afforded in large quantities by vegetables. We have before remarked upon the double office vegetables perform:- first, absorbing atmospheric mephitis, and deriving their nourishment and growth from it; secondly, emitting oxygene to administer to the wants of the animal world. In order to obtain oxygene from them, you ~~[illegible]~~ have only to take the green leaves of any plant, put them in a vessel filled with water, invert the vessel into another vessel with water in it, set it in the light of the sun; soon the bubbles of oxygene will rise to the top of the vessel containing the vegetable. It is the green part of the plant, that afford this gas most readily, & in the greatest quantity. Pine & cedar leaves, evergreens in general, are those from which it is most readily obtained. The flowers of plants, it is to be observed, emit a noxious air: they are therefore not proper to be kept in bed rooms.

Oxigene exhibits different characters or properties according to the state of purity in which it is obtained. The following are the most general properties it possesses. I. It is heavier than atmospheric air: a cubic foot of it weighs 766 grs.

and a cubic foot of the latter weighs 720 grs according to Kirwan, the weight of oxigene is to that of atmospheric air, as 1103 : 1000. —

II. Oxigene is the only air proper to Combustion. We have already made remarks in more places than one, upon this subject. Yet it is in its nature so enticing & curious, that we may be justified in making some particular observations upon it here, even tho' we should, in so doing, be justly chargeable with tautology. Our observations may be reduced to four general principles: First, Combustion never takes place without oxygene: Secondly, In every combustion there is an absorption of oxigene: Thirdly, there is an augmentation of weight in the products of combustion equal to the weight of oxigene absorbed: Fourthly, in all combustion there is a disengagement of heat & light.

1. The first of these ~~questions~~ principles cannot now be questioned. The proofs of it have been anticipated. The most inflammable substances in nature, Phosphorus, hydrogene will not burn, we have already said, without the presence of oxigene.

2. That oxigene is absorbed in every combustion

is a truth no less certain and general. Sulphur confined in oxygene, set on fire by a sun glass, will absorb every particle of the gass: if burned in an atmosphere composed of many gases, the oxygene will be the only one affected. The rancidifying of oils, is (according to Chaptal) a species of slow combustion. They, in becoming rancid, absorb oxygene. In order to purify ym the oxygene, they have contracted, must be extracted. In order to extract it from them you have only to agitate charcoal in them, which has a great affinity for it. Thus rancid butter, putrid water, & stinking meat, which have become so from no other cause than from their combination with oxygene, may be restored to their former sweetness by agitating charcoal in them. — 3. We have already mentioned a fact which leaves not a doubt behind, that in the products of combustion there is an augmentation of weight; & that this augmentation of weight is precisely equal to the diminution in the weight of the air in which the process of combustion is carried on. We have mentioned

that in the calcination, or rather in the oxidation of metals, this phenomenon took place. The oxyd to become such, must have absorbed oxygene: oxygene is matter, & matter cannot be annihilated: it must, therefore, add its own weight to that of the matter it oxygenates.

4. In every combustion the oxygene combining with the body burning, it abandons its caloric: the caloric is disengaged, and produces immediately sensible heat & light, because it endeavours to combine with the neighbouring substances. The combination of oxygene is constantly attended with the production of heat by the disengagement of caloric. Whence we may infer, that oxygene is eminently possessed of caloric; that the greater & more rapid the absorption of the oxygene the greater the heat produced; that to produce heat the most violent, combustion must be carried on in oxygene; that the condensation of air renders most intense Fire & Heat; and that currents of air are necessary to maintain, & expedite combustion.

III. Oxygene is the only gass proper for respiration. It is this property that has entitled it to the honourable denomination of vital air. In every respiration the animal takes in a quantity of atmospheric air, rejects the nitrogene part of it, and absorbs the oxygene. See Page 167 — No animal can live without the assistance of this air: But all do not require it should be in the same purity: Birds man & most quadrupeds require it in a purer state, than reptiles. The manner of respiration varies in different animals. Amphibious animals respire by means of lungs; yet some of them, frogs for instance, have the power of suspending the functions of these respiratory organs. Fish come from time to time, to the surface of the water, to inhale air; which they retain in a vesicle and digest at pleasure. Insects inhale air by means of trachea, placed along their sides like those of vegetables, which they resemble in many points — Count Morozzo placed successively many full grown sparrows under a glass bell, which was filled first with atmospheric air, & then with oxygene. The experiment gave rise to the following

In atmospheric air,

	h. m.
The 1. sparrow lived	3. 0
2nd	0. 3
3d	0. 1

In Oxygene,

	H. M.
The first sparrow lived	5. 23
2d	2. 10
3rd	1. 30
4th	1. 10
5th	0. 30
6th	0. 47
7th	0. 27
8th	0. 30
9th	0. 22
10th	0. 21.

results:— 1 That animals "live longer in oxygene, "than atmospheric air. "2d That one animal "can live in air in "which another has "died. 3d That inde"pendent of the nature "of the air, respect must "be had to constitution "of the animals, as the "6th lived 47m & the 5th "only 30m — 4th That "there was either an "absorption of air, of a production of a new kind "of air, which is absorbed by the water and vitiq."—

We shall now make a few remarks upon the effects of respiration upon the air, & upon blood.

I — The air emitted by respiration is a mixture of nitrogene gass, carbonic acid, and vital air. If the mixture pass thro lime water [illegible], it will redden it. It will precipitate the lime in lime water. The air in which 5 sparrows have vitiated contains 17 hundredth parts of oxigene. Frugivorous animals vitiate air, it is said less than carnivorous ones.

II. – Air brings the blood of some animals to a vermillion colour. The arterial blood which is distributed from the lungs to the other parts of the body is possessed of a brighter colour than the venous blood, which is blackish. – That the effect is produced by the air absorbed by the lungs, is clear from the following experim.t of Beccaria: he put blood under a receiver of the air pump; exhausted the air out of it: the blood became blackish; the air was let in again; & the blood recovered its former hue. – The lungs are a real focus of heat in the animal body. They absorb the oxigene of the atmosphere. They distribute its caloric to the remoter parts of our frame. Those who breathed oxigene know that they feel a kindly vivifying warmth running thro' them. There is a difference in the heat of different animals, & of the same animals at different times. Those animals that have the largest lungs in proportion to their size, have the greatest portion of animal heat. –

In the winter the air is more dense: the animal, therefore, absorbs more atmospheric air: consequently more oxigene; consequently more Caloric: animal heat, therefore, according to the wise dispensations of heaven, is greater in winter, than in summer. — From a comparison of what has been said concerning combustion, and concerning respiration, a very great similarity will be observed between the phenomena they present.

Oxigene Gass has been used as a remedy in certain complaints of the human body; especially those of the lungs. It enlivens the Patient. But it must, I apprehend, be a dangerous remedy. It must be productive of some inflammation. Ardent liquors when properly diluted may be salutary: when they are not so diluted they are the worst of poisons; they are slow in their operation, but sure in their effects. In the same manner, it appears, ought oxigene to be diluted with nitrogene gass, in order that we may enjoy the health it holds out to us, and avoid the evils and improper use of it, w.d occasion. – Chaptal, after relating a case of the phthisis, in which oxigene had been used

Concludes: — "I am very far from being of
"opinion that the respiration of vital ought to
"be considered as a specific in cases of this nature
"I am even in doubt, whether this powerful air
"is perfectly adapted to such circumstances; but
"it inspires chearfulness, renders the patient happy,
"and in desperate cases it is certainly a precious
"remedy, which can spread flowers on the
"borders of the tomb, & prepare us in the gentlest
"manner for the last dreadful effort of nature."

Part. III. of Azotic, or Nitrogene Gass. —

Air, which has once served the purposes of res-
=piration, or combustion, is no longer fit for ei-
=ther of those purposes. Such air has been termed
phlogisticated air, Mephitical air, atmos-
=pherical mephitis &c. Lavoisier called it
azotic (a word derived from the greek word signi-
=fying its property of destroying life) Gass. Yet as
it is not the only air destructive of life, it has
been rejected by Chaptal, who has substituted
another name in its stead, viz — Nitrogene gass
because it is the radical constituent principle of

Nitric acid. — Altho the atmosphere is com-
=posed of this gass, & oxigene; & altho' in respira-
=tion & combustion oxigene is absorbed; yet these
processes do not absorb all the oxigene; & the resi-
=due of the atmosphere, after it has served these
purposes, is allways mixed with a portion of
oxigene: it has also a portion of carbonic acid
it is not, therefore, pure oxigene. — There are
however, several methods by which it may
be obtained. We shall only mention that
of the celebrated Scheele. — Expose liver of
Sulphur in a vessel filled with atmospheric
air: the lime of Sulphur will absorb the oxi-
=gene: the residue will be pure Nitrogene.

We shall now enumerate its principle properties
I. This gass is improper for respiration and
combustion. — II. Plants live in this air &
vegetate freely in it. — III. It is lighter than
atmospheric air: it is to atmospheric air, as 985
: 1000. — IV. This gass mixes with other airs without
combining with them. — V. Mixed with oxigene
in the proportion of 72 to 28, it constitutes our
atmosphere.

Lect. IV.th In three Parts

Part I. Of nitrous air. — The method by which Dr. M. obtained this gass was the following: — he put into a glass bottle a certain portion of iron filings: upon these he poured nitric acid (commonly called aqua fortis) diluted with water: he fixed in the mouth of the glass bottle, a crooked tube, which he immersed under water: quickly bubbles of air were seen to rise, as is usual in processes of this sort; and they were collected in the ordinary mode in phials and bottles. We shall, by and bye explain the rationale of this process. — Having mentioned the acids frequently in a few preceding Lectures, we shall take this opportunity to make a few remarks respecting them; — what they are; & how they are formed. — Every substance which produces on the tongue a sharp keen sensation, usually termed sour*; which turns the syrup of violets red; & which effervesces when mixed

with an alkali, is an acid. Acids are formed by the combination of oxygene with any elementary substance. This elementary substance is called the base of an acid; and the difference in their bases constitutes the difference in the acids. They take their denomination from their bases: thus, the combination of oxygen with nitre, forms, nitric acid; of oxygen with sulphur, Sulphuric acid; of oxygen with sea-salt, muriatic acid, &c. All acids may be decomposed. Some however may be decomposed more readily & easily than others. Those which part most readily with their oxygene, are in a state of weaker combination & are most easily decomposed. The nitric acid is of this sort. Hence its speedy and powerful effect upon metals. The oxygene it

* It may not be improper to mention here; the difference between the terms "sour" & "acid". — "Sour" is employed to express lower degrees of acidity, "acid," to express higher degrees. The juice of lemon is "sour"; aqua fortis (or nitric acid) is "acid." &c. &c.

containing has an affinity for the metal; and the acid, without reluctance, indulges that affinity. the oxygen then immediately dissolves the metal.

We shall now enumerate the properties of nitrous Gass.— 1 It is invisible, & not miscible with water 2. It is somewhat lighter than atmospheric air. 3 It is unfit for respiration, combustion or vegetation 4. It is not acid according to some experiments. 5 It combines with oxygen, & reproduces nitric acid.—

We shall mention a few remarks on each of these properties.— 1 That is invisible, we need be at no pains to prove to any person, who has seen the phials in which it is contained: they look as if they were perfectly empty.— That it is not miscible with water is evident from hence; that if a quantity of it be let into a phial together with water, & be agitated with violence the water will have acquired no nitrous taste.—

2. That it is lighter than atmospheric air may be proved by weighing it, & by opening a phial of it in the atmosphere; when all the phial contained will soon have vanished, which would not

happen, were not the nitrous air lighter than ye atmospheric. 3. That this air is unfit for combustion, & respiration, will be acknowledged if it can be shewn to be unfit for either of them. Now if you plunge a lighted taper into it, the taper will immediately be extinguished. The reason of this is, that it does not contain a sufficient quantity of oxygen. How it is proved not to be proper for vegetation, I have not heard. 4. According to some experiments it is not an acid: For example, it does not change the colour of syrup of violets. We shall presently see that it does not contain so much oxygen, (which is the true acidifying principle) & therefore has not so good a title to the name of acid, as atmospheric air.

5th That it combines with oxygen, & reproduces nitric air, may be thus proven: mix a certain quantity of oxygen with it; agitate them in water, the water will have a real sub acid taste; as if it had been sparingly tinged with Nitre.—

When it is mixed with common air, the following remarkable phenomena are observable: a diminution in the volume immediately takes place: a red Colour is immediately produced. If it be mixed with oxygen, the diminution will be greater; the red

Colour will be deeper: if with impure air a contrary effect will ensue: and if the air be perfectly impure no diminution at all will take place; no shade of the red colour will be observed. Upon these principles is founded the Eudiometer. The name of this instrument explains its nature. It is derived from three greek words which signify "a measure of the goodness of the air."* We are able to give an imperfect idea of this instrument. Let a tube containing atmospheric air as low as a certain point be below filled with water and immersed in the same. then let in a certain quantity of nitrous gass; which will expel the water and occupy its space: but as soon as a combination takes place between the gasses the water will rise. the red colour will be observed; and according as the rise of the water is greater or less. as the shade of the colour is lighter or deeper will be the purity of the atmosphere, in which the experiment is made.-
But what is the nature of Nitrous gass?-

* i.e. ευ, well. Διος, Jupiter, μετρον, measure. Leighs.

It was first thought to be nitric acid saturated with phlogiston.- But as the doctrine of phlogiston is now entirely exploded we need make no farther remarks upon this idea.- From an experiment of Mr. Cavendish, it may be presumed, that "the acid is a combination of 7 parts of oxygene "& 3 of nitrogene: (with nitre I apprehend)".- "These proportions constitute the ordinary nitric "acid; but when a portion of its oxygene is taken "away, it passes into a state of nitrous gass; "so that nitrous gass is a combination of ni"trogene gass, with a small quantity of oxygene "If this proposition be true, a combination "of nitrogene and oxygene will produce nitrous "gass, and a decomposition of nitrous gass will "yield nitrogene and oxygene. These experiments may easily be made.
From this account of the nature of nitrous gass the rationale of the method by which we obtained it, may be easily understood. as soon as the nitric acid was poured upon the iron filings, a part of its oxygene combined

with them: a small part of the oxygene escaped with the nitrogene of the acid, and yielded the nitrous gass.—

Nitrous acid consists of three constituents principles,— nitrous gass— oxygenous gass— and water, mixed in the following proportion: of nitrous gass P. 17 grs 51¼; of oxygene P. 1 3/8 grs 7½; of water 13 grs in the 2d

Part II.— Of the carbonic acid.—

In the common temperature of the earth this acid is allmost allways found in a state of gass. It was not unknown to the ancients. Van Helmont called it, gass sylvestre becaus it may be extracted from wood. Becher seems to have had some idea of this gass— Venel discovered that the properties of certain mineral waters, arose from a superabundant portion of air possessed by them. Dr Priestly made many interesting discoveries respecting this acid, which he distinguished by the name of fixed air. It has been called mephitic acid, aerial

acid, &c. But having been discovered to be no more than a combination of oxygene with carbone, or pure charcoal the new nomenclature has distinguished it by the name of carbonic acid.

This acid exists in three states.— 1. That of gass.— 2. In that of mixture.— 3. In that of combination. 1.st It is found in a "state of gass in the grotto del Cane, near "Naples; at the well of perols near Mont-"pelier; in that of Vegras in Vivarais; upon "the surface of lake Averno in Italy and "on those of several springs; in various sub-"terraneous places, such as tombs, cellars, re-"ceptacles &c." 2. Certain mineral waters, such as the sweet springs in Virga; contain it in a state of simple mixture. 3. It is found in a state of combination in stone, magnesia chalk &c. It may be collected or extracted by several different processes, which I proceed to mention—

1. When the carbonic acid exists in a state

of gas, it may be collected. - 1 by filling a bottle with water, which empty in an atmosphere thereof. - 2 by exposing lime water, caustic alkalis, or even pure water, in its atmosphere: the acid mixes with the substances from which it may afterwards be extracted by means of re-agents. -

3. When the carbonic acid exists in a state of simple mixture, it may be extracted in three different ways. - 1° By agitation of the liquid "which contains it. as Mr. Venel practised, by "making use of a bottle to which he adapted "a moistened bladder. - 2 By distillation of "the same fluid. - These two first methods are "not accurate. - 3. The process indicated by Mr. "Giovanetti, consists in precipitating the carbo: "nic acid by means of lime-water, weighing "the precipitate, and deducting thirteen thirty seconds "parts for the proportion of carbonic acid; it "having been deduced from analysis, by this "celebrated physician, that thirty two parts of

"carbonate of lime contain 17 lime, - 2 water, & 13 acid. - -

3. "When the carbonic acid exists in a state of combination, it may be extracted. - 1. By distillation with a strong heat. - 2. By the re-action of other acids, such as the sulphuric acid, which has the advantage of not being volatile, and consequently is not altered by its mixture with the carbonic acid, which is disengaged. - We have said, that this substance can now be had in the common temperature of the earth, in any other state than that of gas. Why then is it called an acid? - because it has all the characters of one. If the syrup of violets be agitated in a bottle of this acid (or gas, if you please) the colour of it will become red: if you agitate water in a bottle of it, the water will acquire a taste strongly sub acid: it will neutralize and christallize alkalis.

We shall now enumerate the properties of this acid. I. It is unfit for respiration. Fibrins caused two slaves to descend into grotto del Cane: they expired. Peter de Toledo shut in there, two criminals they also expired. The birds cannot fly over the lake of avernus without death. It was with great judgement, that Virgil made this place the entrance into hell. Bergman thinks that this air destroys the animal by extinguishing irritability. The Chevalier Landriani joins in this opinion. The abbe Fontana & count Morozzo controvert the former. Chaptal inclines to the latter.

II. The carbonic acid is unfit for respiration. Dr Priestly kept the roots of several different plants in water impregnated with this acid: the consequence was that they all perished; which experiment is incontrovertible & conclusive.—

III. This acid is easily soluble in water. We may impregnate water with it. The sweet

Springs owe their properties to this acid, tho' they are ridiculously called "sweet." We can imitate the waters of these springs, by agitating carbonic acid in common water. The reason that these springs are salutary, is that they contain this acid; which, tho' destructive when taken into the lungs, has been found highly conducive to health, when taken in the Stomach. Beer, ale, porter, & all fermented liquors contain it: hence their wholesomeness.

IV. This acid is heavier than atmospheric air. According to Kirwan the proportion between them is as 45.69 : 68.74. This superiority of weight causes it to occupy the lowest situations; It may even be poured from one bottle to another so as to displace atmospheric air. This curious Phenomenon was remarked by Mr. de Sauvages.

What is the nature of this carbonic acid? It is a Combination (as we have before said) of pure

Charcoal, or carbone, with oxygen. To prove
this let carbone be burned in pure air, or
oxigene; the result will be carbonic acid.
The proportion which carbonic acid contains
is 12.0288 of carbone to 56.687 of oxigene.
Dr Black of Edinburgh discovered that
lime stone is indebted for its solidity to this
acid: take this acid from limestone, it be-
comes lime immediately: restore this acid,
it becomes stone again.

Part III. Of the analysis of atmospheric air, and its division into two elastic fluids, oxigene, and Nitrogene.—

In our enquiries into the constituent princi-
ples of bodies the surest Road to arrive at
truth, is the use of the two logical methods
of reasoning, that of synthesis & that of
analysis. By the first, we compound prin-
ciples together, & see what they produce: by
the second, we reduce the compound substance
into its principles, and examine them. In
this way, the two methods serve as proofs of

each other. Both these methods have been
employed by Mr Lavoisier, in determining
the nature & constituent principles of the
atmosphere.— He caused mercury to be oxi-
genated in atmospheric air: the mercury
(oxide) was heavier than before: the air wh
had supplied the process was lighter: the latter
had lost, exactly what the former had
gained. When the remaining air was examined
it was found to be Nitrogene: it was constantly
preserved. The air which the oxigenated Mer-
cury had imbibed was exhausted: that air
was found to be oxigene. This oxigene was
added to the nitrogene before mentioned:
atmospheric air was reproduced; & their
weight was restored to what it was before
the process had been carried on on it.—
Here is both the analytic & synthetic me-
thods:— the air is first resolved into oxigene
and nitrogene, gases: these are then
added together & atmospheric air is reproduced.

In the preceding Lecture upon the carbonic acid, I omitted to mention the usual test of its presence: which therefore I here subjoin. That test is founded upon this circumstance, that the carbonic acid precipitates Lime in Lime water. Whenever, therefore, you suspect the presence of this acid cause the atmosphere in wh. it is contained, to pass thro' lime water, the lime will be precipitated, if the carbonic acid be really in that atmosphere.

Sect. 25th In two Parts.

Part I. – Of Winds. – A Wind is nothing more than the motion of the air upon the surface of the Earth. Winds may be divided into three classes – Viz – 1st the perpetual, 2d the periodical, & 3d the casual winds: the perpetual winds are those, which blow continually from one point of the compass: such

as the wind which blows invariably from East to West, at the Equator: the periodical winds are those which blow in certain directions at certain seasons of the year; such as the monsoons, which blow half the year to the North, & the other half to the South, point: – the casual winds are those, which blow first in one direction, then in another, according to circumstances such as the winds, which blow upon ye coast of very warm countries, the atmosphere of which is, in the day, much rarefied by the reflection of the intense heat of the sun from the Land. –

Various opinions have been entertained as to the cause of winds. Some of the ancients supposed them to be air issuing from caves, & subterranean places in the Earth; some that they were exhalations from the Earth. Some of the modern philosophers, who have embraced the Cartesian Doctrine of a plenum, imagine that when the air is much heated, the atmosphere not being able to rise higher than a certain point;

one part of it, being less elastic gave way to the more heated, and of course more elastic parts. It has been imagined that the perpetual wind which at the Equator blows from East to West, was owing to the daily rotation of the Earth from West to East, whence the atmosphere being left behind appeared to move in a contrary direction, from East to West. This idea is incorrect to the minds of others. because there are many casual winds near the Equator; and because the atmosphere, pressing upon the Earth, would if nothing prevented acquire its motion. The most probable & Philosophical theory of the cause of winds is that of Dr Halley. It is now generally admitted; and from its simplicity may be easily explained. It frequently happens that one part of the atmosphere is more heated, & of course more rarefied, than another. That part, being lighter than the surrounding parts, naturally rises higher from the Earth. It leaves

therefore a vacant space. But as all fluids are subject to the law of equilibrium, and as air is a fluid; the neighbouring air rushes to restore the equilibrium, to fill the vacant space, which the rarefaction, & consequent rise of any portion of air, endeavours to create. Upon this theory we may rationally account for many phenomena relative to winds. There is at the Equator, a perpetual wind, which blows invariably from East to West. This wind is accounted for upon Dr H's theory. The earth moves from West to East. It presents different points of its atmosphere, to the vertical rays of the sun. Those rays rarefy ye air; and the air rushes from the East to restore the equilibrium: hence the easterly wind that blows. But a difficulty has been started upon this point; it has been asked, why does not the western air rush on to restore the equilibrium, as readily as the Eastern? The answer is, that as the air

Earth, revolving on its axis, presents to the sun, new points, still more west, than those he has just rarefied. he rarefies the western air as soon as it attempts to rush to restore the equilibrium & thus prevents it from doing so. - Some have reckoned, that the air passes from both the poles, meets at the equator, & thus resolves itself into the trade winds. No facts can be advanced suf=ficiently strong to support this theory. Were it true, there could be no reason that the trade wind should not indifferently blow either to or from the E. point. The mon=soons may be accounted for upon the same theory. While the sun is moving towards the southern tropic, the air follows his course & blows towards the South: when the sun turns back, & moves towards the northern tropic, the air follows him, & blows towards the North. In and all the regular winds usually distinguished, I believe, by the

general name of trade winds, admit of a singu=lar explanation upon Halley's theory. - It is needless to mention others of them. -

The principal agents, which influence the at=mosphere in producing winds are heat & cold. When heat has rarefied the air, that air rises and the neighbouring air rushes in a current, or wind, to restore the equilibrium. When ow=ing to some great degree of cold, a part of the atmosphere is condensed, that part continually rusts itself in a wind to produce an equilibrium. Thus the condensed atmosphere of the poles it is said, passes towards the equator. But I imagine, that the degree of cold, by which the air is condensed at the poles, operates to keep it in a state of condensation; prevents it from passing towards the equator. It is only when the condensing cold ceases, that the con=densed air disperses in wind. - It is supposed by some that the attraction of the moon pro=duces wind. - A protuberance of the atmos=phere, an aerial tide attending ye course of ye moon.

This draws after it, a current of inferior air, wh will be weaker as other circumstances, other currents oppose it; stronger if they combine with it. Marten advocates this idea. Browning seems to think that the motion in the air produced by the moon, must be very inconsiderable.

A wind constantly blows from the ocean, to the coast of some countries. Why? — The heat of the sun, if very intense, will be reflected from ye land, so as to heat the atmosphere; consequently to rarify it. The air therefore rushes from the ocean to restore the equilibrium, a wind blows. This effect is produced in a remarkable degree, by the heat reflected by the barren sands of Africa: nor can the chill of night, so cool the atmosphere heated by the sun in the day, as to reverse that effect: a breeze constantly blows upon the coast of Guinea. — In some islands, it is observable, that a current sets in from the sea to the land, in the day; and from the island to the sea, in the night. This may be said of sea coasts in general. The reason is that the land reflects the heat of ye Sun

so as to warm the atmosphere in the day which lies over it, more than the atmosphere over the ocean is warmed by a similar reflection, & the air rushing from the ocean to restore the equilibrium. The cold of the night chills the Earth more than the ocean; & a current of air in this instance rushing from the land to ye ocean. The easterly winds in the summer are cold & chilly: why? — they come immediately from the ocean, which is colder than the land. I allude, in this observation, to the easterly winds of America. The countries lying to the north-west in America are colder than those lying more southerly and easterly. The air rushes in the winter to restore the equilibrium between the two Territories: it rushes from the North-West. I shall introduce what Browning has remarked upon the subject of Eolian caves. "We are told "says he, of certain caves that emit wind, if so "it is when the included air is rarefied by heat, "and therefore rushes out for want of room; or "when the pressure of the external air, incumbent "upon the mouth of the cave is diminished, and to permit the internal air to dilate itself and issue out. &c. Whirlwinds are generally accounted for upon the meeting of two currents of air in directions opposite to each other. They take in consequence of that meeting, a circular course. — The velocity of winds is from one, to fifty miles an hour; but their velocities depend upon the causes that produced them, & the circumstances that attend them.

Winds are calculated to answer many useful purposes. We have already mentioned the manner in which they purify the atmosphere. Winds are what principally aid commerce. In this View the benefits they produce must be vast, & incalculable. I leave others to depict, & appreciate them.

Part. II. — Of Sound.

The first proposition upon this subject is, that air is necessary to the propagation of sound. To prove this, put a bell under the receiver of an air pump: Shake the bell, & it may be heard very distinctly: then exhaust the air out of the receiver: the Bell

cannot be heard but very imperfectly: & if the air could be entirely exhausted, this experiment authorizes us to presume, there would be no sound at all. The manner of the transmission of sound has been thus explained. — If a sonorous body be struck, its parts are put into a tremulous motion; that tremor is communicated to the neighbouring particles of air; those particles communicate the tremor to the neighbouring particles, and so on till the tremor becoming less and less every time it is communicated ceases alltogether. The air, thus put into a tremulous motion, strikes upon the tympanum of the Ear (a fine membrane distended across it) & by means of the tympanum, this tremor is made to affect the auditory nerve; & by such an affection of that nerve, the idea of sound is excited. Sounds are propagated in every direction. Like all other emanations, their strength diminishes as the square of the distances they pass thro' increase. —

Two different sounds may be produced in the same room, at ye very same instant of time.

How is this to be accounted for? – Some have thought that the air contained different kinds of particles; some being adapted to the propagation of one sound, & some to the propagation of another; and that whenever a sonorous body was struck, it put into motion the appropriate particles, without at all affecting the rest. – Others have thought, that when a number of sounds were produced in the same body of air, all of them produced their tremors, while none of those tremors, interfered with any other tremor; just as if you should throw a number of stones into the same pond of water, all of which stones have their concentric circles, none of which circles interfere with each other. – Others have thought, that the different sounds gave different, & peculiar tremors to the air; and that the organization of the ear enabled it to give different & peculiar ideas of those sounds. – The identity of sounds seems to be dependent upon the tremor given to the air:

and that tremor depends upon various causes. Thus two strings of the same length, the same thickness, and the same tension, will communicate the same tremor to the air, will produce the same sound, if circumstances don't prevent.

If a gun be fired at any given distance, & the time be marked, between the flashing of ye gun and the report; and the distance between the gun and the observer, be divided by the number of seconds, taken up by the passage of the sound; you may determine the distance the sound passes thro' in a second. – It has been found to pass thro' 1142 feet in a second of time. Rowning thinks that the denser the air, the slower is the propagation of sound. The propagation of sound depends upon the communication of tremor from one particle to another: these communications may be regarded as so many operations. The denser the air, the more communications are to be made, the more operations to be performed: more time is therefore taken in the propagation of sound. Hence the passage of sound is slower in cold than in warm weather; it will not go so far. If the wind concur with the tremor, the sound will go farther, & will be heard more distinctly.—

If the tremor, that conveys any sound, impinge upon any solid substance, the sound will be reflected; and the angle of reflection will be equal to the angle of incidence. All bodies whose particles are capable of receiving a tremulous motion, are capable of conveying sound.— An Echo is the reflection of a sound: in order to hear it one must be placed in the lines which form the angle of reflection.— Acoustic instruments are contrivances to increase the intensity of sounds; such as the speaking trumpet.—

For Notes & theory of Sounds. See Rowning & Martin

In the preceding remarks upon winds, I omitted to account for water spouts.— They resemble a whirlwind at sea. Darwin appears to

account for them most ingeniously. He supposes that the reflection of heat, from the surface of the Earth, may so rarify the air in contact with it, as to render that lighter than a superior stratum of air. The inferior rarified stratum, therefore, has a tendency to ascend, & the superior heavier stratum has a tendency to descend: nevertheless there may be in the superior stratum, some parts more rarified than others. Thro' these parts the inferior air ascends, as thro' a hole; forms an Eddy; & draws up the water with it.—

End of the 4th Part.

Part 5th. Sect. 26th. Of Hydrostatics.

It is the intention of that part of N. Philosophy which we denominate Hydrostatics, to explain the nature, gravity, pressure, & motion of fluids in general. As all fluids, except air, exhibit the same phenomena, as air differs from other fluids in a very slight degree, & as

244 all fluids are governed by the same laws; the experiments in Hydrostatics are made upon one of the fluids water. — A fluid is a body that yields to the least pressure, or difference of pressure. — Philosophers have mentioned as the characteristic properties of a fluid that the particles composing it, must be extremely minute, smooth, and round; and they deduce these properties from the facility with which those particles move amongst each other. But when we know that the most solid bodies may be reduced to fluidity by an addition of Caloric, we can hardly suppose that it is essential to fluidity, that the particles of the fluid should be minute, smooth and round; because we cannot suppose that an addition of Caloric produces any alteration in the shape of the particles of bodies, — and it has been suggested

245 that it is essential to solidity, that the particles of a solid should necessarily be minute, smooth, & round: — neither, therefore, is it necessary that the particles of a fluid should be minute, smooth, & round. —
It is generally laid down, that all fluids except air, are incompressible. In our remarks upon the porosity of bodies, we had occasion to mention the famous Florentine experiment. That experiment incontestibly demonstrates that if water be at all compressible, it is compressible in a very small degree: the experiment is this: — A globe of Gold, the densest of metals, was filled with water: the globe was pressed by a powerful screw: the water instead of being compressed, oozed thro' the small pores of the gold and stood on the outside like drops of dew — I believe (which I have mentioned before, see note p. 19) that water is now acknowledged to be compressible,

Tho in a very small degree. –
Fluids, like all other bodies, gravitate towards the Earth; but their gravity is allways proportionate to their perpendicular height. In their pressure they observe the following singular Case. They press equally in all directions, upwards, downwards, obliquely, laterally. Some of the ancients supposed the particles of a fluid were totally devoid of gravity or weight, when in a fluid of the same sort. They were naturally led to this conclusion by observing that in drawing up a bucket out of a well, they were not sensible of its weight, untill it was out of the water. That this conclusion was erroneous is evident from this experiment. Let there be a pair of scales; to one of which let there be suspended a phial with a few shot in

it, which let be barely sufficient to make it sink in water: see what weight put in the other scale will maintain the equilibrium. Then let the water into ye phial: the phial will immediately sink: see what additional weight will restore the equilibrium:– Take the phial thus filled with water out of the water in which it is immersed: the same weight will maintain the equilibrium in the air: pour the water out of the Phial, and weigh it: it will be found to weigh just as much, as added to restore the equilibrium, after it had been destroyed by letting in the water: all which proves that water weighs just as much in water as in air. The relative and specific gravities of bodies may be readily determined by means of the Hydrostatic balance.

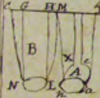
You weigh the same body in different fluids. That body will at each time lose as much of its weight as is equal to the weight of an equal bulk of the fluid. The different weights, therefore, which, placed in an opposite scale, maintain the equilibrium, accurately express the relative gravity of the fluids. The heaviest body may be made to swim in a fluid, of which an equal bulk is infinitely lighter than itself. Brass is nine times heavier than water. If now you immerse a plate of brass nine times deeper than it is thick, and if you protect it from the pressure downwards, exposing it to the pressure upwards only, the brass will swim.

As fluids yield easily to the least

pressure, or motion, and adjust themselves to every change of situation, as they are continually subject to the force of gravity, their surfaces are allways level, as all the particles composing those surfaces are placed at equal distances from the Centre of the Earth. I say their surfaces are level but they are not strictly so: they are level only as being part of the vast circumference of the Globe. Large surfaces being larger parts of that vast circumference, are sensibly convex. The masts of ships are on this account, the first parts that are seen at sea. You may find by a trigonometrical calculation, the distance requisite to render this convexity sensible. In marking. That distance is calculated to be 2 Miles, and 1/4. or thereabouts.

The pressure of a fluid, upon the bottom

of a vessel, is allways equal to the
area of the bottom, and to the perpen-
-dicular hight of the fluid. Upon
this principle is founded the Hydro-
-static paradox, which is that the
smallest quantity of water may be
made to balance the largest. Let there
be two vessels A & B the area of whose
bottoms are equal; and let them be



filled with water both
to the same altitude CD:
it is ascertainable, that
the pressure upon the
bottom of A is as great as
that upon the bottom of B: that is the small
quantity of water in the vessel A would
be able if properly managed to maintain
an equilibrium, against the large quan-
-tity of water in B.- To account for

this surprising Phenomenon draw the lines
HL & GN in the large vessel B: It is
clear, that the water, comprehended with
in the triangles CNG & HLM, press only on
the sides of the vessel not on the base; &
that none but the perpendicular column
CNLH presses on the base NL.- Again in
the vessel A the particles of water on the
base press with a force equal to that they
would acquire by falling from the top D to
the bottom, for they are pressed by the par-
-ticles above them: action is equal to re-
-action: the particles on the base then
press upwards against the circular sides
Xn & ea: here again action is equal to
reaction; & the water presses downwards with
a force equal to what it would have
acquired by falling from M to n, or from
D to a. The same pressure therefore is upon
the base n a, that there is on the base N L.-

252 The Syphon is a crooked tube. The long leg is put in the water. you extract the air out of the tube. The pressure of the atmosphere upon the water in the vessel drives it up in the tube and would drive it as high as 33 feet. But as soon as the water in the vessel gets as low as the outer leg extends the water must cease to flow

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