Hence the evolution of its other principle hydrogen.

As this second principle is one of the elements of water, it has been called HYDROGEN, and when it is an elastic fluid from its solution 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 recomposition of water, one of the most brilliant discoveries of modern chemistry, which was made by the Honourable Mr. CAVENDISH, confirms the analysis of this body; for on uniting by combustion 85 parts of OXYGEN with 15 of HYDROGEN, 100 parts of pure water are obtained.

The composition of water proved by synthesis.

XXVII. The

*Hydrogen air
arises always
from the de-
composition 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 decompo-
sition of wa-
ter.*

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 in-
flammable
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 proper-
ties of hy-
drogen.*

XXXI. The

*The cause of
the aurora
borealis.*

XXXI. The hydrogen air being thirteen times lighter than common air, it rises above the common air, and to the combustion of this air, by means of the electric fluid, arises most probably the phænomenon of the aurora borealis.

*The cause of
detonations.*

XXXII. The disengagement of this principle in the form of gas, which takes place wherever water is decomposed by a combustible body, is the cause of a great number of detonations and fulminations, which occur in chemical processes.

*Of thunder
and rain.*

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

*Sudden ap-
pearance of
storm.*

XXXIV. When in a clear day a storm on a sudden takes place, and the heavens are overcast, it is probable that this sudden formation of water in the atmosphere, arises from the rapid union of the hydrogen gas and vital air, occasioned by the necessary re-establishment 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 homogeneous 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
character-
ised.*

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 com-
mon 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 these substances, forms their generical name, while the particular name of the bases of each may with propriety designate each particular acid. Thus sulphur is the basis of the acid we call sulphurous, carbon that of the carbonic, and so on.

The new nomenclature.

XLI. Various metals decompose WATER, and this the more rapidly the higher the temperature is raised. Thus iron decomposes water with the greatest rapidity when much heated, though it requires a considerable time to effect its decomposition at the highest temperature our atmosphere ever attains.

Metals decompose water.

LXII. Sulphurous acid, diluted with water, greatly facilitates the decomposition of the aqueous fluid by means of metals, and evolves in this process hydrogen gas; this is eminently the case in the dissolution of iron or zinc by the diluted sulphurous acid.

Sulphurous acid promotes the decomposition of water.

XLIII. There are some cases in which the WATER and the ACID are at the same time decomposed by the metal, as in the solution of tin in the nitrous acid. Tin is so greedy of OXYGEN, and requires so large

Sometimes acids are also decomposed.

* G 2

a quantity

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 oxyd, or calx, forms water, while the metal is restored to its metallic splendour and its other characteristic properties*.

One may here pause a moment to consider the causes that pervert the understandings of men, and the difficulty there is to root up error when once established.—It is natural in the rudest state of science to consider the changes of property in chemical bodies as resulting from the loss or acquisition of *something*, and, if this could not be demonstrated, to give it some general appellation. Hence the term PHLOGISTON. It was this principle, which escaping from a metal during calcination converted it into a calx, or earthy substance; and it was the union of this principle which rendered the air mephitic. Here the PHLOGISTIANS appealed to the senses.—But when these 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 close vessels, the volume of air was diminished during the process; and the air, after the calcination was complete, weighed exactly 12 pounds less than before.—This

*The progress
of the new
chemistry.*

* Many of these positions are proved by *analysis* and *synthesis* 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 difficulties 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 PRECIPITATUS 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 residue of this air remained it was not *mephitic*, and when combined with mephitic air in the proportion of one to four it made common atmospheric air, it was then that the ANTIPHLOGISTIANS truly triumphed, and the VITAL AIR, which forms a fourth part of our atmosphere, became the universal ŒDIPUS that unlocks all the mysteries of chemistry; the *causa sine qua non* of the antiphlogistic school.

The *new doctrine* was combated by Dr. BLACK for ten years, who finally became a convert to it. Writing to LAVOISIER, he says, “such is the force
“ of PREJUDICE that it requires ten years to overcome this hydra, but now I feel the force of truth,
“ and assent to it.”—The celebrated KIRWAN next writes to LAVOISIER, “that he has renounced his
“ work in favour of the *phlogistic doctrine*, and means
“ himself to refute it.” Even Dr. PRIESTLEY declares,
“ that he has been more than once upon the point of
“ abandoning the doctrine of *phlogiston*,” and in his sixth volume he actually declares “in favour of
“ the decomposition of water,” and adds, “nor shall
“ 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, biases 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

Plants are distinguished by possessing a living principle.

of the hedyfarum gyrans; the retraction of the stamina of the cestus; the advance of the stamina to the pistillum in other flowers; by the leaves turning to the light; and some plants following the sun; by their closing against rain; by the roots turning out of their direction to plunge themselves into water, or a more favourite soil, &c.

They reproduce their species.

XLVIII. The reproduction of *vegetables* is effected in the same manner as that of *animals*; and modern botanists have supported the comparison between these two functions in the most conclusive manner.

Their relation to air.

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

They have no locomotive power.

L. The *great difference* which exists between *vegetables* and *animals* is, that the latter in *general** are capable of conveying themselves in search of nourishment; whereas vegetables, being fixed in the same place, are obliged to take up in their own vicinity all such materials as are capable of nourishing them:

* Oysters, muscles, polypi, &c. connect this chain, and seem as it were intermediate links, having no locomotive power.

and

and nature has therefore provided them with leaves, to extract from the atmosphere the air and water, while the roots extend to a distance 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 discovered, in the year 1772, that plants emitted VITAL AIR and absorbed FIXED AIR; for which discovery he received the thanks of the *Royal Society*, in an eloquent speech delivered by the president, “From your discoveries,” says Sir JOHN PRINGLE, “we are
 “affured, that no vegetable grows in vain, but
 “that, from the oak of the forest, to the grass in the
 “field, every individual plant is serviceable to man-
 “kind; if not always distinguished by some medi-
 “cinal virtue, yet making a part of the whole,
 “which cleanses and purifies our atmosphere. In
 “this the fragrant rose-tree and deadly night-shade
 “co-operate: nor is the herbage, nor woods that
 “flourish in the most remote and unpeopled regions,
 “unprofitable to us, nor we to them, considering
 “how constantly the winds convey to them the
 “FIXED AIR issuing from our lungs, while they
 “send out VITAL AIR for us.” Mr. SCHEELE

*Dr. Priest-
ley's and Dr.
Ingenhouz's
discoveries
respecting
plants.*

*Dr. Ingen-
houz's dis-
coveries.*

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

* 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 phenomena 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. INGENHOUSZ 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 sunshine flowers, roots, and ripe fruit, always produced these deleterious airs. Hence he taught us the true relation we stand in with regard to the *vegetable race*, and he has also extended these curious and beautiful researches by ascertaining the different proportions of VITAL AIR to the AZOTIC AIR in different situations, and has demonstrated, that in a given quantity of atmospheric air, “there is more VITAL AIR in the country than “in towns; and more near the sea than inland;” nevertheless he found by his *eudiometer*, “less in the “marshy lands of *Holland* than at *Vienna*, and he “attributes the *keenness of appetite, and quickness of digestion, in the latter place, to this circumstance.*” He formed great expectation of the VITAL AIR in diseases, and after inhaling it himself, “he experienced,” he says, “a remarkable *alacrity of mind* “and *body*, and thinks he *slept sounder* than usual that “night.” He was the first who administered the VITAL AIR in ASTHMA, and he has had the honour of giving it to the ARCHDUCHESS OF RUSSIA, who also experienced the same benign effects as this philosopher*.

*Dr. Ingen-
houz's expe-
rience with
regard to
vital air.*

LII. When

* In 1779 Dr. INGENHOUSZ discovered that the animal body threw out AZOTIC, and FIXED, AIRS. In the very same 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 1.). Mr. CRUIKSHANK has extended this discovery to the phenomena 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 processes, which might otherwise
 “ make an useful addition to the *materia* and *ars*
 “ medica.”

*The effects
 of fixed air.*

LIII. It is not in the order of this work to trace here minutely the progress of the *pneumatic practice* of physics, we shall therefore pass over the testimonies of Dr. PERCIVAL, &c. respecting the salutary effects of FIXED AIR in consumption, mortification, and ulcers, and hasten briefly to record the introduction of the OXYGENATED NITROUS ACID VAPOURS, for arresting the progress of *contagious fever*.

Dr. Percival's experience.

Dr. Smith's important discovery.

*The efficacy
 of the nitrous
 acid vapour
 in arresting
 pestilential
 fever.*

In the year 1782 an infectious fever broke out among the prisoners in *Winchester*. This excited the attention of Parliament, and many eminent physicians in London were applied to, to take charge of the prisoners there; but they refused venturing upon so hazardous an office. The late Dr. FOTHERGILL then waited on Dr. SMITH, and requested him, in the most urgent manner, to accompany the commissioner to Winchester. Two hundred and forty persons had already perished by this dreadful malady,
 whose

whose violence seemed daily increasing. Most of the officers and servants belonging to the hospital had fallen victims to this fatal distemper. But such was the powerful influence of the NITROUS ACID VAPOUR, the number was reduced to 9, 5, 3, and 2,—and afterwards none died. Dr. CAR-MICHAEL SMITH himself was seized with this disorder, and confined to his bed, yet, like a true hero, he would not yield to his disease, but continued to give directions. In a memorial which he afterwards sent to the minister of state, in mentioning these circumstances, he says, “ But these, my lord, are only
 “ the sufferings of an individual. I readily com-
 “ plied with your lordship’s wishes, and as to the
 “ conditions of my attendance I made none: con-
 “ vinced that no pecuniary recompence could be an
 “ adequate compensation to me, circumstanced as I
 “ then was, for the risk I ran ; and that if I was for-
 “ tunate enough to survive, and *succeed*, I was cer-
 “ tain of the first of all rewards, the *consciousness* of
 “ having *discharged* 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 success

“ which even my friends could hardly expect, and
 “ which I believe stands *without example* in the an-
 “ nals of physic. I have already received from the
 “ *public* the fullest approbation of my conduct, and
 “ make no doubt that, in consequence of your lord-
 “ ship’s favourable representation of it to the *king*, I
 “ shall receive from *his majesty*, ever attentive to re-
 “ ward merit in the lowest of his subjects, some
 “ mark of his Majesty’s royal favour.” In conse-
 quence of which discovery, he was appointed phyfi-
 cian extraordinary to the king.

This *antiseptic vapour* was afterwards applied, in the
 year 1795, by the order of the lords-commissioners
 of the Admiralty, on board the Union hospital ship,
 and with the same happy success*.

DeMorveau. LIII. Near about the same time in *France* a very
 important discovery was made. Mons. DE MORVEAU,
 the associate of LAVOISIER and FOURCROY, employed
 for the same purpose the OXYGENATED MA-
 RINE ACID in the form of air, or vapour, and

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

purified the infected hospital at Dijon. This method was afterwards extended to the different military hospitals by a decree of the national assembly.

LIV. Since there is no disorder to which human nature is subject, more destructive or alarming than contagious fever, the humane reader will not require an apology for delaying his attention upon so important a point, more especially as it confers the highest honour on the present enlightened age, and holds out a prospect that one of the greatest scourges to mankind will be at last banished 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 justly say,

Dr. Crawford's discovery.

—————Par nobile fratrum,

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

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

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 uneasiness in breathing was instantly removed. On the 27th the salivation abated considerably, when his respiration became proportionably oppressed, he therefore returned to the use of the pills. On the 28th the salivary discharge was again abundant, and it is not a little remarkable, Dr. CRAWFORD adds, “ that as “ this increased, the difficulty of breathing, and all “ the other symptoms of the disease, diminished.” This observation led me, he adds, to keep up the spitting for a few days, at the same time care was taken to prevent it from being too copious*. On the 29th, 30th, and 31st, the soreness of the mouth was the only disease, and this decreasing, the sailor was soon restored to sound health.

*Dr. Wade's
and Dr.
Chisholm's
experience.*

LVI. This practice has been since pursued with equal success by Dr. WADE, in Bengal, in the year 1791, and by Dr. CHISHOLM in the island of Grenada, for the cure of the yellow, or bilious autumnal, fever. Dr. WADE did not lose one patient, and

* When violent salivation came on, this able practitioner had recourse to opium. This often occasioned violent torment in the bowels, which was as instantly removed by juice of limes. Please here to consult 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

*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,

fever, I anticipated all the numerous and complicated distresses in our city, which pestilential diseases have so often produced in other countries. The fever had a malignity, and an obstinacy which I had never before observed in any disease, and it spread with a rapidity and mortality, far beyond what it did in the year 1762. Nevertheless I did not abandon a hope that the disease was curable, for I had long believed that good was commensurate with evil, and that there does not exist a malady, but would yield to our knowledge of the laws of the animal œconomy. Under the impression of this belief, I applied myself with fresh ardour to the investigation of the present disease. I ransacked my library, and pored over every book that treated of the yellow fever. The result of my researches for a while were fruitless. The accounts of the symptoms and cure of the disease, by the authors I consulted, were contradictory and uncertain. Before I desisted from the inquiry to which I had devoted myself, I recollected that I had, among some 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 short time before his death.

I had

I had read it formerly, and made extracts from it. I now read it a second time. I paused upon every sentence; even words in some places arrested and fixed my attention. In reading the history of the effects of different modes of treatment, I was much struck with the following passages.

“ It must be carefully noted, that *evacuations* are
 “ more necessary in the yellow fever, than even in
 “ the inflammatory. The abdominal viscera are the
 “ parts principally affected in this disease,—and by
 “ this timely evacuation, their feculent, corruptible,
 “ and irritating contents are discharged before they
 “ overpower the whole constitution. They always
 “ require some *evacuation* to bring them to a perfect
 “ crisis. Where the primæ viæ, but especially the
 “ stomach, is loaded with the poison of the conta-
 “ gion, and convulsed with the irritation of this sti-
 “ mulus, there is no procuring a desirable sweat,
 “ until this is removed. Also by *evacuating* the
 “ bowels, the seeds of the disease, which is mixed
 “ with the bilious and inguiline matters in the in-
 “ testinal canal is nipped in its birth, and a breathing
 “ sweat then breaks out of its own accord. I can
 “ affirm, that I have often given *evacuants*, when
 VOL. I. * K “ the

“ 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, notwithstanding

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 nevertheless 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 sons, and a servant-maid, and Mr. Baynton's whole family, nine in number, were some of the first trophies of this *new* remedy. The credit it acquired brought me an immense accession of business. It was uniformly effectual in all whom I attended, either in my own person, or by my pupils. Dr. GRIFFITH, Dr. SAY, Dr. PENNINGTON, and my former pupils who were settled in the city, Drs. LEIB, PORTER, ANNAN, WOODHOUSE, and MEAR, were among the first physicians who adopted it. In my note-book I put down, "Thank God! "out of one hundred patients, whom I have visited, or prescribed for, this day, I have lost *none*;" nor shall I ever forget the transport with which Dr. PENNINGTON ran across the street to inform me, a few days after he began to give strong purges, that the disease yielded in every instance.—But I did not rely on purging alone to cure the disease. Conceiving it to depend upon a morbid *stimulus* acting upon and overpowering the system, I was led to use those remedies which we know abstract stimuli in general. These were blood-letting, cool air, cold, watery, and sub-acid drinks, low diet, and the application of cold water to the body. My success with

this practice was beyond measure great, never before did I experience such sublime joy. It repaid me for all the toils and studies of my life: and the conquest of this disease was not the effect of accident, nor of the application of a single remedy; but it was the triumph of a PRINCIPLE in *Medicine!*

“ During the course of my extensive practice, the
 “ exhibition of calomel purges produces frequently
 “ *salivation*. By this accidental effect of mercury I
 “ was taught to administer it with other views, than
 “ merely to cleanse the bowels, and with a success
 “ which added much to my confidence in the power
 “ that this medicine has over the disease*. I began
 “ by prescribing the calomel in small doses, at short
 “ intervals, and afterwards I directed large quantities
 “ of the ointment to be rubbed upon the limbs. The
 “ effects of it, in every case where the mouth was af-
 “ fected, was very salutary and speedy, and even fe-
 “ veral persons appeared to be benefited by the mer-
 “ cury introduced in the system in the form of an
 “ ointment, where it did not produce salivation. In

* Vide Vol. III. page 650, where mercury is shewn to be a cure of *hydrophobia*, and hereafter it may be found to be the sovereign antidote against all other animal and most vegetable poisons.

“ 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 fore
 “ 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 effi-
 cacy 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 *narencado*, 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 first 24 hours; the change, indeed,
 “was often so great and sudden, that I could scarcely
 “credit my own senses, until repeated experience
 “stamp the firmest conviction upon my mind.
 “Previous to the practice which I now pursue, I
 “never visited in typhus, without experiencing some
 “of those feelings, which the physician is obliged to
 “suffer, who expects an unsuccessful issue; but now
 “I have no fears, and I trust that one of the most
 “crowded avenues to the grave is at length closed,
 “and, judging from the rapid progress acquired in the
 “knowledge of philosophy and medicine within a
 “very few late years, I may venture to predict,
 “that, by similar attempts, every disease, whose
 “nature is at present obscure, will be at last clearly
 “explained, and the professors of medicine be finally
 “in possession of the *ne plus ultra* of their science.”

LIX. In these trials the *vital principle* was at-
 tempted to be restored as fast as it was consumed by
 the excessive stimulus of the contagious matter taken
 into the system, and producing the putrid fever, or
 this stimulus was attempted to be evacuated; but
 this enlightened age has also produced another philo-

*Rev. Mr.
 Cartwright's
 discovery.*

fopical method, namely, its *correction*. “Seven-
 “teen years ago I went,” says the Rev. Mr. CART-
 WRIGHT, “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 unequivocal-
 “ly 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 severely. While I was in conversation
 “ on this distressing subject with his mother, I ob-
 “ served in a corner of a room a small tub of wort
 “ working. The sight brought to my recollection
 “ an experiment I had somewhere met with, *of a*
 “ *piece of putrid meat being made sweet by being*
 “ *suspended over a tub of wort in the act of fermenta-*
 “ *tion.* The idea instantly *flashed* into my mind
 “ that the *yeast* might correct the putrid nature of
 “ this disease, and I instantly gave him two large
 “ spoonfuls. I then told the mother, if she found
 “ her son better, to repeat this dose every three
 “ hours. I then set out for my journey. Upon my
 “ return after a few days I anxiously enquired about
 “ the boy, and was informed he was recovered. I
 “ could not repress my curiosity, 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 himself opened the door, looked fur-
 “ prisingly well, and told me he felt better from the
 “ instant he took the yeast.

“ After I left Brampton I lived in Leicestershire.
 “ My parishioners being there few and opulent I

“ dropped my medical character entirely, and would
 “ not even prescribe for any of my own family.
 “ One of my domestics falling ill, accordingly the
 “ apothecary was sent for. His complaint was a
 “ violent fever, which in its progress became putrid.
 “ Having great reliance, and deservedly, on the
 “ apothecary’s penetration and judgment, the man
 “ was left solely to his management. His disorder
 “ however kept daily gaining ground, till at length
 “ the apothecary considered him in very great danger.
 “ At last, finding every effort to be of service to him
 “ baffled, he told me he considered it as a lost case,
 “ and that, in his opinion, the man could not sur-
 “ vive four and twenty hours. On the apothecary
 “ thus giving him up, I determined to try the effects
 “ of *yeast*. I gave him two large table spoonsful.
 “ In fifteen minutes from taking the yeast his pulse,
 “ though still feeble, began to get composed and full.
 “ He, in thirty-two minutes from his taking the
 “ yeast, was able to get up from his bed, and walk
 “ in his room. At the expiration of the second
 “ hour, I gave him a basin of sago, with a good
 “ deal of *lemon*, wine, and ginger in it; he eat it
 “ with an appetite: in another hour I repeated the
 “ yeast:

“ 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. Thorn-
 ton's practice
 in putrid fe-
 ver.

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, immediate-
 ly 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 sthenic diathesis is succeeded by the asthenic or putrid. He therefore advises to *expel* this morbid and excessive stimulus by evacuations*; secondly, to *correct* this stimulus, which may be accomplished by antiseptics†; and thirdly, to *supply the principle of irritability*, which may be done by oxyds, or the inhalation of factitious vital air.

“ When my physician, Dr. THORNTON,” says the Rev. Mr. *Townsend*, “ who had recovered me, “ when in the worst stage of a putrid fever, was re- “ turned to town, he was called in for his advice,

talk, together with the other signs which infallibly denote a certain degree of intoxication, especially when you are well acquainted beforehand with the manners of the party. In the course of the day, during which I saw him frequently, he became heavy, had febrile shiverings, and complained of head-ach. The next day he became more feverish, but was not confined till the fifth day, though the head-ach and other symptoms never quitted him. He then passed into putrid fever, which continued until the 21st day, when he recovered. Does not the alkaline urine in such persons denote, continues Dr. BEDDOES, a deficiency of the oxygen?

† Vide Vol. III. page 625. Sect. LII. *Of Asphyxia from opium.*

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

† Chiefly such 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 little 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

“ 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 resumed *, but shall hasten briefly to relate the new trials which have been lately made in *scurvy*. From the resemblance of the blood taken from the arm with that of a person labouring under a putrid fever (for the blood does not, or very feebly coagulates), from the fallowness of the countenance,—the black and blue spots suffused over the surface,—the coldness of the body,—&c. the illustrious Dr. BEDDOES first conjectured that in *scurvy* there was a deficiency of OXYGEN in the blood, and suggested a plan of treatment according to this theory †. Soon after, a practical treatise ‡ appeared, written by Dr. TROTTER. “It is our duty,” says this learned and humane physician, “to draw philosophy from the

Of scurvy.

Dr. Beddoes's hypothesis

first realized by Dr. Trotter.

* We shall then do justice to the *discovery* of Sir William FORDYCE, and relate the extraordinary recovery of the son of Lord BUTE, by means of the MURIATIC ACID, which from the hurry of writing was omitted; and we shall then likewise consider the practice of Dr. JAMES, and enter fully into the merits of his justly celebrated powder.

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

‡ *Medical and Chemical Essays: containing observations on scurvy; communications from South Wales; the case of a blue boy; and thoughts on the chemical nature and decomposition of water, with a certain method of preserving it pure and sweet in long voyages.* By THOMAS TROTTER, M. D. Physician to his Majesty's Fleet under the command of Admiral Richard Earl Howe.

“ laboratory of the chemist, and make her subservient
 “ to the practical purposes of life. Whilst I had the
 “ advantage of collecting facts on the subject of
 “ scurvy, Dr. BEDDOES had superior advantages to
 “ me, in improving and extending the doctrine
 “ which I had adopted. A situation infinitely more
 “ favourable to philosophical retirement, a know-
 “ ledge of chemistry inferior to none in our age, a
 “ love for the study, and a desire to reduce it in
 “ practice, to the relief of his fellow-creatures, have
 “ brought us to an æra in the history of medicine,
 “ that has unfolded to our view, secrets of nature,
 “ on which our predecessors in science were not even
 “ able to form a plausible conjecture. In February
 “ 1793, I was removed,” says Dr. TROTTER,
 “ from the Centurian to the Vengeance of 74 guns,
 “ then at Spithead, and fitting to receive the broad
 “ pendant of Commodore Charles Thomson, now
 “ Rear Admiral; and intended for the Leeward
 “ Island station. 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

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

“ sugar enough to sweeten it, for breakfast, in lieu
 “ of oatmeal, butter, and cheese. They had for
 “ dinner excellent salt meat. Yet scurvy was not
 “ prevented from making its inroad. The officers of
 “ this ship, who at first had always plentifully shared
 “ their fresh stock with the sick, could in the present
 “ instance afford them no assistance, for they had
 “ but a very small store on board, not sufficient to
 “ last them a third of the present voyage. Many
 “ persons were in consequence violently afflicted with
 “ sea-scurvy.

“ Robert Bell, aged thirty, was a seaman, and
 “ impressed: his symptoms of scurvy were spungy
 “ gums, hardened and contracted hams, livid spots
 “ on the thighs and legs, very much depressed in
 “ spirits, and apprehensive. He was ordered vitrio-
 “ lic acid diluted in water, in as great a quantity as
 “ his stomach and bowels would bear without pain.
 “ For the first two or three days Bell had better
 “ spirits and looked more lively; but the benefit did
 “ not continue, for he grew much worse at the end of
 “ a week. It was then changed for juice of LIMES, *Dr. Trotter's*
 “ which in a few days effectually cured him. *discovery.* The
 “ effect of LIME JUICE, as I have had many occa-
 “ sions

“ fions 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 enthuiſaſm 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*

“ *tifcorbuticum* 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 medicine, and in no particular instance more than in scurvy. In various stations, and in opposite climates, I have had frequent opportunity of observing 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 attentive. I could not fail to observe the great desire that scorbutic patients have for *acids*. People, labouring 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 several cases of scurvy, and knowing,
 “ from the discovery in chemistry, that it contained
 “ a vast quantity of the *acidifying principle*, or VI-
 “ TAL AIR, I was led to make a solution of this
 “ salt in *vinegar*. Before I administered this new
 “ remedy, I made the following experiments out of
 “ the body. I took the blood from a patient in
 “ scurvy, and from a man in health, and having cut
 “ off the florid surface of the coagulum, I poured
 “ some diluted *vitriolic acid* on the dark coloured
 “ coagulum, and it assumed a *black* appearance in
 “ both cups. On the contrary, when I poured this
 “ solution 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 first favourable occasion, I was resolved
 “ to try this solution, and I had soon occasion to put
 “ it to the test of experiment; and with inexpressible
 “ pleasure I found it, in a vast variety of cases, suc-
 “ ceed beyond my most sanguine expectation. By
 “ means of the *nitrous vinegar*, the belly, in general,

“ is kept gently lax ; the discharge of urine is in-
 “ creased, and changes from an alkaline to a healthy
 “ nature ; the skin becomes open, and more agree-
 “ able to the touch ; the chilliness is changed to a
 “ pleasing warmth ; and the pulse acquires steadiness
 “ and healthy strength. 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 lose
 “ faster than could be supposed their livid hue ; they
 “ gradually become softer, less painful, and more
 “ flexible ; and ulcers put on an healthy appearance,
 “ and soon skin over. The great oppression about
 “ the breast gives way ; and the cough and breathing
 “ become less laborious. The appetite and the sense
 “ of taste is restored. The depression of spirits and
 “ the lassitude are forgot. The strength increases ;
 “ and, at last, health is re-established. In the month
 “ of July 1794, I made comparative trials with this
 “ solution, and the juice of *limes*, and after having
 “ duly weighed all circumstances, I am inclined to
 “ decide in favour of the former ; one advantage,
 “ however, it certainly possesses over the latter, as it
 “ consists of articles which may at all times, and
 “ with

“ with very little expence, be obtained, and without
 “ difficulty preserved; in short, it is the *desideratum*
 “ which Dr. BEDDOES has attempted to establish.”

LXIII. We are now arrived at the most brilliant æra in phyc, The different factitious airs were soon after tried at the Hotel Dieu in Paris, many of which proved successful, but some turning out inauspicious*, and the revolution succeeding, with the tyranny of ROBIESPIERRE, who put to death LAVOISIER, and many other literary characters, a veil was drawn over this new branch of science for a time, but as FOURCROY justly observes, “ the
 “ analogy of action which has been discovered between digestion, respiration, circulation, and insensible perspiration, has begun to establish on
 “ new views, more solid than were heretofore possessed, a *system of* ANIMAL PHYSICS, which promise an abundant harvest of discoveries and improvements. Unquestionably it will be, in pursuing the chemical changes that are undergone in
 “ the system, that an EDIFICE equally *novel* and *solid*

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

“ will be erected. Every thing is ready for this
 “ ground-work ; several philosophers pursue this un-
 “ beaten path of experience ; fresh ardour, springing
 “ from these new conceptions, animates those who
 “ are engaged in this branch of physics ; and the
 “ track they have just begun to explore appears such
 “ as must lead them to more precious and accurate
 “ results, than any that have hitherto been advanced
 “ on the functions which constitute animal life.”

Dr. Beddoes.

LXIV. Whilst the progress of the pneumatic practice of physic was stopped in France by the revolution, Dr. BEDDOES, the celebrated professor of chemistry at Oxford, endeavoured to turn the attention of the faculty in *England* to this new branch of science. His works soon passed into the hands of every one: for he possessed the rare art of diffusing through his writings that lively interest, that enchanting colouring, and that delicate and vigorous touch, which influence, attach, and subdue the mind. The profundity of his reasoning is every where united to all that agreeable imagery, which the most brilliant imagination can furnish. The sacred fire of genius animates all his productions ; his theories constantly

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

* ROBESPIERRE.

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

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 *Dr. Darwin* 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 basin, for the lower surface of the crassamentum 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 possesses no oxygen.”—It may also subsequently answer another important purpose, as it probably affords the *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. Towns-
end.

The Rev. Mr. TOWNSEND, the learned author of *the Guide to Health*, observes, when speaking of the different FACTITIOUS AIRS, “ that these promote, under the skilful management of Dr. BEDDOES at the Hot Wells, Bristol, and Dr. THORNTON in London, to be a remedy well worthy the attention of the medical practitioner. The VITAL 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 Larva 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.”

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

*The effects
 of the vital
 air when
 given in a
 properly di-
 luted form as
 a remedy.*

* 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 likewise proved, that the blood and solids are composed in part of VITAL AIR, he has also the power of altering the *mass of blood* *, and therefore of changing the constitution. He possesses in the VITAL AIR a means of unlocking *obstructed vessels* †, promoting the *insensible perspiration* ‡, quickening the *digestion* ||, increasing the *animal heat* § and *muscular powers* **, and of raising the *spirits* ††. He can render the *respiration easy* ‡‡, and give *bloom* ||| to the complexion.

* Vide the celebrated Experiment of Dr. BEDDOES, which at the risk of life he generously undertook in the cause of humanity, and for the improvement of science. Vide Vol. II. p. 254.

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

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

|| Vide Vol. I. Sect. VII. *On the Balance betwixt Digestion 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 Cause of Voluntary Action*, p. 125.

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

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

||| See *Minutes of Philosophic Experiments*, p. 169. Also 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 successfully 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.

Hysterical 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 Facitious 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 less due to the OTHER ELEMENTS of *organized bodies*; and if the importance of OXYGEN seems to have been chiefly insisted on in the foregoing observations, it is only because we have very few facts which afford a foundation for reasoning concerning the connection of an excess or deficiency of CARBON, HYDROGEN, or AZOT, with the functions of life: and yet much obscurity and many difficulties must be expected to remain, till we acquire the knowledge of such facts. Let us however set a due value on our present knowledge, though it be imperfect; and restrain those rude hands that are ever ready to pluck up the tender plants of science, because they do not bear *ripe fruit* at a season when they can only be putting forth their blossoms,

*The diseases
in which the
mephitic airs
have been
successfully
employed.
Consumption.
Cancer.*

The CARBONIC ACID AIR, or *fixed air*, has however been applied in PHTHISIS by Drs. PERCIVAL, WITHERING, BEDDOES, and EWART. It has been also employed by the latter physicians in CANCER, whose fætor it corrects, and whose torture it alleviates. The HYDROCARBONATE (which appears to be a mixture of *fixed*, and *inflammable*,

mable, airs) has been applied in PHTHISIS by Drs. *Consumption.*
 BEDDOES, ALDERSON, CARMICHAEL, FERRIAR,
 and THORNTON; in HÆMOPTOE by Drs. RED- *Spitting of*
 FEARN and THORNTON; and the HYDROGEN AIR *blood.*
 (or *inflammable air*) has been applied in PHTHISIS
 by Drs. BEDDOES and THORNTON; in CATARRH *Catarrh.*
 by Drs. THORNTON, BEDDOES, and Mr. BARR;
 in CROUP by Dr. THORNTON; and in PLEU- *Croup.*
 RISY by Drs. BEDDOES, THORNTON, FERRIAR, *Pleurisy.*
 and MACDONALD.

To conclude.—The pneumatic doctrine of phytic 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 some appearances exhibited in the late destructive fever at Philadelphia. In other parts of *America* physicians of the greatest celebrity have spoken in favourable terms of this investigation. Dr. GARNET has gone out from this country, with an appointment of three hundred a year, to *North America*, as a professor of experimental and natural philosophy, and is deeply engaged in
 unfolding

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. INGENHOUSZ 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 physicians, neither *liberal* in their conceptions, nor *conversant* in that great branch of natural philosophy, which unfolds the properties of PERMANENTLY ELASTIC FLUIDS.

Mr. CLINE, the justly admired lecturer on anatomy at St. Thomas's Hospital, instead of an introductory lecture, immediately enters upon his course, and defers this general account of the progress of the science, as a summary, at the conclusion, when it can, as he says, be better understood: but we have here followed the plan of the late Dr. HUNTER, father of a no less illustrious school, thinking that this preface may be read with *some* advantage at the commencement; it must inspire ardour, and command attention, in the reader, and may be *re-perused* at any subsequent time, should the indulgent reader confer on it that honour.

found among physicians, neither liberal in their con-
 sideration, nor restrained in their praise of natural
 philosophy, which regards the properties of matter.
 NEWTON'S CLASSICAL

Mr. Clark, the newly admitted lecturer on sci-
 ence at St. Thomas's Hospital, instead of an intro-
 ductory lecture, immediately enters upon his course,
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 stead of a better illustrated school, thinking that this
 practice may be read with some advantage in the con-
 nection. It must inspire ardour, and command
 attention, in the teacher, and may be expected in any
 judicious man, should the indulgent teacher confer
 on it that honour.

PART I.

A SUMMARY
OF THE
PNEUMATIC CHEMISTRY.

VOL. I.

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PART I

A SUMMARY

OF THE

PNEUMATIC CHEMISTRY

1845

Vol. I.

OTHER ages may have surpassed the present in the greatness of some single event, such as the rapid conquest of half the globe by an ALEXANDER or a TAMERLANE. Nevertheless, the age in which we live, seems to me, of all the periods in history, the most distinguished for the sudden and extensive impulse which the human mind has received, and which has extended its active influence to every object of human pursuit. The diffusion of a general knowledge, and of a taste for science, over all classes of men, in every nation of Europe, or of European origin, seems to be the characteristic feature of the *present age*. The study of the sciences 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 seem to excel those of the present day; although in justice to these, it should be remembered that luminous bodies shine brightest in obscurity. But in no former age, was ever the light of knowledge *so extended*, and *so generally diffused*. Knowledge is not now confined to public schools, or to particular classes of men. It is not at this day, that some celebrated and immensely learned professor delivers from his academic chair dictates to his auditors, who press from all quarters to catch the oracular sounds, and afterwards to revibrate his ipse dixits. In *this age*, the flame that passes over all, kindles the sparks of genius wherever they may happen to lurk, and every man forms an opinion for himself.

KEIR.

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 respective circle: but *chemical attraction*, or the *attraction of cohesion*, we are about to consider, is that principle which joins and combines into little systems those several and distinct corpuscles which form different substances. It is that *attractive force* by which they tend mutually towards each other; which force only exists in the very point of close contact, at little distances is less, and at a little further distance is quite insensible.

The *attraction of gravitation* acts only upon large bodies, and is always in proportion to their masses; whereas *chemical attraction* affects only minute bodies, and has absolutely no influence upon such as are of any considerable bulk. *Gravitation* acts upon bodies placed at immense distances from each other; whereas *chemical attraction* never acts but with bodies in mutual contact.

We see then that these two attractive powers are different, and they are not natural to inert bodies, but a property implanted by the CREATOR no less confounding to the philosopher than that amazing property in animal bodies, which we denominate the life or soul.

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 texture 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 sufficiently considered, let us, for a moment, conceive what would take place in the various substances which compose our earth, if its *temperature* were suddenly altered. If, for instance, we were transported into the region of the planet MERCURY, where probably the common temperature is much superior to that of boiling water. The rivers of the earth, and all the other fluids which are susceptible of the gaseous state, at the temperature near to that of boiling water, would become rarefied; and all these substances would be changed into permanent aeriform fluids or gasses, which would become part of the new atmosphere.

By a contrary supposition to the one we have been forming, if the earth was suddenly transported to where the GEORGIUM SIDUS is, or some planet equally cold, the water which compose our seas, rivers, and springs, and probably the greater number of the fluids we are acquainted with, would be converted into solid mountains and hard rocks, at first transparent and homogeneous, like rock crystal, but which, in time, being mixed with different coloured earths, would form opake stones of various colours. In this case the air would lose its elasticity for want of a sufficient temperature to retain it in that state: it would return to the liquid state of existence,

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

VOL. I.

* Q

water

water and bodies which are penetrated by it. If we put a loaf of bread into water, this fluid will gradually insinuate itself into its pores, and the bread is soon considerably augmented both in weight and magnitude.—Or if we put a piece of wood into water, it will swell by admitting the water into its substance.—Or if a dry sponge be dipped in water, the sponge swells, its particles are separated from each other, and all its intervals are filled up by the water. The same circumstance undoubtedly takes place with regard to bodies which are immersed 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 side of the tube, you will find it also longer than the tube, which when cold it appeared so exactly to fit. Its dimensions are therefore *increased* both in diameter and length. It is so 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 vessels and the wheels of carriages are bound with hoops heated red hot, and applied in this their expanded state, after which they

* Distinguished thus from latent or combined heat.

pour cold water upon them, when the iron contracts with such force as to make a deep impresson on the wood, and in this way the vessels are bound much faster than they would be by any other means. It is also upon this principle that our *thermometers* are constructed.

The first invention of this curious and useful instrument is somewhat obscure : but previous to the time of *SANCTORIUS* it does not appear that the expansive power of heat was much observed. *SANCTORIUS's* thermometer was a hollow glass ball, with a long cylindrical tube attached to it, with a small opening at the top, and therefore containing a quantity of air, and in order to observe the variation of the bulk, or elasticity which the air in the ball and tube underwent from the application of heat, he first expelled a small quantity of air out of the vessel by applying heat to it. In consequence of which the air expands, and a small quantity of it comes out. He then puts the extremity of the tube immediately into a coloured liquor, and allows the vessel to become cool again; the consequence is, that the air loses the increase of its elasticity, and the internal air presses 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

The Thermometer.

* Vide Vol I.

* Q 2

having

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 loss from exhalation; thus the first useful thermometer was contrived by the Honourable Mr. BOYLE. These thermometers were used for twenty or thirty years, till Dr. HALLY and Sir Isaac NEWTON preferred *mercury*.

The *pulse glass*, as it is improperly called, depends also upon this principle. It is a bulb with a long neck to it. As the heat of the hand, following its natural tendency, immediately passes into the colder spirit of wine, in proportion as it enters it increases its bulk, and makes it gradually rise higher into the neck of the vessel, till it has acquired its utmost limit, when it appears to bubble; and to shew that it depends upon heat merely, it will do the same if immersed in hot water; and then if it be removed it will again diminish in bulk, and return to its former place.

The pulse glass.

Before I quit the subject of *expansion*, it may not be improper to notice, that a knowledge of this law enables us to understand the effect produced upon bodies that are remarkably brittle. Chemists know this but too well, and in private families glasses are repeatedly broken by pouring into them warm water, and even the backs of grates are soon cracked if cold water be thrown upon them after they are quickly heated. In these cases 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 basin, 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 Fahrenheit'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 change of the ice from the *solid* to the *fluid form*, it *absorbed* a quantity of HEAT, even so much as to render mercury similar in its properties to all the other metallic bodies.

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

If you put a cup of æther in a basin of water, and place them in the exhausted receiver of an air-pump, the æther will assume an aeriform state, and the water in the basin will be frozen. In this experiment we see, that in the ordinary temperature of the earth, æther would always exist in an aeriform state, but for the pressure of the atmosphere, and that the passing of the æther from the liquid to the aeriform state is accompanied with a considerable diminution of heat; because during the evaporation a part of the caloric, which was before either free or latent in the surrounding bodies, combines with the æther, causing it to assume the aeriform state.

The effect of the pressure of the atmosphere in the conversion of bodies into these different states was first

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
digestor.*

In consequence of this discovery PAPIN formed his *digestor*. 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 exclusion 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 the present age in the midst of his useful labours ; his house, filled with the most expensive chemical apparatuses, free for his numerous visitants, was despoiled ; and the honourable rendezvous of men of letters was converted into a den of political thieves. The subject we hope, however, will not be dropt. The laws which regulate the formation of elastic vapour, and the phænomena they exhibit, give us that link which closely connects chemistry with mechanical philosophy. Here we see chemical agents and mechanical forces set in immediate opposition to each other, and the one made the indication and measure of the other.

The *steam engine*, is the name of a machine which derives its moving power from the elasticity of the steam of boiling water. It is the most valuable present which the arts of life have ever received from the philosopher. The mariner's compass, the telescope, and other most useful discoveries, were the result of chance, and we do not know to whom we are indebted for them ; but the steam-engine was, in the very beginning, the result of reflection, and the production of a very ingenious mind ; and every improvement it has received, and every alteration in its construction and principles, were also the results of philosophical study. This invention was made

*Steam
engine.*

in the reign of Charles II. by the Marquis of WORCESTER, which he published with ninety-nine other contrivances of his own, which he extols, as of the highest importance to the public. It does not, however, appear that the noble inventor could ever interest the public by these accounts. He was branded as a projector, and the many failures which persons of this turn of mind daily experience, probably prejudiced people against him, and prevented all attention to his projects. The scheme however was revived in the year 1696 by Captain SAVARY, but it owes its present improved state to the philanthropic Mr. WATT, a person of a truly philosophical mind, eminently conversant in all branches of natural knowledge, and the pupil and intimate friend of Dr. BLACK, whose illustrious 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 diffusely into examples of the consequences of the change of capacity in bodies when they are altered in their form, it may be observed, and repeated once more, that as the powers of

* Vide p. 608. note *.

gravity and *projection*, in continual opposition to each other, produce all the beautiful effects in the great system of the universe; so, among the actions of the minute parts of bodies, the *cohesive attraction*, and the *repulsion of heat*, are in continual opposition to each other, and are concerned in almost every process by which changes are produced in the peculiar properties, or chemical combination, of bodies.

To conclude. Besides the extensive influence of *heat*, chemists, in order to destroy as much as possible THE ATTRACTION OF COHESION, employ the mechanical operations of *pounding*, *hammering*, *rasping*, *filing*, or *cutting*, and not unfrequently the operation of *solvents*. Hence that adage, “*Corpora non agunt nisi sint soluta*,” by which means they give free scope for THE ATTRACTION OF COMPOSITION, or AFFINITY, or that attraction which takes place between bodies of different natures.

and a system in constant agitation to each
 other, produce all the beautiful effects in the
 system of the universe; for among the atoms of the
 infinite power of bodies, the various attractions and
 repulsions that are in constant agitation to each
 other, and are connected in almost every power of
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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

B

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, 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.

† Other more important effects will be given, when we come to treat *On the Nature of Disease*. Dr. PITCAIRN, in the year 1687, being at his country seat near Edinburgh, in February, on a fairer day than usual at that season, was seized with a sudden bleeding of the nose after an uncommon faintness, and on the next day, on his return to town, he found that the BAROMETER was *lower* at that very hour than either he or his friend Dr. GREGORY, who kept a journal of the weather, had ever observed it; and that another friend of his, Mr. COCKBURN, professor of philosophy, had died suddenly at the same hour by an eruption of blood from the lungs; and also five or six others of his patients were seized with different hæmorrhages. MEAD.

SECT.

A CHEMICAL TABLE.

ELEMENTS.		COMPOUNDS.	
Hydrogen	1	Water	H ₂ O
Carbon	12	Carbonic Acid	H ₂ CO ₃
Nitrogen	14	Nitric Acid	HNO ₃
Oxygen	16	Sulphuric Acid	H ₂ SO ₄
Phosphorus	31	Phosphoric Acid	H ₃ PO ₄
Potassium	39	Potash	K ₂ O
Sodium	23	Soda	Na ₂ O
Calcium	40	Slime	CaO
Magnesium	24	Magnesia	MgO
Zinc	65	Zinc Oxide	ZnO
Iron	56	Iron Oxide	Fe ₂ O ₃
Copper	63	Copper Oxide	Cu ₂ O
Lead	207	Lead Oxide	PbO
Mercury	200	Mercuric Oxide	HgO
Antimony	121	Antimony Oxide	Sb ₂ O ₃
Arsenic	75	Arsenic Oxide	As ₂ O ₃
Strontian	87	Strontian Oxide	StrO
Barytes	137	Barytes Oxide	BarO
Alumina	78	Alumina	Al ₂ O ₃
Silica	28	Silica	SiO ₂
Fluorine	19	Fluorine	F ₂
Chlorine	35	Chlorine	Cl ₂
Bromine	80	Bromine	Br ₂
Iodine	127	Iodine	I ₂
Hydrochloric Acid		Hydrochloric Acid	HCl
Sulphuric Acid		Sulphuric Acid	H ₂ SO ₄
Nitric Acid		Nitric Acid	HNO ₃
Carbonic Acid		Carbonic Acid	H ₂ CO ₃
Phosphoric Acid		Phosphoric Acid	H ₃ PO ₄
Potash		Potash	K ₂ O
Soda		Soda	Na ₂ O
Slime		Slime	CaO
Magnesia		Magnesia	MgO
Zinc Oxide		Zinc Oxide	ZnO
Iron Oxide		Iron Oxide	Fe ₂ O ₃
Copper Oxide		Copper Oxide	Cu ₂ O
Lead Oxide		Lead Oxide	PbO
Mercuric Oxide		Mercuric Oxide	HgO
Antimony Oxide		Antimony Oxide	Sb ₂ O ₃
Arsenic Oxide		Arsenic Oxide	As ₂ O ₃
Strontian Oxide		Strontian Oxide	StrO
Barytes Oxide		Barytes Oxide	BarO
Alumina		Alumina	Al ₂ O ₃
Silica		Silica	SiO ₂
Fluorine		Fluorine	F ₂
Chlorine		Chlorine	Cl ₂
Bromine		Bromine	Br ₂
Iodine		Iodine	I ₂

* Chlorine was considered a light, though in the strict sense it was not so.

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 ANCIENT OPINION RESPECTING OUR AIR.

FORTUNATELY for my readers, the chemical knowledge necessary first to be learnt in order *clearly* to understand the INFLUENCE of 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 AIR, therefore, which every where presses on us, and upon which we subsist, bears very little resemblance to that *pure, simple, elementary body* formerly imagined; and which is rather a substance that can be conceived, than experienced to exist.

MODERN CHEMISTRY, however, has made great advances in *this curious research*, and it will soon appear that the composition of atmospherical air has been more *rigorously* determined.

Chemistry affords two general methods of ascertaining the constituent principles of bodies, the method of ANALYSIS*, and that of SYNTHESIS†.

When, for instance, by combining *water* with *alcohol*, we form the species of liquor called BRANDY, we certainly have a right to conclude (by this synthesis) that BRANDY is composed of *alcohol* and *water*. And when, by distillation of BRANDY, we obtain separate, *water*, and *alcohol* (by this analysis), our evidence of the constituent principles of BRANDY is then rendered complete; and in general it ought to be considered as a *principle* in chemical science, never to rest satisfied without *both these species of proofs*.

* From the Greek word *αναλυσις*. The *separation* of any compound into its *several parts*.

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

SECT. III.

THE MODERN ANALYSIS

OF

ATMOSPHERIC AIR;

Or its Separation into { 1. VITAL AIR,
2 ELASTIC FLUIDS, { 2. AZOTIC AIR.

LAVOISIER'S FAMOUS EXPERIMENT.

THIS illustrious chemist having placed 83 *grains* of fluid 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, weighed 90 *grains*. The MERCURY, therefore, by being calcined, had acquired 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 DISTINGUISHING 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 $\zeta\omega\eta$, *life*, as THIS AIR destroys 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 our air.

† Not from any peculiar property of its own, but because the *vital or respirable part* was abstracted from it, as will be seen from the next experiment.

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 phenomena 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 *ὄξυς*, *sour*; and *γενναίαι*, *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 SELTZER, 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 same experiments as before related, and *re-combined* the 2 ELASTIC FLUIDS, which he had separately 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 *precisely similar in all its properties* to ATMOSPHERIC AIR, contributing in the same way to a repetition of the same experiments, and possessing the same power of supporting animal life and combustion.

The philosopher can have no remaining doubt as to the *composition* of ATMOSPHERIC AIR: but the circumstances of these experiments might appear to him *more correct*, though probably at the time *less clear* to others, were it said, 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 these be smooth and rubbed together, they will strongly unite and form *one whole*. This is from a law impressed on matter called the *attraction of cohesion*. But should a particle of sand, or any roughness exist, 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 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 *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,
 “ ARE AERIFORM, AND MAY BE PROCURED IN
 “ SEPARATE STATES, VIZ. IN THE CONDITION OF
 “ VITAL, AND AZOTIC, AIR, WHICH BEING MIXED
 “ IN A CERTAIN PROPORTION CONSTITUTES OUR
 “ ATMOSPHERE.”

* That AZOT is a *solid substance* as well as OXYGEN, can be easily proved by experiment, consult page 39. 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!

Although

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 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 torn by the MERCURY from its union with 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.

SECT. IV.

THE ANALYSIS

OF

OXYGEN AIR.

THAT OXYGEN GAS, is composed of { 1. OXYGEN,
2. CALORIC,
3. LIGHT,

will be *evident* from the following very elegant experiment first made by the celebrated Dr. INGENHOUSZ.

A fine *iron wire*, twisted into a spiral *, being heated at its extremity red hot, and thrust into a jar containing only *oxygen air*, it instantly took fire, and burnt away rapidly †, exhibiting a bright light similar to that of Chinese fire-works, throwing out brilliant sparks, which fell to the bottom in the form of round globules ‡.

At the beginning of the combustion there is a slight augmentation in the volume of the air in the bell-glass, from the dilation caused by the caloric or heat ; but presently

* This was done to render the experiment more striking.

† This experiment shews that *azotic air* retards the union of *oxygen* with bodies attracting it, which in some cases altogether prevents it.

‡ These were found floating on the mercury, and are natural *Martial Æthiops*. How much slower is the *calcination* or *rusting* of *iron* in other circumstances!

after a *rapid diminution* takes place, and the *mercury rises in the glass*, infomuch that when the *quantity of iron is sufficient*, and the OXYGEN 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 VITAL AIR †.

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.

SECT.

* 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 Dr. INGENHOUSZ's experiment, where the *combustion* of the metal was more rapid, and unconnected with any furnace.

The burning of all bodies is then nothing more than the *decomposition* of oxygen air. It is the *air*, therefore, and not the combustible body, that gives out *light* and *heat*. When we are sailing on the water in a still day, *distinct objects appear to*

SECT. V.

THE ANALYSIS

OF

WATER ;

Or its separation into its { 1. HYDROGEN,
2 CONSTITUENT PARTS, { 2. OXYGEN.

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 expe-

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 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*.

riment

riment performed by Dr. PRIESTLEY made it for a while totter on its basis.

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

* *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. The difference therefore between these two airs is great.

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, 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†.

* 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.

† WATER and AIR, says Sir ISAAC NEWTON, composed of old worn particles and fragments of particles, would not be of the same texture and nature now as at the beginning, did not the primitive particles of MATTER continue entire, and compose bodies of one and the same nature and texture in all ages. The changes of corporeal things are to be placed only in the various separations and new associations of these PERMANENT PARTICLES. OPTICS, p. 376. How beautifully has modern chemistry confirmed this great man's ideas!

But

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.

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 adopted 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 *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.

* 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 *ὕδωρ* water, and *γεννέω* to beget.

Having

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 *OXID** OF *IRON*, which accounts for the *oxygen*, the other constituent principle of water.

Another proof that *WATER* is composed of *hydrogen* and *oxygen* may be drawn from the celebrated experiment of Mr. *WATT*. This illustrious chemist wet powdered charcoal, and put it so moistened into a retort. Fire being applied, *HYDROCARBONATE AIR ** is soon formed; that is, *hydrogen air*, or *inflammable air*, mixed with fixed air, which, in the next section, we shall find is composed of charcoal and *oxygen*.

* This air, which is applied medicinally, was the happy discovery of Mr. *WATT*. This benevolent philosopher also taught physicians an easy process for obtaining *VITAL AIR*. His simple apparatus is a furnace, in which is placed an iron retort filled with finely powdered *manganese*. An iron gun-barrel enters the mouth of the retort, and at its other extremity is connected with his *pneumatic receiver*, or with any vessel filled with, and immersed over, water. The furnace is then filled with charcoal and lighted, and *VITAL AIR* is obtained very rapidly, and in considerable quantity. The luting that Dr. *THORNTON* discovered to be the best, is putty mixed with sand.

SECT. VI.

THE ANALYSIS

OF

CARBONIC ACID AIR, OR FIXED AIR;

Or its separation into its $\left\{ \begin{array}{l} 1. \text{ CHARCOAL,} \\ 2. \text{ CONSTITUENT PARTS,} \end{array} \right. \left\{ \begin{array}{l} 1. \text{ CHARCOAL,} \\ 2. \text{ OXYGEN AIR.} \end{array} \right.$

MR. TENANT, a famous chemist of Emanuel College, Cambridge, having procured a glass tube hermetically sealed at one end, luted it over with clay and sand to prevent the sudden action of the fire. He then introduced into it some PHOSPHORUS and powdered MARBLE*, and having closed the open extremity, he applied to the tube a quick heat, and the result was, when cold,

1. PHOSPHORIC ACID† combined with *calcareous earth*.
2. PHOSPHORUS combined with the *same 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 assumes this data, *that marble contains FIXED AIR*. As the residue is *vitriolic acid* and CALCAREOUS EARTH, *marble* is known also to contain CALCAREOUS EARTH.

† *Phosphorus* and *oxygen*. The answer to this natural question, *Whence this oxygen?* is clearly demonstrated 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 { 1. OXYGEN, combined with
2. CHARCOAL, or the *carbonic acid*; and
3. CALCAREOUS EARTH.

The *theory* of Mr. TENANT's *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, however, by *synthesis*, that the constituent principles of FIXED AIR, are *charcoal*, and *oxygen AIR*, is more beautiful, as being easier understood.

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 ||.

* 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.

‡ 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 *oxygen air* will saturate or take up 28 grains of *charcoal*.

E

THIS

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, like FIXED AIR, weighed *heavier* than *common air*. A candle being put in it, was quickly *extinguished*, and an animal died *convulsed* in it.

* 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 becomes a *chalybeate*, we are indebted to the happy industry of Dr. PRIESTLEY.

The reader, from the above account, may wish to know how FIXED AIR (*charcoal, oxygen, and caloric*), differs from 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 *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.

SECT.

SECT. VII.

THE ANALYSIS

OF

ADEPS, OR ANIMAL FAT;

Or its Separation into its { HYDROGEN, and
2 CONSTITUENT PARTS, { 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,

EXPERIMENT I.

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 surface of which floats ESSENTIAL OIL,—and there remains in the retort, unvolatilized by *caloric*, CARBON or CHARCOAL.

But had the heat at first been considerable in the furnace, we should have had *from the same materials*, instead of WATER,

EXPERIMENT II.

ELEMENTS.

From
the furnace.

	1.	2.	3.	4.
1. CARBONIC ACID GAS,	oxygen,	- -	charcoal,	& <i>caloric</i> .

The *oxygen* under these circumstances has a greater affinity for *carbon* than for *hydrogen*. And instead of OIL,

	1.	2.	3.	4.
2. HYDROGEN GAS, -	- -	hydrogen,	- -	& <i>caloric</i> .

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

3. CHARCOAL.

It is an axiom in chemistry, that in all its operations nothing is *created*, but only a new *arrangement of parts* takes place: for *the quantity of matter* still remains the same after every process.

In the SECOND EXPERIMENT we have seen *vegetable matter* reduced to *its primeval elements*, HYDROGEN, OXYGEN, and CHARCOAL. If we carefully ascertain the quantity of HYDROGEN and CHARCOAL produced in the first experiment, and *compare this quantity* with the quantity of HYDROGEN and CHARCOAL produced in the second experiment, we shall find a *loss* or *deficiency* of these *two simple elements* in the produce of the FIRST EXPERIMENT, which corresponds exactly with *the weight* of the OIL.

VEGETABLE OIL is composed therefore of HYDROGEN and CHARCOAL.

I cannot

That ANIMAL OIL or ADEPS is composed, like VEGETABLE OIL, of *charcoal* and *hydrogen*, will appear evident from the following *analysis*, or separation of ANIMAL OIL into its constituent principles.

In the first rectification of *animal oil* a small quantity of WATER is formed by the union of the *oxygen* contained in the air of the distilling vessel, and the *hydrogen* of the oil. We can at length, by frequent distillations, decompose 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 corresponding with those of the OIL and the OXYGEN AIR consumed.

I cannot help here observing the use that vegetation is of to animal life as first discovered by Dr. INGENHOUSZ, in furnishing the atmosphere during the day with abundance of VITAL or OXYGEN AIR. Dr. PRIESTLEY's experiments likewise prove that vegetables absorb the NOXIOUS AIR (*fixed air*) produced from combustion, respiration, and putrefaction; for which discovery he received the thanks of the Royal Society.

Dr. FRANKLIN, in writing to this illustrious experimentalist, says, "That the *vegetable creation* should restore the air, which has been spoilt by the *animal part of it*, looks like a rational system, and seems to be of a piece with the rest." Having observed the rapid increase that plants had in *air fatal* to animals (*fixed air*), he adds, "This seems to prove that something is taken from the air."

It now appears that the vessels on the under surface of leaves absorb WATER from the air, which passing along the capillary tubes of the superior surface, by the action of the *sun*, and the influence of *light*, becomes decomposed, and the HYDROGEN of the *water* unites with the *substance* of the plant as one of its principles, while the superabundant OXYGEN is thrown out in the form of the PUREST VITAL, or OXYGEN GAS.

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, enclosed 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

perience had taught these grave-diggers that *this period* was not sufficient for the total destruction of the bodies, whilst it made them acquainted with the change which we are about to describe.

The opening which the *French chemists* ordered to be first made, was that of a grave which had been filled and closed up for near 15 years. On raising the covers of some of the coffins, which were in perfect preservation, we saw, say they, the bodies enveloped in linen, which marked out the shapes of the different regions; but when these were lifted up, there was presented to us nothing but *shapeless irregular masses of a soft, ductile, whitish substance*.

These masses every where surrounded the bones. They possessed little solidity, and yielded to pressure. This substance had no unpleasant smell. The grave-diggers had not the smallest repugnance to handle it, and they called this substance, which so much startled the French philosophers, by the term *FAT*.

After examining several bodies with great attention, they found that all the bodies were not *equally advanced* in this process. In *several, portions of muscular flesh*, distinguished by its *fibrous texture* and *reddish colour*, were
still

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 SPERMACEI. 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*, also, in the center of the cylindrical bones was wholly converted into a very pure fat; it even insinuated itself between the bony plates, filling up their interstices.

Although there is no doubt but that the quantity of this matter is larger in the bodies of such as have been fat than in those who have been lean, the facts we have mentioned prove that other parts, besides the cellular texture, and fat it contains, are susceptible of this alteration. The following observations are decisive with regard to this point. It is to be presumed, that the greater number of bodies found in this common grave, were, previous to their death, emaciated by disease, and in these the bodies were found *universally* converted into fat, which we cannot suppose to have had a previous existence.

Our curiosity was sufficiently roused, continue these chemists, to extend our researches into other churchyards. In those, where bodies were buried in common graves, we found similar appearances. We met with the fatty matter in a sufficient variety of cemeteries to convince us, that the formation of this singular substance was by no means peculiar to the soil in which we had at first observed it, but that it takes place every where,

F

where

where bodies are deposited in great numbers, close to one another, excluded from the action of external agents, and exposed solely to the effects of their constituent principles.

We could obtain no positive information relative to what became of the bodies after they have been once changed into fat; the oldest and most experienced gravedigger knew nothing of this matter.

This conversion of the several parts of the human body into *true animal fat*, must arise, says Mons. LAVOISIER, from the disengagement of AZOT, naturally contained in all animal substances, 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 spontaneous dissolution of bodies buried in the earth; phenomena heretofore equally unknown and undescribed, so that even words were wanting to convey our ideas. The present must merely be considered as a very imperfect outline of the picture, which posterity must fill up and finish. For this purpose it will be necessary

* If *nitrous acid* be poured upon *lean meat* AZOTIC GAS is plentifully disengaged, and in three days it is changed into a fatty matter, resembling *spermaceti*. LAVOISIER thinks that this discovery may hereafter prove of great service to society.

to live among the tombs, to follow up a long and repeated examination of various graves, and bestow indefatigable attention on the most unpleasant, as well as 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*.

* Dr. GIBBES, and the Rev. Mr. TOWNSEND, found that lean beef secured in a running stream was converted into this fatty matter at the end of a month. The latter having a cow killed by an accident, buried it in a water meadow at Pewsey. The grave was but slightly covered with earth, and a constant stream of fresh water continually passed over it. *Spermaceti*, or a substance much resembling it, was formed, and the experiment promises to be of advantage to the community.—Shall I not excite an emotion of ridicule, when I mention that, as the flesh is capable of being changed into spermaceti, the bones are at the same time capable of being converted into a pure *glass*. The illustrious BECKER, father of the Phlogistic school, was long ago perfectly acquainted with this fact. He tells, in determinate language, “*Homo vitrum est, et in vitrum redigi potest, sicut et omnia animalia.*” He regrets that the Scythians, who drank out of disgusting sculls, were not acquainted with the art of converting them into glass. *Phosphorus*, which amuses while it astonishes the beholder, is made, we know of bones; and, to conclude, the skin of John ZISCA, after his death, was employed as a covering of a drum, to excite the holy crusade.

SECT. VIII.

OF PUTREFACTION ;

OR

THE RESOLUTION OF ORGANIZED MATTER

INTO

ITS CONSTITUENT PRINCIPLES.

AMMONIAC { 1. AZOT,
is composed of { 2. HYDROGEN.

PUTREFACTION is the great process appointed by the CREATOR, for the resolution of animal and vegetable substances into *the elements* from which they were first formed. By this process, the oak and the bramble, the cedar and the hyssop, fruits, whether delicious, or nutritive, or acrid, or poisonous, the most beautiful of the human species, and the most frightful of the other tribes of animals, are all reduced to one common lot: they finally return back to their original and primeval elements.

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 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*,

fermentations *, they at length became 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.

The addition of AZOT not only accelerates the putrefactive process, but the *azot* combining with the *hydrogen* affords a new product, which is AMMONIAC

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.

OR

OF 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 substances* 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 upon the eyes, and fometimes, as in putrid herrings, the PHOSPHORATED HYDROGEN GAS is moft abundant.

* The beft method of obtaining *azotic gas* for medicinal purpofes, is, by burning a wax candle, or charcoal, in a given quantity of atmofpheric air confined in a bell glafs inverted over water. The oxygen is confumed, and fixed air formed, which may be eafily abforbed by fquirting into the bell, lime, or even common, water, by means of a fyringe. Dr. THORNTON ufes this fimple procefs for impregnating water with fixed air.

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 foetor 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 some 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-

* An instance of this happened, when the ground of the church of St. *Benoit*, at *Paris*, was dug up a few years ago; a nauseous vapour was emitted, which, besides its deleterious effect upon the grave-diggers, injured persons even who lived in the vicinity. Messrs. MARET and NAVIER have given us several similar occurrences.

hood must, in some measure, injure the health of the inhabitants *.

• Mr. CAREY, in describing the pestilential *fever* which 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 portion 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 custom which allows of burying in churches ought certainly to be suppressed. This is an abuse which calls aloud for reformation. It is but just that the vanity of the individual should be sacrificed to the public safety. It is necessary, likewise, to prohibit burying in vaults. The grave should be deep, and covered over with a clayey earth, that the exhalations, vapours, and gases, which are developed and formed by decomposition, should not have an easy escape. At *Bath* the parish church is famous for a fine roof and extensive prospect, and strangers frequently walk on the top. If, at any time, the nostrils be applied to any of the openings, the stench which ascends is so abominable, that the face is hastily withdrawn. Though more diffused in the church, can we doubt a moment of the insalubrity of such an atmosphere?

PART II.

~~THE AGENCY OF OXYGEN, OR VITAL, AIR~~
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 recreetque 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 foubah, 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 second in command; who, with the assistance of a few gallant officers, and a very small garrison, maintained the place with singular courage and resolution, till at length, the enemy having forced their way into the castle, he was obliged to surrender; the foubah having first promised him, on the honour of a foldier, “ that no injury should be offered him or his garrison.”

Having made them prisoners, he ordered them, to the number of 146 persons, to be put into a place called the BLACK-HOLE prison, a cube of about 18 feet, open only to the westward by *two windows* strongly barred with iron.

The humane reader will conceive, with horror, the miserable situation to which they must have been reduced, thus stewed up, in a *close sultry night*, under the climate of Bengal, especially when he reflects that many were *grievously wounded*, and all of them *greatly fatigued* by the exertions of the preceding day.

A *profuse sweat* quickly broke out on every individual, attended with an *insatiable thirst*, which became the more intolerable as the body was drained of its moisture.

It was in vain that they stripped 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? — — — — —

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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 rush on the swords of the monsters, by whom they were surrounded, and who derided their sufferings; but all their efforts proved ineffectual. They then used execrations and abuse to provoke the guard to fire upon them.

The jemmaudar was at length moved to compassion. He ordered his soldiers to bring some skins containing *water*, which, by enraging the appetite, only served to increase 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 eagerness and transports of the wretched prisoners who struggled for it in fits of delirium.

The cry of *Water! Water!* issued from every mouth.

The consequence of this eagerness was, that very little fell to the lot even of those who stood nearest the window; and even these, who were esteemed the most fortunate, instead of finding their thirsts assuaged, grew more impatient.

The confusion soon became general and horrid; all was clamour and contest; those who were at a distance endeavoured to force their passage to the window, and

the weak were pressed down to the ground never to rise again.

Mr. HOLWELL observing now his dearest friends in the agonies of death, or dead, and inhumanly trampled on by the living, finding himself wedged up so close as to be deprived of all motion, he begged, as the last mark of their regard, that they would for one moment remove the pressure, and allow him to retire from the window, and die in quiet.

Even in such dreadful circumstances, which might be supposed to have levelled all distinctions, the poor delirious wretches manifested a respect for his rank and character: they forthwith gave way, and he forced his passage into the center of the place, which was less crowded, because, *by this time*, about one third of the number had perished, while the rest still crowded to both the windows.

He retired to a platform at the further end of the room, and lying down upon some of his dead friends, recommended his soul to heaven.

Here his *thirst* grew insupportable; his *difficulty in breathing* increased, and he was seized with a *strong palpitation of the heart*.

These

These violent symptoms, 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 sake!*

He had been supposed already dead by his wretched companions, but finding him still alive, they exhibited another extraordinary proof of regard to his person: *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 ceased: but finding himself still more thirsty after drinking, he abstained from water, and moistened his mouth, from time to time, by sucking the *perspiration* from his shirt sleeves, which tasted soft, pleasant, and refreshing.

The miserable prisoners now began to perceive it was AIR and not *water* that they wanted.

They dropt fast on all sides, and a *pungent steam* arose from the bodies of the living and the dead, as *pungent* and *volatile* as *hartshorn*.

Mr. HOLWELL being weary of life, retired once more to the platform, and stretched himself by the Reverend Mr. Bellamy, who, together with his son,
a young

a young lieutenant, lay dead, locked in each other's arms.

In this situation he was soon deprived of sense, and seemed to all appearance dead, when he was removed by his surviving friends to one of the windows, where the fresh air brought him back to life *.

The faubah, being at last informed that the greater part of the prisoners were *suffocated*, inquired if the chief was alive; and being answered in the affirmative, sent an order for their immediate release, when NO MORE THAN 23 SURVIVED of 146 who entered into this prison alive,

Mr. HOLWELL and his surviving companions were directly seized with a *putrid fever* †, and in this condition even dragged before the faubah to be questioned about a treasure, which he believed they had secreted.

* How persons apparently dead are brought back to life by the means of *fresh air*, will be in the sequel better understood. Vide Section on the Recovery of drowned Persons.

† 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 tarpaulings 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 senators! 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.

S E C T. III.

HAVING proved the connexion betwixt *life* and *air*, it is necessary now to shew WHAT ARE THE CHEMICAL ALTERATIONS AIR UNDERGOES BY BEING RESPIRED.

Dr. PRIESTLEY having formed NITROUS AIR by the solution of various metallic bodies in *nitrous acid*, he discovered that it possessed this singular 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 considerable heat.

I hardly know, says this philosopher, 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 itself, and yet, instead of acquiring *larger dimensions*, becomes itself *considerably contracted**.

This

* We are not so much surpris'd when we find an *aeriform body* starting out from a *solid substance*, as in the formation of *this* and *other facitious airs*; but we are more sensibly affected, when, on the reverse, *two invisible 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 EUDIOMETER is thus constructed. Having filled a cylindrical glass tube with quicksilver, he immerses it in a basin 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 Thuleries 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 of OXYGEN AIR,
and 73 — of AZOTIC air,

100 parts.

Towards the conclusion of the piece, which was acted before an unusual concourse of spectators, 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 diminished 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 atmosphere, therefore, which is originally composed of 2 *fluids*, is composed of 3 *aerial fluids*, in all places which contain numerous assemblies of people. *These* 3 aerial bodies, though blended together, arrange themselves in some degree according to their specific gravities; that is, the proportion of AZOT, which is the lighter body of the 3, will be found most

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

Unless *this were the case*, and unless *the air was constantly renewed*, the spectators would be exposed to the most fatal accidents long before the conclusion of the performance.

To convince ourselves of this truth, nothing more is necessary than to take the example of a room, let it be supposed 30 feet long by 25, and 30 feet high.

A room of these dimensions would contain 100 spectators. Now since each person consumes about 5 cubic feet of air in an hour, that is, deprives such a quantity of air of its *oxygen* or *vital principle*, it would follow, that as such a room could contain only 22,500 cubic feet of air, that unless the air was constantly 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 seriously incom-

in the mouth-piece, would be *sooner heated*, than *that at the base*, and therefore the *rarefaction of air* be more certain, were any given quantity of heat applied to the *smaller* than the *larger portion of air*. It is thus with chimneys, the more they resemble the *French horn*, the more certain the ascent of the smoke, for the *smaller* the *portion of air* at the bottom, the *sooner* will it be heated, and the *BALANCE* at the *lower and upper parts* of the chimney being destroyed, the *lighter air* cannot but ascend and carry with it the smoke.—THE APERTURE at the *bottom* of chimneys should, therefore, be *small*.—Dr. FRANKLIN.

moded,

moded, or even perish, long before the end of that period *.

The same calculation applies to all confined places, where a number of persons are assembled together; especially if the air circulates in them slowly, or with difficulty: *the oftener it is respired the more it will become vitiated*; and it is easy to observe how the attention of the audience fails them in such places. They can no longer listen to the discourse. The irritating quality of the mephitic air excites a general coughing. The preacher now receives none of those marks of attention or respect, which in more favourable circumstances he had a right to expect. They experience a drowsy headache. They express even a physical anxiety to be gone, and the congregation feel themselves on returning home jaded, and till revived by a *more wholesome or oxygenated air* they look wan, like persons 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 supposition of LAVOISIER'S.

† Vide the communication of this physician, as published by Dr. BEDDOES.

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 faſh liſted 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-fix* 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 especially in the bathing-rooms at BATH, where great *faintness* is often brought on the patients who are bathing by breathing a *reduced atmosphere* from the extrication of AZOTIC AIR, which is given out in a considerable quantity by those waters*.

be forced in at the lower opening of the tube, and ascend into the apartment in proportion to the quantity that escaped from the upper region by means of the other tube: and since weighty air would no sooner enter the room than it would tend downwards by its own natural gravity, it would gradually be heated by the warm air in its descent, and would thus be dispersed about the room, so as *mildly* and *imperceptibly* to reach the company, and supply them with a sufficient quantity of fresh and vivifying air, without any of those inconveniencies to which the company are subjected by the usual way of admitting *fresh air*. This simple contrivance might be made as *elegant* as it must be beneficial, and supersede in a great measure the patent stoves, which admit hot and cold air. Vide note p. 17.

* In every hundred weight of MINIMUM OR RED LEAD, there is combined about 12 *pounds* 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 MINIMUM OR RED LEAD should produce 800 *cubic feet of oxygen air*, or about 600 *gallons*. And, since the substances, which contain *oxygen*, or *vital, air*, in immense quantities, are of little value, we have a right to expect, that a perfect, salubrious, *pure air*, may, as chemistry advances, be obtained from such materials by a *cheap* and *easy process*.—Dr. DARWIN.

Dr. BEDDOES, we are informed, has discovered the method of separating *water* into its elementary principles, so as to obtain from thence *oxygen air*. How great an advantage does this discovery promise to the world!

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*,

I. OXYGEN AIR,
and 2. AZOTIC AIR,
will presently consist of 3 *aerial fluids*.

I. 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.

I. 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 quick-silver.

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. 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 physics, 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 PULMONARY VEINS (8), (9), (10), (11), into THE LEFT AURICLE (12), and from thence it passes into THE LEFT VENTRICLE (13), by *which* it is distributed through THE BODY by means of THE AORTA (14), and its branches. *These* 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* separation. *These* 2 parts are formed into 2 cavities by a *lateral* separation.

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 division* of the heart THROUGH THE LUNGS to enter the *left division* of the heart:—and from the *left division* of the heart, the blood passes THROUGH THE VARIOUS PARTS OF THE BODY to enter again the *right division* of the heart.

SECT.

SECT. VI.

THE OFFICE OF THE LUNGS.

Respiration we cannot explain : we only know, says Dr. HUNTER, that it is, *in fact*, essential and necessary to life. Notwithstanding this, when we see all the other parts of the body, and their functions, so well accounted for ; we cannot doubt but that *Respiration* is so likewise. And IF EVER we should be happy enough to find out clearly the object of this function, we shall doubtless, as clearly see, that this organ is as wisely contrived for *an important office*, as we now see the purpose and importance of the heart, and vascular system ; which, till the circulation of the blood was discovered, was wholly concealed from us.

If this learned teacher was to rise from the grave, I believe, no subject would give him higher delight than to see, issuing from the furnaces of the chemist, a new and simple philosophy, which has clearly developed the nature and necessity of respiration.

In the lungs the blood coming into contact with ATMOSPHERIC AIR * works many *chemical* alterations in it.

* Every chemist has learnt, from the discoveries of LAVOISIER, “ that
“ ATMOSPHERIC AIR consists of *two parts*, viz. *oxygen air*, blended with
“ *azotic air*,” which by chemical means may be separated, and confined in dif-

Here it is (in the LUNGS) that the dark blood, throwing off attenuated *charcoal*, forms with the *vital air* of the atmosphere,—FIXED AIR*.

Here it is, that the purple blood parts with its *hydrogen*, which uniting with the *vital air*, forms—the HUMID VAPOUR that issues 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 *spur to action* of the HEART and ARTERIES—the *source* of ANIMAL HEAT—and *the cause* of SENSIBILITY, IRRITABILITY, and MOTION ‡.

ferent jars, and that a mouse, or any other animal, will live a considerable time in the *one*, being lively, brisk, and active; whilst, in the *other*, he soon languishes and dies. *This part* of the air, therefore, as so much contributing to *life*, is with the utmost propriety denominated by physicians, VITAL AIR.

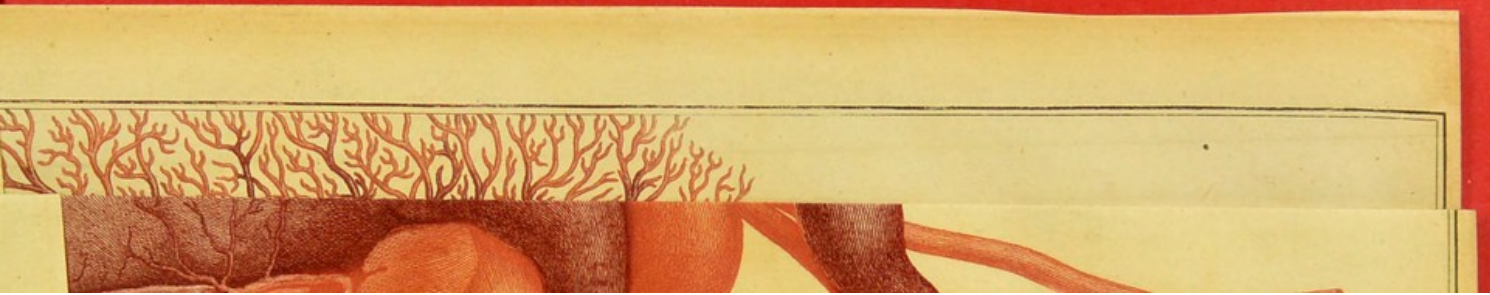
* This is proved by making an expiration through a tube containing LIME WATER, which will become instantly *turbid*.—Or if black blood be confined in a phial containing *vital air*, the whole of *that air* will be converted into FIXED AIR.

† This you may prove by placing venal blood in *vital air*, when the sides of the vessel 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 shewn by BERTHOLET to be nothing more than *hydrogen* combined with *azot*. Vide Part I. p. 39.

‡ Hinc quoque apparet sanguinis *principalitas*, quod PULSUS ex eo ortum ducit. Nec sanguis solum pars primigenia et principalis dicendus est, quod ab eo motus pulsusque principium orietur; sed 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. 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 *sponge* 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 begun 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 af-

* The matter of heat.

fume 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 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*

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animal

animal body those principles which are attractive of OXYGEN, the base of vital air.

The *chemical analysis* of such substances as are to support animal life confirms this opinion; for no substance affords proper nourishment, which contain not principles that readily combine with OXYGEN; and the instantaneous support, and refreshment, perceived by those, who are much exhausted, upon taking into the stomach certain inflammable substances, as diluted spirits*, &c. depend, in Dr. THORNTON'S opinion, on the same principle. *Very different matters*, therefore, will support ANIMAL LIFE, if they contain principles, separable by the animal process, that have an affinity with oxygen.

* A pleasing glow is first perceived in the stomach, which extends itself afterwards over the whole body.

Æther I conceive also acts in this way, rather than from the expansive property of this volatile fluid in the stomach. 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 explosion 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 spoonful of clear WATER. Here the *hydrogen* of the *æther* unites impetuously with the *oxygen* of the pure air, and WATER is formed, and *caloric* disengaged. You have here, en petit, a flash of lightning, thunder, and the thunder-shower.

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 FUNC-
TIONS*.

* The saliva and a juice secreted in the stomach, called in us the *gastric juice*, has a solvent power on *certain substances*. Our aliment is therefore broken down in the stomach into its constituent principles, and these comminuted parts then enter and pass along the capillaries of the intestines, which are incapable of admitting any substance, unless in an highly attenuated or aerial form. Vide the Section, on Muscular Motion.

SECT. VIII.

ON THE BALANCE BETWIXT DIGESTION AND THE
OXYGENATION OF THE BLOOD.

I HANE had, says the celebrated Spanish traveller, the Rev. Mr. TOWNSEND, frequent opportunities of remarking a beautiful balance betwixt RESPIRATION and DIGESTION.

During a putrid fever, which attacked me last summer, it was too evident to escape the observation even of my nurses. When the *stomach* was oppressed, *respiration* laboured; and when the lungs were plentifully supplied with *vital air*, the breathing became easy, and the superabundant quantity of food was no longer a burthen.

I am happy to find my ideas on this subject confirmed not only by Dr. THORNTON, to whom I first practically noticed it, but also by the correspondence between two of the most ingenious medical practitioners and chemists 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 see the reason why men who are oppressed with food *pant*; and why in a close room, where they are confined within the curtains of a bed, where the air is vitiated by passing frequently through their lungs, they open their mouths wide to breathe, and therefore why they *snore*.

I have often had occasion to converse with miners in Cornwall, who had been almost deprived of life by breathing a mephitic air, and have been informed by them, that on reviving they have constantly been seized with *nausea*, and that commonly the stomach has rejected its contents quite *crude* *.

Whenever the imperfect tribe of animals, or such as sleep out the winter, are exposed to a cold so great as, in a great measure, to rob them of their *inbred heat*, their powers of *motion* are proportionably diminished, and as they cannot have, at that season, a very copious generation of caloric, but only enough to keep up the spark of life (their animal oil, which is composed of

* From the Rev. Mr. TOWNSEND'S Guide to Health. Observation V. on *Vital Air*.

principles attractive of oxygen) being sufficient for that purpose, they lose also the power of *digestion**.

At Bellisle, in the beginning of the winter 1761, I conveyed, says 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 substances which I had introduced entire, and without *any the least alteration*.

A hedge-hog, while the heat of the body was at 30 degrees, had neither *desire for food*, nor *power of digesting it*; but when by artificial means it was increased to 93 degrees, the animal seized a toad which happened to be in the room; and upon being offered some bread and milk, it immediately eat it. 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 the principles separated by the stomach:

* Observations on Digestion, by John Hunter.

This accurate experimental philosopher has the *muscular* ANIMAL HEAT, the *digestive*, and the *procreative*, to mark the three intensities; 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 there 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 arose from the decomposition 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 state. The principles of life are then called into action. A gradual extension of the parts commence. During the time of incubation, the living principle every day increases in quantity and power with the perfection of the animal, and the capacity of its organs for performing its functions, and *generating heat*, which last does not happen till the time of its exclusion from the shell: after which, the chick does not de-

pearance of flame outwardly, but only a smoke or mist ascending from his carcass till it was consumed.

GRACE PETT, a fisherman's wife, of the parish of St. Clement's, Ipswich, about sixty, was also consumed by an internal fire. She appeared like a heap of charcoal, covered with white ashes; the legs, arms, and thighs, were very much consumed. However it is remarkable that the deal floor on which she was extended had no appearance of being in the least singed.

These remarkable instances of the *quick combustion* carried on in the body, if I may be allowed to continue the expression, is adduced only as exceptions to Dr. THORNTON's general rule, that within the body there is always carried on a *gentle combustion*, 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

der 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 Economy.

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*.

S E C T. 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 considerable degree of cold, we are surpris'd to find the mercury at a moderate temperature ; and this may be observed usually 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 constant production of heat within the animal, and of its tendency to pass off by the surface*: for the thermometer very soon acquiring the temperature of the air, becomes at once stationary, varying only with the real changes which take place in the atmosphere ; whereas the constant succeſſion of heat, which there is in the living animal, prevents its acquiring the temperature of the air, and it cannot, therefore, like the mercury, deſcend to its temperature, and then become ſtationary ; and as the ſenſe of cold felt by us, muſt conſequently be owing to the conſtant eſcape of heat which is thus promoted, the degree of cold felt muſt obviously be in proportion to the celerity with which the air is enabled to carry off the warm atmosphere around us.

The effects produced by *fanning*, when perſons are very hot, may be underſtood from the principles of the foregoing doctrine : when the ſurface is loaded with heat, and the air which is in immediate contact with it, has
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already taken up so much, that it is either unable to carry off any more, or performs this office so slowly, as to be unequal to the removal of the quantity which is constantly arriving at the surface, the driving away such air by the fan, and permitting other colder air to approach, which not being so loaded, is able to carry off the heat more quickly, the skin must in consequence feel cooled.

Moist air is, likewise, a better conductor of heat than when dry, because *water*, though of the same temperature with air, is well known to carry it off more quickly than air will do.

If, therefore, *these two causes unite*, as is the case in *moist and windy* weather, we may easily understand why the heat from animals should be carried off more quickly, and the animals should experience a greater sense of cold, than when the air is *still and dry*, though the thermometer should, in both cases, stand at the same point.

I. OF THE RETENTION OF HEAT.

It may be remarked, that all animals, when the heat is passing off them in an *inconvenient degree*, endeavour
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to CHECK IT by lessening the surface of their bodies, which is exposed to the surrounding medium ; thus we see why dogs, cats, &c. when lying on the ground, and not in a warm situation, draw their limbs close to them, and endeavour to acquire such a posture of the whole body, as shall bring all the parts as much into contact as possible ; and when in a contrary situation, as exposed to the warm rays of the sun, or near the fire, they stretch out their limbs, and extend their whole surface as much as possible : and we all know, that we ourselves, when naked, or when entering a cold bed, do exactly the same thing ; and in bed we continue such a posture until such a quantity of heat has been accumulated, and confined by the bed-clothes, as to remove all sensation of cold, when, like the before-mentioned animals, we stretch forth our limbs, and acquire our accustomed posture.

The universal custom of the inhabitants of all countries in which the temperature of the atmosphere is below the standard of the heat of the human body, making use of apparel, and this being thicker or thinner in proportion to the respective differences of seasons or climates, is founded on the same principle, “ *to prevent such an escape*

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 so exquisitely tender, as to suffer pain from the contact of whatever has weight, or occasions pressure. The slow conducting powers of this down being evidently owing to its rare texture, it is obvious, that to retain this quality it should remain perfectly dry, as the plumage, when *wet**, will very soon collapse together, and form a body capable of carrying heat off, perhaps, too quickly. To guard against this circumstance, nature has kindly furnished *these aquatic birds* with a peculiar kind of OIL, and has given them the power of occasionally opening the receptacle where it is deposited,

* Mr. HUNTER, having put a *dormouse* in a freezing mixture, could not freeze the whole animal, but only the feet, the hair being so 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, says this great physiologist, that the hair should not a second time be an obstruction to our success. Having, therefore, first made the animal *wet all over*, that its heat might be more expeditiously carried off, it was put into a leaden vessel, and the whole placed in the cold mixture as before. The animal soon gave signs of feeling the cold, by coiling itself into a round form, and repeatedly attempting to make its escape; and the breath and water evaporating from its body being soon frozen, appeared like a hoar-frost on the sides of the vessel, and on its whiskers; but as long as the vigour of life lasted, it seemed to defy the cold. However, from the hair being wet, and thereby rendered a good conductor, there was a much greater consumption of heat than in the first experiment; which hastened on a diminution of the power of producing it. The animal soon became stiff; and upon being thawed, was found quite dead.

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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

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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 volatile 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 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 the 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.

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The matter of heat, or caloric, finds, moreover, other outlets to escape by, besides the surface of the body; as a considerable quantity must, evidently, pass 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 first imagine, “for we know that the heat contained in one breath of air, will, if properly managed, raise Fahrenheit’s thermometer *ten degrees* *.” And provident nature seems to take advantage of this circumstance, when an extraordinary quantity of heat is suddenly excited in those animals, which are but little able to carry off a superabundance: thus *dogs*, which do not sweat, and *sheep*, whose cloathing is so particularly unfavourable to the carrying off an unusual quantity of heat, always open their mouths very wide, that the whole surface of the fauces may be exposed, and move the tongue remarkably quick, to agitate the air in contact with it †.

When heat is accumulated in the system, either by fever, by strong exercise, or by the scorching heat of the sun, nature constantly cries aloud for ACIDS, and a

* Vide Critical Review for January 1782, page 6.

† Vide Rigby’s ingenious Dissertation on *Animal Heat*.

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, obedient to the voice of nature, during the sultry heats of summer, we equally desire our lettuce, oil, and vinegar, and we may remark, that in warm climates, and in summer in the *more temperate regions* of the globe, the acescent and watery fruits abound, but in the autumn *we* have chiefly those which produce oil and sugar*.

* That ACIDS only impart to the system *oxygen*, and not *oxygen air*, and are therefore cooling, is the judicious observation of the celebrated Spanish traveller, the Rev. Mr. TOWNSEND. It is mentioned in the chemical part of this work, in the note †, p. 25; and was suggested, also, some years back, as probable, by Dr. BEDDOES, in his lectures on chemistry at Oxford. A question here then naturally occurs, Why, in these sultry climates, do sugar, spices, rum, &c. so much abound? *Ans.* As excessive heat drains the body, a speedy reparation may sometimes be required, and as the stomach cannot quickly act upon a load, we may therefore have, perhaps for this reason, these highly antiseptic perspirable and nutritious aliments. People who drink at intervals much porter, and live in public houses, in *colder climates*, are commonly observed to be very *fat*.

S E C T. XI.

ON THE CAUSE OF MOTION

IN THE

VITAL, OR INVOLUNTARY, ORGANS.

IT was observed before, that the HEART was the center of motion, distributing and receiving the blood from every part of the body ; or, to use other language, the *arteries* and *veins* resemble distinct trees, whose *branches* inosculate at top, and whose *trunks* are fixed in the heart, as the common basis. The *nervous system* may, in like manner, be compared to a tree, whose root is from the BRAIN, and whose *stem* is confined within the spine *.

From some experiments that have been made on *nerves*, it appears, that they do not shorten their dimen-

* The *brain* and *spinal marrow*, improperly so called, send off small portions of their substance, surrounded by a part of their membranes. *These portions* are called NERVES, of which 10 pair issue from the *brain itself*, and 30 pair from the *spinal marrow* ; and these 80 nerves, divided and subdivided into an almost infinite number of small cords, are distributed to every point of the body. Dr. ADAIR.

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 wisdom 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 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 the 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.

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These moving fibres are also affected by *other* than their *natural stimuli*, which stimuli often appear to have a peculiar determination or action on a particular organ. Thus if *ipecacuanha* be injected into a vein, it excites the stomach, equally as though it had been taken by the mouth; and the same is the effect of *jalap*, or any other purgative, it will be constantly found to ruffle the intestines*. Thus, if *mercury* be oxydated, that is, combined with oxygen, the absorbents † will convey it into the

* A plaister of Arsenic applied to a scald head, has been known to kill suddenly; I have seen convulsions and death from a quicksilver girdle applied to cure the itch. A decoction of tobacco used in washing the head, brought on vomiting, delirium, and convulsions: a poultice of this plant applied to the region of the stomach, produced vomiting, purging, and delirium: white lead applied to cure a scurfy eruption, brought on shortness of breath, vomiting, and fainting. In all these instances the mischief was done by *uninstructed old women*, and equally ignorant and *impudent quacks*; for when such applications are made with *learning* and *judgment*, they are equally safe and effectual. Thus a bitter poultice applied to the belly destroys worms; flannels dipped in hot brandy allay vomiting; and opium applied externally mitigates pain; in one case, however, it produced, from the ignorance of the adviser, convulsions and death. Thus several children have had their agues cured by a waistcoat of bark. At Guadaloupe, a physician, not long ago, by infusing certain remedies into the veins, is said to have cured several persons labouring under inveterate diseases, and the expedient seems to merit the attention of practitioners, especially as we are assured that alarming symptoms from the bite of a viper were removed by injecting the diluted spirit of hartshorn into the blood.—Dr. ADAIR.

† I think I have proved, says the illustrious Dr. HUNTER, that the lymphatic vessels are the absorbing vessels, all over the body; that they are

the blood, and a decomposition taking place, the metal will be *revived*, and the METALLIC BASIS (the learned Dr. GIRTANNER thinks it is solely the *separated oxygen*)

the same as the lacteals; and that these altogether, with the thoracic duct, constitute *one great and general system*, dispersed through the whole body for absorption; that this system *only* does absorb; that it serves to take up, and convey, whatever is *to make, or to be again mixed with the blood*, from the intestinal canal, from the skin, and from all the internal cavities and surfaces whatever. In our times, after schools of anatomy have long flourished in all the civilized nations of Europe, and when, from the number of men who have been employed in such researches, it might have been imagined that discoveries were exhausted, PROVIDENCE has allowed me a greater share of that sort of honour, than at first I could have expected. My discovery of the ABSORBENT SYSTEM gains credit daily, both at home and abroad, to such a degree, that I believe we may now say, that it is almost universally adopted: and, if we mistake not, in a *proper time*, it will be allowed to be the *greatest discovery*, both in *physiology* and in *pathology*, that anatomy has suggested, since the discovery of the circulation of the blood.

Having ventured to throw out, continues Dr. HUNTER, so bold a proposition, that my reputation may not suffer through want of a little reflection upon the subject, I must beg leave to explain my opinion. The discovery of a duct of a gland, an undescribed muscle, an artery, or a concealed vein, all such discoveries certainly are trifling, when compared with the introduction of a *new and general system*, which is interwoven with, and performs a peculiar and important function in, every part of the body; so *important*, indeed, that it was necessary, and accordingly has since been actually found out in brutes, likewise in birds, and in fish. *Such is the discovery* of the ABSORBENT SYSTEM: and every person, who is really an anatomist, or physiologist, will, upon a little reflection, admit what has been here advanced; and, looking over the whole progress of anatomy, he will allow, that since the time of Aristotle to the present day, there have been only *two great discoveries* with regard to the physiology of our bodies; to wit, the CIRCULATION OF THE BLOOD, and the ABSORBENT SYSTEM. Vide Dr. HUNTER's Second Lecture.

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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 *sensitive*; 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. 343.

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 an instant the whole body of the frog was shook by a violent convulsion.

The professor was astonished at the phenomenon, and believing it to be owing to his having wounded the nerve; to assure himself, whether this was really the case, he pricked it with the point of his knife, without any motion being produced: he now touched the nerve with the instrument as at first, and desired a spark to be taken from the machine, on which the contractions were renewed.

The experiment was repeated a third time, but the animal remained motionless; however, as the ivory handle of the dissecting knife was a bad conductor of electricity, he changed it for a metallic one, and re-excited the movements, which he constantly failed in doing whilst using an electric substance.

After having made a great number of experiments with the electrical machine, he resolved next to make trial of atmospheric electricity. To this end he raised a conductor upon the roof of his house, from which he brought an iron wire into his room, and to this attached metal conductors, connected with the nerves of the animals destined to be the subject of his experiments, and to their legs he tied wires, which reached the floor.

Considerable

Considerable movements were observed in the animals, whenever it lightened. These preceded the claps of thunder, and always corresponded with their intensity and repetition; and even when it did not lighten, the movements took place, whenever any thunder cloud passed over his house.

Having next laid bare the nerve leading to the wing of a duck, the scissars of the operator being under it, whenever any of the company present applied a shilling, or a half crown, to the nerve so disposed, the nerve was agitated by a violent movement, which occurred as often as the shilling or half-crown was employed, till the nerve was exhausted 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 disagreeable feel, which it is difficult to describe, 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 contact

tact with the zinc, the person fees immediately a flash of lightning.

After performing this experiment repeatedly, I constantly felt, says Dr. MONRO, the Professor 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 nose into two nostrils, and repeatedly touched it with a crown piece of silver applied to the tongue, I thereby produced the appearance of a flash of lightning, and several drops of blood fell from that nostril. Dr. FOWLER, after making a similar experiment on his ears, observed a similar effect.

The experiment of producing sparks by stroking the back of a cat in frosty weather, readily shews that the electric fluid naturally exists in a very active state in the bodies of some animals. Possibly, says the celebrated Dr. PRIESTLEY, the *light* which is said to proceed from animals, as from wild beasts, when they are in pursuit of their prey in the night, may not only arise, as it has hitherto been supposed to do, from the mere friction of their hairs or bristles, but violent *muscular exertion* may also contribute to it. *This light* may,

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with the electric flashes from their eyes, assist them occasionally to catch their prey; as glow-worms and other insects are provided with a constant electric light for that purpose.

Mr. HARTMAN having neglected to supply his parouquet with water to wash himself, he observed that its feathers, in a state of dryness, 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, just as they would have done if they had received electricity from an excited glass tube.

The following is a very remarkable instance of the existence of this fluid in the human frame, and of the ease with which it is put into action. BRIDONE, in his travels, mentions the story of a lady, who, on combing her hair in frosty weather in the dark, had sometimes observed sparks of fire to issue from it; this made him think of attempting to collect the electrical fire from the hair, without the assistance of any other electrical apparatus. To this end he desired a young lady to stand on wax, and comb her sister'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.

Monf. CAVALLLO 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 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, whose stroke or shock proved *instant death* to any person who had the misfortune to touch it.

MONS. FERMINS, in his Natural History of *Surinam*, published in 1765, also tells us, that making 14 persons grasp each other by the hands, while he grasped the hand of the last with one of his, and with the other touched the GYMNOTUS with a stick, the whole number felt the shock, and he could not prevail on any of them to repeat the experiment *.

DR. PRIESTLEY relates, that the sensation is strongest when the fish is in motion, and is transmitted to a great distance, so that if persons in a ship happen to dip their fingers or feet in the sea, when the fish is swimming at the distance of 15 feet from them, they are effected by the shock.

MR. WALSE gives us the following beautiful experiment, to prove that the *gymnotus* is very sensible whether the substances brought near him are proper or not for receiving the electric shock.

The ends of two wires were put into the water of the

* VANDELOTT makes two species of the *electric eel*, the black and reddish; though he acknowledges that, excepting the difference of colour and degree of strength, they are not materially different.

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
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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*.

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* 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 Monsr. VALLI observes, also, that the size and number of the nerves, which are bestowed upon the *electrical organs* of the torpedo and gymnotus are truly extraordinary and astonishing.

The nerves of the *muscles* in animals are likewise very large, and their minute ramifications so great, that several physiologists have been led to believe that muscular contractile fibres are the same thing as nervous fibrils.

The blood-vessels of the *electrical organs* are very numerous, follow the course of the nerves, and distribute the smaller branches along with them.

The quantity of vessels expended upon the *muscles* is also prodigious, and they likewise are found to accompany the course and distribution of the nerves.

There exists in *muscles* as well as in the *electrical organs* of the torpedo and gymnotus, cylinders, partitions, and a great subdivision of parts.

Have we not therefore every reason to believe that our *muscles* are so many *electrical organs*, each muscle being as it were a battery, and muscular intumescence and contraction, in consequence of a sort of explosion

NERVES, that great principle, thus exalted, would be directed into the *muscles*, and force them to act, in the same 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.

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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. 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 un-nerved*.

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 muscles of a dislocated shoulder bone are, from losing their antagonist power, in a constant state of spasm or action *.

They are also kept in a proper state of *tension* by ligaments, by tendinous bands, by the natural weight of depending parts; and lastly, by the fulness of the blood vessels which traverse the muscular fibres.

The *effects* of the *vascular system* on *muscular parts* have not as yet been properly scrutinized. If we consider the numerous vessels that every where spread themselves on muscular fibres, and, as they are more or less replete with blood, must give them a greater or less degree of *tension*, it can scarcely be doubted but that they must have some effect this way: which observation will appear more striking if we observe the peculiar manner of the distribution of the trunks of blood vessels, which are seen running parallel to the muscular fibres, and all their branches entering them at right angles. Hence, if

* This proves that in *muscular fibres* such a contractile power always *during life* exists. Thus a plant stands erect, and all its leaves are beautifully disposed around it. Only transplant this flower, how will it droop; but as *fresh life* is poured into it, it then reassumes its erect position. This *perpetual action* in the moving fibres arises, therefore, from their *vis vitæ*, or *living powers*; or, as physiologists darkly express it, on their *vis insita*. The sphincters, or circular muscles, confining the contents of certain parts, have no antagonist powers, and therefore are in a constant state of action from their *vis insita*, which alone is overcome by distention.

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 their *tone* or *tension**, and are therefore properly called *tonics*; and upon the same ground may be called, also, *corroborants*, or *strengtheners*.

The most obvious operation of bark, and other tonics, is, that being taken into the stomach, they increase the appetite for food, and promote the digestion of it. But we are led to believe, that these functions depend in a great measure on the *tone* of the muscular fibres of the stomach; and therefore may suppose, that the improvements of these functions depends upon an increase of *tone* of those fibres. And farther, as the loss of appetite and indigestion are supposed to occur from a loss of *tone* in the stomach; so bitters, as they are often effectual in curing these disorders, may be presumed to do it by restoring *tone* to this organ. There is then hardly any doubt but that astringent remedies are powerful *tonics* with respect to the stomach; and there is as little doubt, that the state of the stomach is as commonly communicated to the other parts of the system: so it is sufficiently probable, that by an improvement of digestion, the vigour of the system may be in general amended; and that with the *tone*, the activity of the whole *moving fibres* may be increased. That the tonic power of astringent

* Or *spring*. Vide note *, page 130.

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 physicians believe that the TONE of the fibres depends not so much on a due tension, as on the *oxygen* imparted to them from the *arterial blood*.

It is not from the sleek countenance, not from the plump habit, as indicating *distended vessels*, that we are to form our judgment of strength, for HYPOCRATES has well observed, “*otium humectat et corpus reddit debile; labor ficit et corpus robustum efficit.*” To see, therefore, vigour in perfection, we must look at the hardy and laborious rustic, whose turgid muscles, as in the statue of the Farnesian HERCULES, can be readily distinguished through the skin.

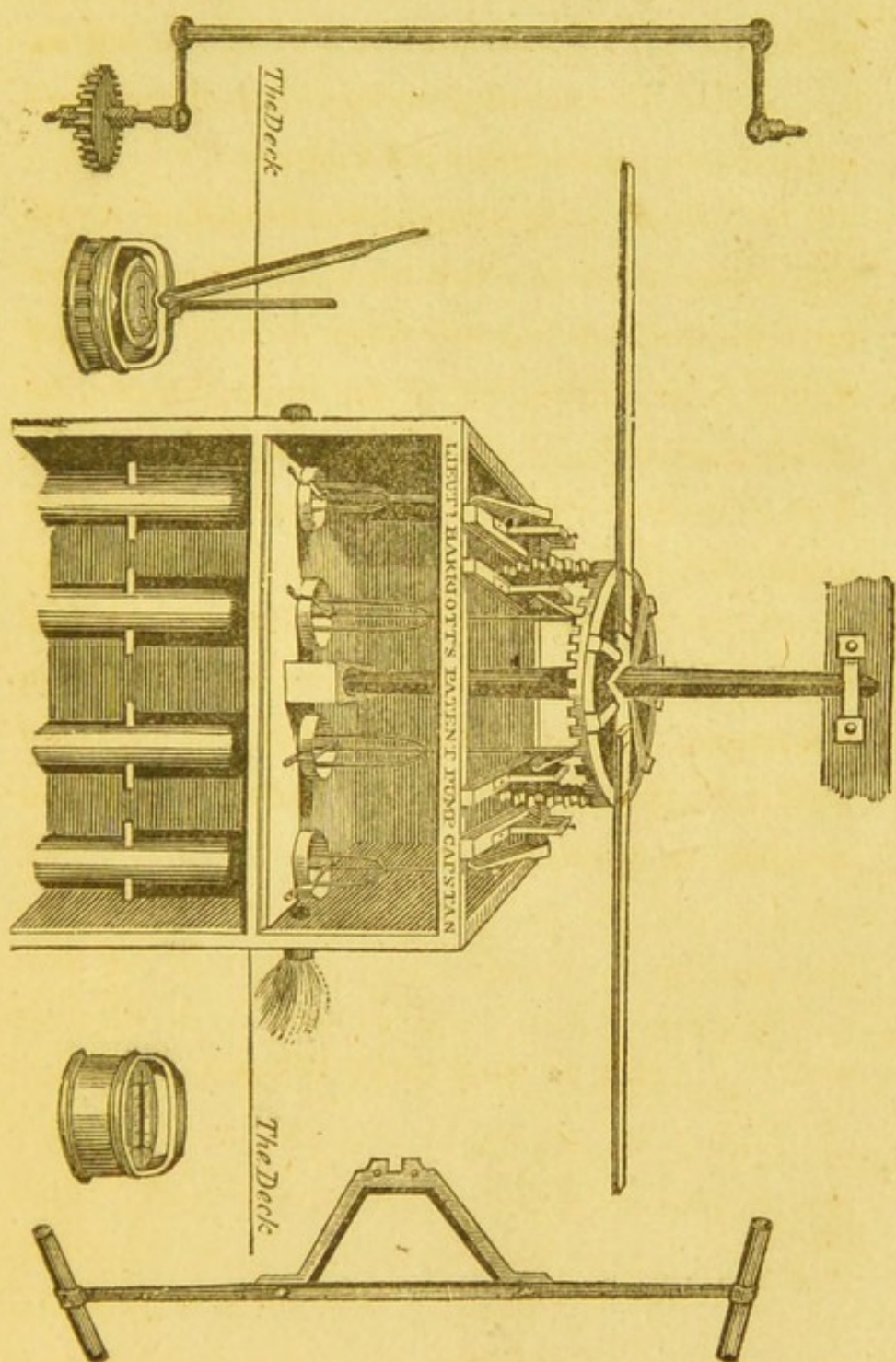
In fattening poultry we feed them to the full, but we endeavour to keep them perfectly at rest. In consequence of this treatment the vessels are *distended*, but the fibres are relaxed, tender, and weak, in their cohesion. To fatten our ducks, we not only confine them in a place of small dimensions, but keep them from the water, because we observe that their cold bath and exercise render the skin and all their fibres tough.

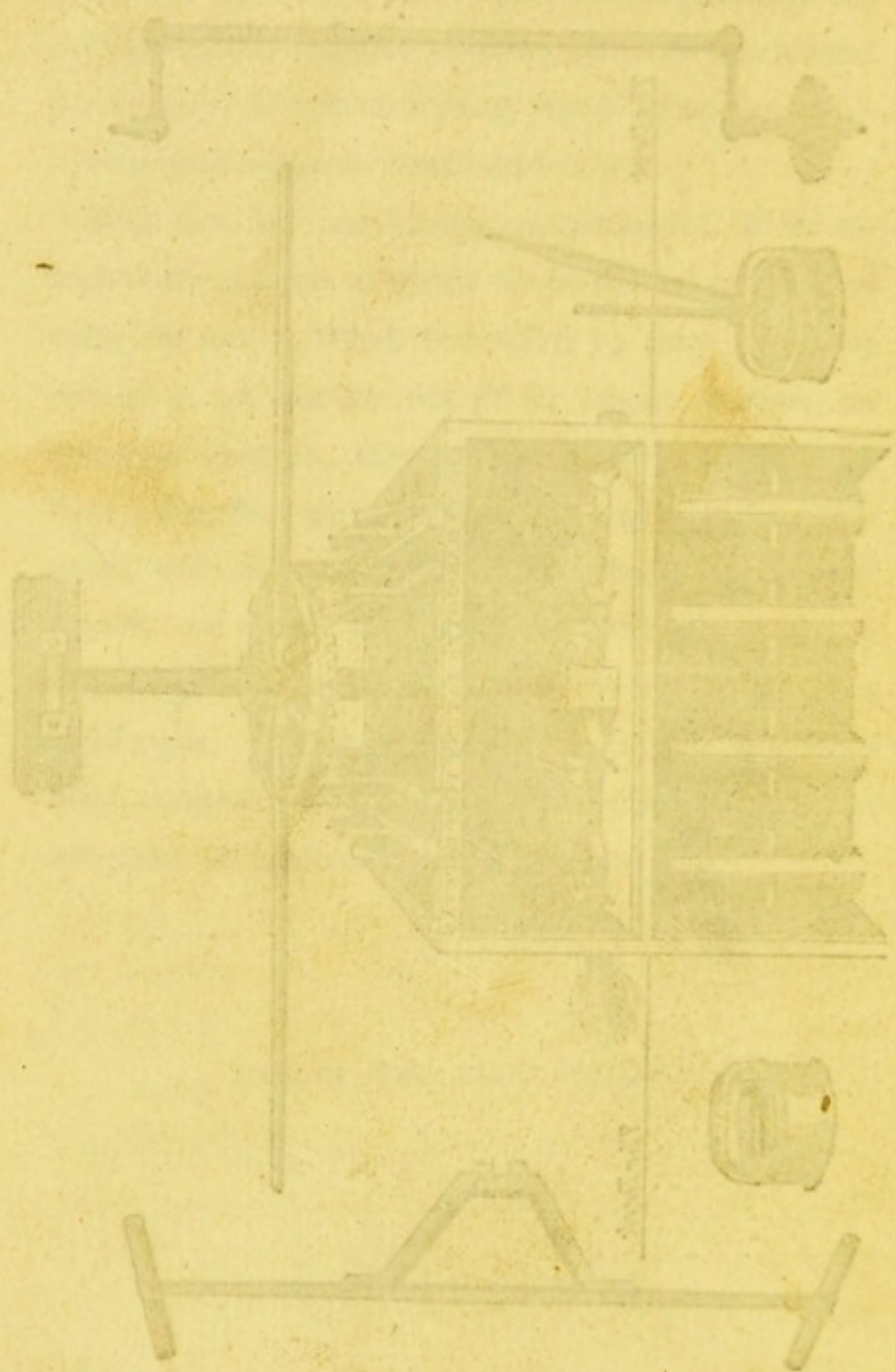
It may be received as an axiom, says the learned author of the Guide to Health, “*that the living power or energy of an organ is in proportion to the quantity of oxygenated blood that circulates through it.*” For it is not

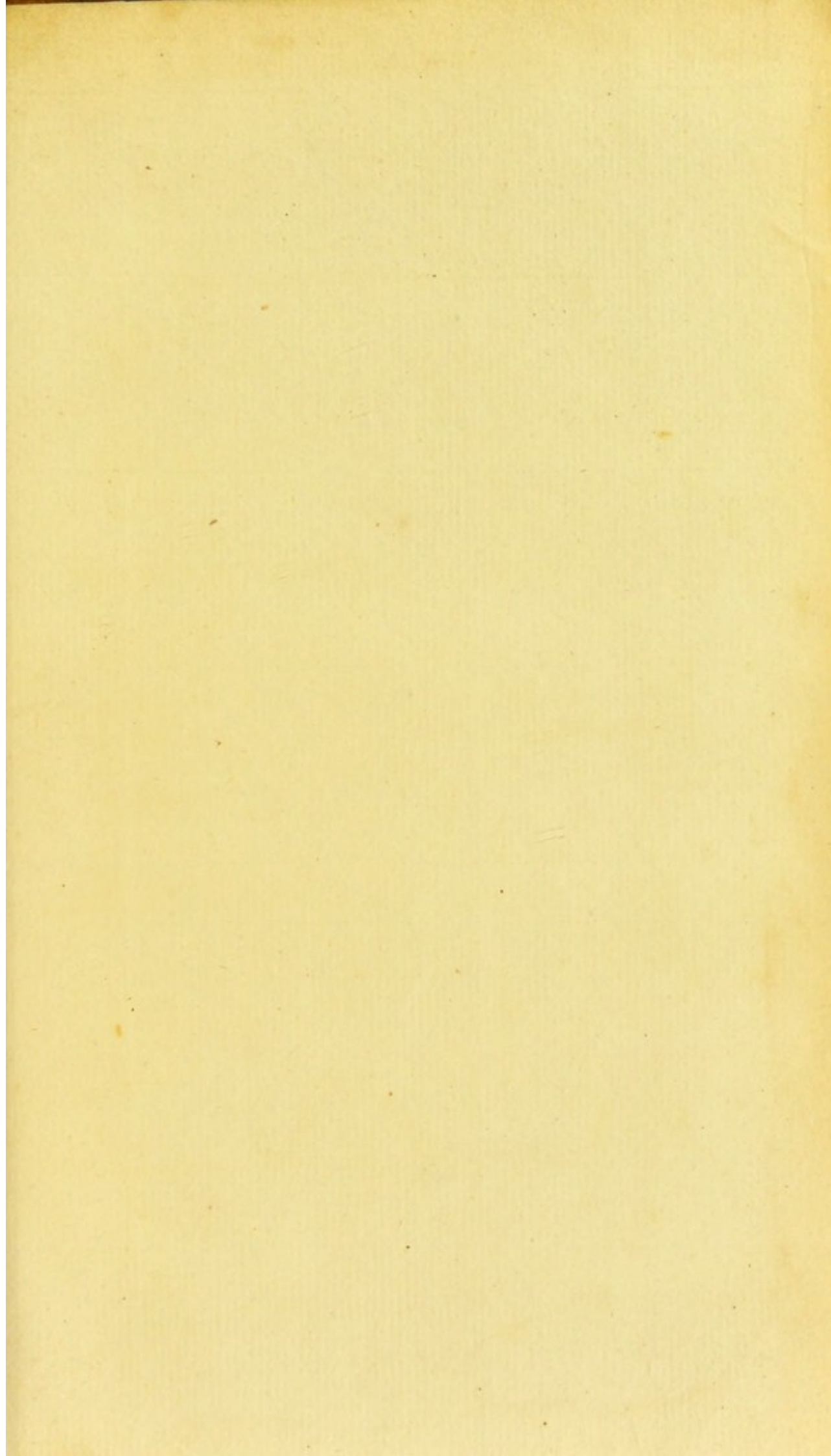
merely the quantity of fluids feebly creeping through the vessels, nor fat stagnant in every part of the system, but the quick succession and strong impulse of well oxygenated blood that produces TONE and VIGOUR.

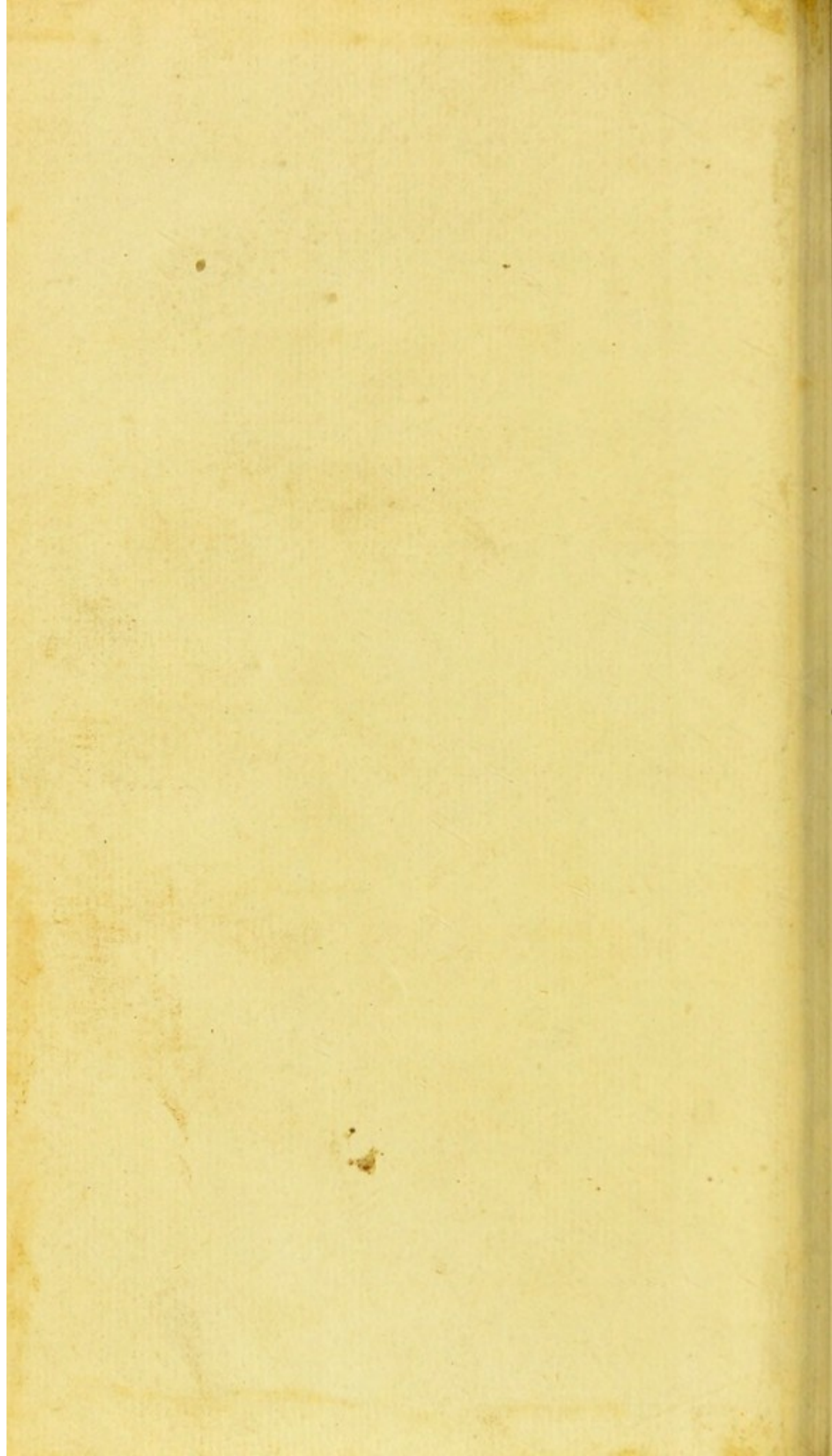
This may be more clearly comprehended, if we attend to the manner in which horses are fed and worked upon the road. When first taken up from grass they abound in fat, but are not fit for labour, because, on moderate exertion, they are bathed in sweat, and are soon exhausted with fatigue. If, when taken 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.









164

