• A Dissertation "On the reciprocal changes which
" take place in the blood, and in the air, in the process of
" respiration!"

This question has been proposed, under different forms, ever since the first establishment of the Boylston Prize questions, but from the difficulty of its solution has been left to this time without being crowned by the approbation of the committee. Being aware of the difficulty of the subject, we shall, to render it as simple as may be, treat the matter "ab ovo!"

It appears from the dissection of the gravid uterus, that the human body, at its first formation, is very small, appearing like a seed, or rather like the egg of the tadpole, which grows up to the frog. It appears that the human embryo encreases gradually in size by accretion & by evolution, very much like that of a plant.

In a month from conception the embryo is about an inch long, at which time the bones appear like fine threads. among them the ribs are distinguishable, disposed on each side the spine, but as soft as a jelly. In two months it is so far grown, that the ossifications are perceivable in the arms thighs, & point of the chin; and the umbilical vessels which before went side by side, now appear twisted like a rope one over the other, so as to encrease the length of the vein & the artery, & to break the impelling force of the latter. In four months the nails appear on the fingers & toes; & soon after the stomach & intestines seem to perform their functions of receiving & digesting; for in the stomach is found a liquor similar to that in which it

it swims; & in the larger intestines an excrementitious substance. The head of the embryo appears to be first formed; & then the Spinal-marrow is seen to stretch along ~~from~~ the back bone from the brain. At length the heart is seen to beat. By & bye the Liver with its gall bladder is formed; & last of all the Lungs.

As soon as the embryo begins to grow, the womb, of course begins to grow also in size; but, what is rather surprising, it encreases in thickness as it extends its bulk. After the seventh month the embryo changes its name to that of foetus, which is now seen to be close wrapped around by two membranes, the chorion & amnios; & thus furnished, it floats in a transparent fluid; and taking the whole together, it very nearly resembles the chick in its egg-shell, as has been finely illustrated by the immortal Harvey.

The umbilical vessels, consisting of a vein, two arteries & a nerve, issue from the navel of the foetus, & branch out upon the Placenta, & seem to form its chief substance. By ~~the~~ means of this navel string, the child adheres or grows to its mother, just as the apple adheres or grows ~~&~~ by its stalk to its parent ~~the~~ tree. The placenta serves here the same use as the two large seminal-leaves subserves that of the embryo-plant, viz to oxygenate its vital fluid.

The child never breaths in its mothers womb, because it swims in the water of the uterus. ~~The~~ Lungs of the foetus remains as quiet as its liver, & never move untile the child passes from its watery habitation into the atmosphere; nevertheless the blood passes through the heart of the child in the womb; but then it is by a particular contrivance, which is a wide open passage from the right auricle to the left, called the foramen Ovale; ~~but then~~ it however passes much slower

than it does after the child has once breathed; which fact it would be well to bear in mind in this discussion —
The child then receives its nourishment while in the womb from its mother, in the same way that a growing fruit receives its nourishment, & consequent growth from its parent stock; which again receives its nourishment, verdure & beauty from nutriment drawn from the earth by its lacteals or roots; & from the air, the oxygen, & the light of the sun. But the child while in the womb of its mother must receive something more than mere sanguineous nourishment. Its blood must be oxygenated; & possessed of that vital something, which imparts to it the bright vermillion colour; for without possessing that splendid colour the fœtus dies — We cannot suppose that the breathing of the mother can oxygenate the blood of her ~~infant~~ fœtus, shut up as it is in the thick uterus, like the chick in its egg-shell. We could not suppose this, even if we admitted the strange idea that the air, inspired by the mother, penetrates the fruit of her womb, like the inhalation of air in birds in the action of flying. How then is the oxygenation of the blood in the fœtus in utero effected? Let us examine it, & adore the Divine hand that framed & fashioned us in the womb!

We have every reason for believing that the Placenta is the organ by which the blood of the embryo is oxygenated. If we examine its structure we shall find that it has a nearer resemblance to the Lungs than any other in the body. There even appears a structure resembling the air-cells of the Lungs; but whether there has ever been

observed an inflation of this structure in the Cæsarean operation we know not. It is worthy of note that it was conjectured, more than a century ago, that the Placenta was a respiratory-organ; or what would be called with more propriety now, an oxygenating-organ; but the too scanty time allowed for composing these prize-questions does not admit of searching out the precise place in the works of a Latin writer. We say however, generally that Hervey & Malpighius were not satisfied that the placenta conveyed only a stream of red blood & lymph. Both these philosophers saw the necessity for the imbibition of the vital air through the shell of the hen's egg; and by parity of reason, they concluded that the fœtus in utero must derive the same benefit through some unknown organ or apparatus; & no other presented but the placenta.

We learn from the Anatomists*, that the two umbilical arteries arise from the internal iliacs of the fœtus; that they ramify all over the placenta, & their branches inosculate together in its substance, & the smallest extremities are lost in that part of the membrane called chorion, which is interposed between the placenta & Uterus. We learn from the same source, that the origin of the umbilical vein is from small venous tubuli arising from the chorion, where the smallest twigs of the arteries are lost, which uniting and forming larger & larger branches, at length run all into one large trunk, entering the umbilicus of the fœtus; & then it goes on to the Liver, & opens into the sinus of the Vena portarum;

* See Flemyng & Haller

from which sinus there arises, ~~there arises~~ in the fœtus, a particular large trunk, called the venous duct, opening directly into the Vena cava, which transmits the blood to the heart, where without entering, or in any degree moving the lungs of the fœtus, it passes through the heart by an organic hole, which is completely closed up after the child has once breathed.

From this history, it appears that the arteries of the Uterus bring the blood to the placenta, which being taken up by the beginning of the veins of the placenta, is transmitted to the fœtus through the umbilical vein, into the Vena portarum; & from thence into the vena cava, & so into, & through the heart, the lungs of the child remaining quiescent. On the other hand, the two umbilical arteries in the fœtus, being continued from the aorta, carry the blood to the placenta; which blood, at the adhesion of the placenta to the Uterus, is taken up by the beginnings of the uterine vessels, & transmitted to the cava & heart of the mother; — and thus, the blood flows from the mother to the child, & from the child to the mother again; and what was arterial blood in the one, becomes venous in the other alternately.* But in this alternation, for we hardly dare call it circulation, we can discern no process by which the blood of the fœtus is oxygenated. We must therefore refer it to the lung-like structure of that temporary organ the Placenta, without pretending to explain its modus operandi. But suppose we should not be able to explain satisfactorily, nor even conjecture with

* See Solemyng & Haller.

pro-

probability concerning the cause of vitality it is no more than what happens to the oldest & most learning physician & philosopher, every day, in his enquiries into the works of nature. We find inexplicable difficulties in the inanimate world, what wonder then if in the human body, a system so curious so subtle & com-pounded, we should meet with things which we cannot account for? Every step we take convinces us of our ignorance, & how little we know of the works of Him, who made us, and all things. "as thou knowest not "what is the way of the spirit, nor how the bones do grow "in the womb of her that is with child; even so thou know-"-est not the works of GOD who maketh all". Eccles. Chap. ~~XI~~. verse. 5th.

Chapter 2d

From observations made, ever since the birth of the children of Adam & Eve, we learn that the human body grows up from a small particle, or egg in the womb during the space of nine months. Even in the last period of its existence in that receptacle, it appears that its sensations are very few, & very obtuse. It nevertheless seems by its quiet, & afterwards, by its motions, to sleep, & to wake. How the fœtus comes to be marked & maimed by shocking sights & very strong impressions of the mother, we know not. The fact we admit, because it is testified by all nations, savage as well as civilised, in all ages, & parts of the world. — "causa latet, vis est notissima."

The fœtus in utero, even in the last period of its existence there, does not appear to possess any feelings above the fœtus of any other quadruped. The commencement of the living state of all animals is, as far as we can discover, on a level with that of man. They have the like imbecility, & are equally unconscious of their existence. If it might not be used to evil purposes, we should say, that there is no one fact attending the human fœtus, anterior to its breathing, that would allow us rationally to conclude that it possessed a soul, or the conscious principle, in contradistinction to the anima, vitality or simple life, equally enjoyed by the brute. Our opinion is, that the infant does not possess a soul untill it breathes the vital air of the atmosphere; and in this we are

countenanced by the opinion of the wise in all ages; and we are supported in it by the sacred scripture which says ~~expressly~~, that GOD first formed man as in the womb, & afterwards breathed into his nostrils "the breath of life; and the consequence was "he became a living soul". We therefore think that we are justified by reason, & countenanced by holy writ, in the opinion that the human fœtus is devoid of a soul untill the moment of its first inspiration, & that it quits it at its last expiration, & returns to GOD ~~to~~ WHO gave it"; & that this is the language of reason & revelation.

The doctrine we wish to maintain is explicitly this; that breathing & animation, are two terms for the same state, or condition of man; and that the state, or condition of the fœtus in utero, previously to its first inspiration of ~~vital~~ atmospherical air, was, in the scale of vitality, little more than vegetation.

~~Let us now to~~

Let us now take up the state and circumstances of the child in the womb, which was at the latter end of the ninth month. At the termination of about forty weeks from conception, the ~~ex~~ infant gives its mother painful proofs of its existence; for now the stalk of the fruit is beginning, if we may so speak, to separate from the parent tree; and the head of the child falls down to the aperture of the womb, which organ becomes uneasy, & strives instinctively to be freed from its too heavy burden. Both these causes operating, the infant at length issues into life. Now

Now let us attend to the important change which at this momentary ~~parcit~~ period, takes place. — As soon as the child issues into light, the atmospheric air rushes into its nostrils; & the Lungs that had till this time been inactive first begin their functions. This rushing air through the nostrils seems to occasion pain, which the infant expresses by a shriek. It appears then, that when the child is wholly disengaged from the Uterus & placenta of its mother, it depends in future upon the operation of its <u>own</u> organs, instead of the organs of its parent; & that in order that it may live, it must be allowed the free use of the atmos-phenicae air.

When a child issues into light, or is born, that is to say, when it passeth from its watery habitation into the at-mosphere, it becomes dependent on a <u>new prin-ciple</u> for the continuance of its existence. A new determination now takes place in <u>all</u> its organs; and instead of receiving life from its Mother, as heretofore, through the umbilicae-cord, the common air becomes forever after <u>the fountain of its heat</u>, & the main-spring of all its actions & functions, both corporeal & intellectual. No sooner does the infant <u>inspire</u> the atmospheric air, than the Lungs are, for the first time expanded; and the great volume of blood, which had hitherto passed only through the heart, now takes a wider circuit, & the <u>foramen ovale</u>, or hole through the heart closes forever. The Lungs now first begin their functions, & they cease not their action so long as life continues. What a complicated, intervolving,

simultaneous, & alternate revolution is here, in the tender & delicate frame of the infant!

The strict order of our disquisition compells us to concentrate our attention on the function, or process of Respiration.

Beside the Bronchial artery & vein which nourish the lungs as an organ, there is another and a larger set of vessels pervading them, which contain blood; and another set of vessels which contain air. The air in the Lungs, as well as the blood in the pulmonary artery is in constant motion; for either that portion of air which is, at present, contained in the cells, is passing through the wind-pipe into the atmosphere; or else a fresh parcel is passing from the external atmosphere, through the wind-pipe into those cells. The whole of this compound motion is very aptly termed Respiration.

To breathe & to live are terms synonymous. All animated nature breathes, & the vegetable also. "The breathing Leaf", is a phraze not merely poetical. The large leaves of Aquatic plants have a breathing structure that is easily to be traced, constituting an apparatus resembling the gills, or breathing apparatus of fishes. The insect breathes; the reptile that lives under a stone, and the animal that burrows in the bottom of ships breathe, & so do Spunges, & polypi, that adhere to crustaceous habitations. They all, in a greater or less degree, paint after the vital principle in the atmos-

-phere. Nay farther, the seed, if planted too deep in the ground, perishes for want of the vital principle in the atmosphere.

The question now is — What is that vital principle?

Some persons of circumscribed views, & confined reading have imagined that the wise men of antiquity were entirely ignorant of this vivifying something in the air; but it is a mistake. Aristotle had an idea that a vivifying something was absorbed from the air; & he imagined that it underwent some change in the Lungs. King David says in 104th Psalm — "Thou sendest forth thy spirit, "and they are created; — thou takest away their breath, & they "die!" This finely expresses the effect of inspiration, and expiration, which phrases were then as they are now synonymous with living & dying, all of which depended on the function of Respiration.

Modern Physiologists, enlightened by the discoveries of recent chymists, have said that the process of Respiration may be aptly compared to a slow combustion; for as in combustion, the oxygen of the atmosphere unites with some inflammable body, & forms an acid, as in the production of vitriolic acid from sulphur; or carbonic acid from charcoal, which gives out at the same time, a quantity of the matter of heat, so in Respiration, the oxygen of the air unites with the phlogistic part of the blood, and changes the colour of it from a dark to a bright red*.

The Antients had a similar idea. They supposed

* Darwin

there

there was an internal combustion; & that by the action of respiration, it assisted in the expulsion of a mephetic, fuliginous, or poisonous vapour, which was continually passing out from the centre of the body, through the wind-pipe into the air, & which was of so destructive a quality as to convert good & wholesome air, in a short time, into a poison. And their reasoning on these facts marks their sagacity. Their theory was explicitly this, — They supposed from the heat of the blood, that there resided in the heart, a flame or vital spark; & it seems they were confirmed in this notion by observing the appearance of smoke in our breath, in a very cold day. They were still farther confirmed in their theory, by noticing that fire was extinguished when deprived of air; hence they concluded that the process of respiration, was to fan, or blow up this internal flame & to keep the original, vital spark, from going out; and, at the same time, to ventilate, & moderate the heat of the blood in the arteries of the Lungs & in the heart. All this was very natural & consistent. They saw that the flame was extinguished if you prevented the ~~air~~ entrance of the air into the Lungs; and that if you obstructed the exit of the foul or fuliginous matter, the patient was thereby poisoned, by the retention of that mephetic vapour which ought to have been expelled. We meet with few theories more natural & consistent. They were however far from being agreed as to the modus operandi of this vital process. Some more sagacious than the rest, as Aristotle, supposed that a certain vivifying principle was absorbed from the air, to which they gave the name of Pabu

"pabulum vitæ", or the provender of life.

In the 17th century Lower in England, & Borelli in Italy, paid great attention to the functions of the heart & lungs. They observed that those animals, which respire the most, or quickest, have the warmest bloods, such as man; & some smaller animals; while those which respire the least had the coldest, as the Turtle; & some other amphibia & fishes. They proved that the air lost something by coming in contact with the Lungs. Dr Mayo, a learned & ingenious physician, in the reign of King Charles the 1st of England, shewed that this something was contained in Salt Petre. This was first observed by those who were employed in the manufacturing this article; they said that there was something powerful in Nitre that was absorbed from the atmosphere; and it was left for the great Dr Priestley to shew what that something was.

If we turn to the writings of the great Boerhaave we shall find that he was not ignorant of this acidifying of the air; or, as some called it "nitrous acid". "The upper surface of
" blood, when exposed to air, is, says Boerhaave, of a
" bright scarlet, while in every other part, which the air
" does not come at, grows as black as the blood of a
" cuttle-fish; & yet as soon as this black part is laid
" open to the air, the black colour is immediately chang-
" -ed into scarlet. This vivifying principle in air so necessary
" to the support of life, & of flame, as well as animal &
" vegetable life, seems by every phenomenon to be that
" universal acid, which is distributed through the entire at-
-mos

» atmosphere, in a certain ~~degree~~ proportion; inso-
» much that no portion of air seems to be without it.
» It is this acid that corrodes the baser metals. By
» this acid the calx of vitriol, of alum, and the earth
» from which Salt Petre is procured are again re-
» plenished, in such a manner, as to be capable of
» producing acid spirits afresh. There is reason, says
» Boerhaave to suspect that Flowers are indebted to
» this acid of the air for their beautiful colours;
» all concerned in dyeing observe that a cloudy,
» moist air interferes with the beauty & vividness of
» their colours; & that a serene sky exalts them, &
» makes them more elegant". And then this ornament
» of the medical world adds " This acid of the air
» finds some way of mixing with the blood; and it
» is believed that this grand operation is performed
» in the Lungs; & that then the blood acquires a
» Scarlet colour".

We may remark on this passage, that if we here substitute the term of the new nomenclature Oxygen, for that of the acidifying principle, we have a pretty correct idea of the modern doctrine of the oxygenation of the blood, as we shall see hereafter; for it seems that Boerhaave, a century ago, was not ignorant of this vivifying agent. We every day see old doctrines & discoveries brought into fashion under new names. Boerhaave, Boyle & Newton had an indistinct view of this principle in nature; but neither of them a correct one. They knew that the common air

was impregnated with a certain vivifying spirit, which was necessary to continue the life of animals; & that this in a gallon of air was sufficient for one man during the space of a minute, & not much longer. They knew that this spirit in the air was destroyed by passing through the Lungs; & also by passing through fire, particularly through charcoal fire; or the flame of sulphur. They knew likewise that, air which had lost this spirit deadened fire, extinguished flame, & destroyed life. They knew full well that this thin transparent, elastic fluid, which encompasses the whole earth to a certain height, & which we breathe, was to us "the breath of life"; and that it was, at the same time, the very spirit of fire & flame; but they knew not what this spirit was; or how to detect it, & exhibit it per se. Boerhaave spoke of it as we have related, and the immortal Newton spoke of a materia subtilis, which he supposed to be of so subtle & refined a nature, as to be void of gravity, & of the other properties of common matter.

This spirit in the air could not escape the penetrating eye of Newton, who says — "That there is an unknown something "which remains behind when the air is taken away, as "appears from certain effects which we see produced in "vacuo (in the air-pump.) Heat is communicated through "a vaccum almost as readily as through air." And this great philosopher subjoins, that this communication of heat cannot be without some interjacent body, to act as a medium; and that such body must be subtle enough to penetrate the pores of glass, as a glass vessel is that part of the air-pump

where the vaccum, as it regards air, is made. If this sub-
-tle unknown something, or spirit of the air penetrates glass,
we may, it is said, well conclude that it penetrates
the pores of all other bodies, & consequently is diffused
through all the parts of space.

Newton supposes this subtle ether to be rarer in the
pores of bodies, than in open spaces; & even rarer in small
pores, & dense bodies, than in large pores & rare bodies. He
also supposes that its density increases in receeding
from gross matter, so as to be greater, for example at
the $\frac{1}{100}$th of an inch from the surface of any body, than
at the surface. He farther more infers that this ethe-
-real medium is not only rarer, & more fluid than air,
but exceedingly more elastic and active; in virtue of
which properties, he shews that a great part of the phe-
-nomina of nature may be produced by it. He ascribes
to it the elastic force of the air; & the nervous energy
in the living fibre & nervous system; the phenomena
of light, as well as the effects, & the communications
of heat, together with sensation & muscular motion.

It is not for me, who am but a collector, arranger,
and comparer of facts, widely scattered, to attempt to
draw the line, if a line can be drawn, between this prin-
-ciple, or element, & that of Oxygen. That task must be
left to this learned Committee.

We however draw a line between this spirit in the air,
and that igneous fluid, or matter of heat, which the
vulgar call Fire, and the Philosopher "Caloric"; by which
term they mean that exquisitely elastic fluid which
cause

causes heat. Over & above these, there is a third grand agent viz Light; but whether light be a modification of caloric, or if caloric be a modification of light, we leave to others, older than ourselves, to determine; and shall close this chapter by saying in the words of the celebrated Lavoisier. — "Organization, sensation, "spontaneous motion, & all the operations of life, exist "only at the surface of the Earth; & in places exposed to "the influence of Light. Without Light (and its con-"-mitant heat) Nature itself would be lifeless, & in-ani-"-mate. By means of Light, the benevolence of the "DEITY hath filled the surface of the Earth with "organization, sensation, & Intelligence!" *

* How sublime & beautiful is that expression of Scripture, which calls our great Creator, the Father of Light!

Chapter 3d

Having discussed the wonderful economy of the gravid Uterus in our first chapter; and of certain principles, or agents in the economy of the Atmosphere, let us now try to make an application of them, with a view to ex-plain "the reciprocal changes which take place in the "blood; and in the air in the process of respiration".

The Atmosphere is a chaos; for in it float the attenuated particles of all terrestrial substances. In it are the seeds of life; & the causes of death; yet from this mixture of all things Nature takes the elements of the composition of bodies, which when they decay, by decom-position, return the same principles which were before extracted from it. This great solution or mixture of all things is continually operating upon itself; & it would seem that the salubrity of the air is owing to the variety of its mix-ture; for the predominance of any one vapour, from any body however wholesome in itself, soon becomes deleterious

The mathematical physicians of the last century, endeavoured to make the world believe that respiration was only the mechanical distention of the air vessels of the Lungs, by an elastic fluid. More modern Physiologists have entertained almost as narrow ideas of this im-portant function, when they tell us, that the object of respiration is confined merely to the reception & emission of a fluid. The truth is, the Lungs is a digestive organ; for while the Stomach is digesting solid food, the Lungs

is digesting air. The Lungs is an organ which is nourished by the air; & in digesting that which is presented to it, it retains what is beneficial, & rejects what is noxious. And as the stomach is liable to receive articles that are pernicious, so is the Lungs constantly exposed to the inhalation of noxious particles. The Stomach rejects unwholesome materials by vomiting, & by diarrhea; & the Lungs by sneezing & coughing. The Stomach can bear, for a little while, a poison; so can the Lungs endure a very short time the hydrogen gas.

The ancients had pretty correct ideas of respiration. Hippocrates knew that the air contained a principle, or *pabulum vitae* to nourish & support life. He says, *spiritus etiam alimentum est*. This simple & just idea has been made to give way from time to time to theories void of all foundation. Borelli in his Essay *de motu animalium* built a theory of respiration on the dilatation & contraction of the Lungs in inspiration & expiration. Jurin adopted the same ideas. Sauvage looked no farther than this mechanical theory; nor did Bernouilli; & Boerhaave and Haller wasted much mathematical knowledge in their vain attempts to subject the vital function of respiration to the laws of mathematical & mechanical philosophy. Vitality, or the *Vis vitae* cannot be explained on mechanical principles; nor even on chemical ones: not but what chemistry has now dispelled the clouds of hypothesis, & let in the dawn of truth.

In the course of our researches we have found no writers who has treated the subject of respiration more clearly, or shewn the connection of life with this function, in a manner more satisfactory

satisfactory than Dr Edmund Goodwyn, "on the effects of submersion & strangulation, & of noxious airs upon animals" If this ingenious physician has not added greatly to our stock of facts, he has arranged them in so clear & satisfactory a manner, that we shall avail ourselves of his industry; for we presume that the Committee who sit in judgement on these prize questions expect from us, the young worshipers in the Temple of Apollo, an offering that we have collected & sifted & prepared for his alter, instead of the mere smoke & vapour of hypothesis, that shall leave nothing but a caput mortuum behind. —

Dr Goodwin tells us, as the result of experiment, that when an animal is plunged under the surface of water his pulse becomes weak & frequent with an anxiety about his breast, which he struggles to relieve, & in these struggles he rises towards the surface of the water, & throws out a quantity of air from his lungs. after this his anxiety encreases, his pulse becomes weaker, the struggles are renewed with more violence; he rises towards the surface again, throws out more air from his lungs, & makes several efforts to inspire, and in some of these efforts a quantity of water commonly passes into his mouth. His skin then becomes blue, particularly about the face & lips; his pulse gradually ceases; the sphincters are relaxed; & he falls down, without sensation, & without motion.

" If the body be immediately opened, it has the following appearances.

" (1.) The external surface of the Brain is of a darker colour than usual; but the vessels are not turgid with blood; nor are they any marks of extravasation about them.

"(2). The cavity of the Lungs contains a considerable quantity of frothy fluid; & the pulmonary arteries & veins are filled with black blood throughout their whole extent.

"3d. The right auricle & ventricle of the heart are ~~still filled~~ still contracting & dilating; the left sinus venosus & auricle more feebly; but the left ventricle is at rest.

"4th. The right auricle & ventricle are filled with black blood, and the left sinus venosus & left auricle also; but the left ventricle is ~~[illegible]~~ only about half filled with the same coloured blood.

"5th. The trunks & smaller branches of the arteries proceeding from the left ventricle, contain a quantity of this black blood also."

Dr Goodwyn afterwards proves, by a set of judicious experiments, that the water produces all the changes that take place in drowning by excluding the atmospherical air from the Lungs, and not by its entering directly into that ~~lungs~~ organ

He proves also by experiments, that the dilatation of the Lungs is not the final cause of Respiration, as Borelli, Hales, Jurin, Sauvage, Bernouilli, Boerhaave & Haller believed. Dr Goodwin therefore turns his attention to the changes which the air, and the blood undergo in the process of respiration. In order to determine this, he first states the

constituent parts of the atmospheric air, as ascertained by analysis with the well known chemical tests; and which he finds composed of Azote — oxygenous gas — and carbonic acid gas. — The relative proportions are generally thus in a given quantity — two thirds azote; one third oxygenous gas; & a very small quantity of carbonic acid gas.

With these data Dr Goodwyn attempts to shew the changes which the atmospheric air undergoes in the process of respiration; and he says "if an 100 parts of analysed atmospherical air be inspired, & expired again into a receiver it is found to have undergone a change in the proportion of its constituents parts, viz — the quantity of oxygenous gas is diminished; the quantity of carbonic acid gas is increased; and the azotic remains the same.

The celebrated Lavoisier proposed to ascertain the changes which these airs undergo by a single respiration, which means one inspiration, & one expiration. Dr Goodwin tried the experiment on himself, to ascertain the degree of these changes in twelve cubic inches of atmospheric air. He first ascertained the proportion of these airs in 12 inches of atmospheric airs; then he inspired an equal volume of the same air, & expired it into a glass receiver, & then analyzed the whole quantity, and the medium result after several trials was as follows:

The volume of air taken into the Lungs at a single inspiration contained of

Azote	80 parts.
oxygen gas	18
Carbonic acid gas	2
	100.

The Volume

The volume of air expelled from the Lungs by the next succeeding expiration contained,

Azote	80 parts.
Oxygenous gas	5
Carbonic acid gas	13.
	98.

From whence it appears that the diminution of the oxygenous gas, and the increase of carbonic acid gas, is considerable.

It appears by Lower's Tractatus de Corde, published 150 years ago, that he knew that the blood acquired its scarlet colour in passing through the lungs, & that this was produced by the chemical action of the air.

But the grand question is, which of these three component parts of the atmospheric air is it that produces this change of colour? Does it arise from the addition of the carbonic acid gas, separated from the blood? or does it arise from the chemical action of the azotic gas? or from the chemical action of the Oxygenous gas?

It is found by experiment that if you confine fresh drawn blood with carbonic acid gas, it does not become black. If you confine black blood, fresh drawn with the azotic gas, it suffers no change of colour whatever. But it is found that if black blood be confined with the oxygenous gas, it directly becomes of a bright florid or scarlet colour.

Priestley knew this fact, & so did Boerhaave before him.

Priestley found that atmospheric air would change the colour of blood from black to scarlet even when enclosed in a bladder. Can we then wonder that it changes the colour of the blood through the more delicate & living coats of the blood vessels of the lungs?

But by what means the air is applied to the blood in respiration, is a subtle & curious question — Some suppose it is by means of the absorbents; others that it is by the influence of chemical attraction. We are doubtful if it be either. Comparative anatomy, or rather comparative Natural history, teaches us that nature works different ways in the respiration of animals of different classes. Although no animal can live without air, nor vegetable either, yet we find that they require air of a different degree of purity. Birds require the purest; & in those that fly high there is a structure and economy by which the air penetrates their bodies even to their feathers; & which is kept in circulation by the motion of their wings; while their lungs in the action of flying are, in a great measure, collapsed. Next to birds man requires the purest air; but can accomodate himself, by degrees, to air of almost any state of impurity, & yet live. Some, as the class of Vermes, live in the earth, & receive the benefit of air in a manner peculiar to them, who naturally have no red blood, but instead of it a colourless fluid. Amphibious animals can live in the air, & out of it, and this by a peculiar structure & economy*. The whale, the porpoise, the Alegator & the Tortoise can, at will, collaps their lungs and open their foramen ovale, in which state the blood passes direct through from one side of the heart to the other, without passing through the lungs; in which case they

* The heart of the amphibious has only one auricle & one ventricle; the pulmonary artery is a small branch from the aorta, & the pulmonary veins proportionally small compared with the size of the lungs.

they are exactly in the state of the fœtus in utero; but they cannot remain in this state very long. They must of necessity come up to the surface of the water to inspire the vital air of our atmosphere; or in other words to oxygenate their blood, & change it from a black to a scarlet colour; so we see that it is possible to drown a whale, or an alligator. The greater part of Fishes have not lungs in their thorax, like the whale & porpoise, but in their heads; together with an air-bladder, containing, as Fourcroy afirmes, nitrogene gas, or azote.

Insects have a ~~breathing~~ structure & a breathing apparatus still more remote from ours, & approaching the respiratory economy of plants, which apparatus pervades all parts of their bodies. Insects like plants are nourished by atmospheric mephitis. These facts are mentioned to shew the resources of nature; & how wonderfully means are adapted to ends; & to remind us that our mode of breathing is not the standard by which we are to judge exclusively of this vital function; for we find that one animal will live in an air in which another has died. Returning from this digression let us pursue the enquiry relative to the recipreal changes in the air & in the blood by the process of respiration.

We learn from various sources that the vapour or gas, emitted by expiration is a mixture of azote, carbonic acid, and oxygen gas; for if the air which issues from the lungs pass through lime-water, it renders it turbid; if it be received through

lime-wa

tincture of turnsole, it reddens it; and a pure alkali causes it to effervesce. We learn also that when carbonic acid has been absorbed by the foregoing processes, the remainder of this air consists of azote, & oxygen gas; the presence of the latter is demonstrated by means of nitrous air. We also know that a portion of the air is absorbed in respiration.*

The first effect which the air appears to produce upon the blood is, that of giving it a scarlet, or bright vermilion-colour. Hewson found, that by injecting a portion of a vein, between two ligatures, he rendered the blood of a brighter colour. Blood that had been confined in a vaccum remained black, but no sooner was it exposed to the open air than it assumed the most beautiful vermilion colour. Dr Priestley filled a bladder with blood and exposed it to pure air; when that portion of it which touched the surface of the bladder became red, while the internal part remained black.

All these experiments, & many more that can be adduced, demonstrate that the bright scarlet, or vermilion-colour assumed by the blood in the lungs is owing to the pure air inspired; while air which has remained in contact with blood extinguishes a candle, & precipitates lime water. These are precious facts.

And by the experiments instituted by Dr Goodwyn it appears that the contractions of the heart were diminished in frequency in proportion as the blood from the Lungs became dark-coloured; & that they were excited again, when it became florid; but that when it was quite black, the contractions ceased entirely; whence it clearly appears, that

* Chaptal.

that

something whatever it be, that gives to the blood the scarlet or bright vermilion colour, imparts best life & animation. It appears from a train of experiments, that the quality of the blood, influences the action of the heart, even when the quantity is fully sufficient for the purpose of circulation. And it also appears, from what has been advanced, that if the blood does not acquire its florid appearance in the Lungs, its stimulus is insufficient to excite the heart to action. And hence says Dr Goodwyn, it follows — "That the chemical change which "the blood undergoes in the lungs by respiration, gives "it a stimulating quality, by which it is fitted to excite "the left auricle & ventricle to contraction." And from all his experiments he draws the following conclusions;

"(1.) A quantity of oxygenous gas is seperated from the atmosphere air in the Lungs by respiration, & a quantity of carbonic acid is added to it."

"(2.) The oxygenous gas exerts a chemical action on the pulmonary blood; in consequence of which it ~~exerts~~ acquires a florid colour."

"(3.) In ordinary respiration this florid colour is seen distinctly as the blood passes into the left auricle*; and the heart contracts then with its natural force & frequency".

"(4) When respiration is obstructed, the florid colour is "gradually

* In dogs, toads & frogs, subjected to his experiments."

gradually diminished, & the contractions of the left auricle and ventricle soon cease."

"(5) This cessation of contraction arises from a defect of a stimulating quality in the blood itself!" — and hence it follows,

"That the chemical quality which the blood acquires in passing through the Lungs, is necessary to keep up the action of the heart, and, consequently, the health of the body."

The deductions from Dr. Goodwyn's experiments are these, viz — "that in proportion as the colour of the blood passing through the Lungs is darker, the contractions of the left auricle & ventricle, & the corresponding pulsations of the arteries become weaker, and the current of the blood slower; & whilst the blood moves slowly in the larger trunks, it begins to stagnate in the smaller branches of the arteries & veins, where the resistance to its passage is greatest. at length, when the pulmonary blood is no longer fitted to excite the sinus venosus & auricle to contraction, they receive it into their cavity, and remain at rest. As soon as they cease to contract, and propel the blood to the head, all the intellectual operations cease, sensation, and voluntary motion are suspended, & the external signs of life disappear; and the black blood remaining at rest in the arteries, & particularly in the smaller branches of the arteries & veins, ~~gives~~ occasions that blue colour upon different parts of the body." And if this state continue many minutes death ensues.

Chapter 4th.

It appears from what has been said in the first part of this dissertation, that before a child is born its lungs are quiescent, & entirely useless, the child depending on its mother for life & nourishment, as much so as the apple ~~xxx~~ depends on the parent tree for nourishment & growth. The ~~bx~~ existence of the child depends on the warmth & life of the mother; & on a partial circulation of its blood through a temporary opening in the heart, without ever passing through the lungs; which open-ing is closed forever after the child has once breathed the vital air.

When a child is entirely disengaged from the Uterus and placenta of its mother, it depends, in future on the operation of its <u>own organs</u> for its existence; and in order that it may live, it must be allowed the free use of the atmospheric air, which is drawn into, & alternately expelled from the lungs, which compound action is called <u>Respiration</u>.*

When a child is born it becomes dependent on a <u>new</u> principle for ~~its existence~~ the continuence of its existence; for when it passes from its watery habitation into the atmosphere, a <u>new</u> determination takes place; and instead of receiving its life & growth, as heretofore, by the navel string, from its mother the common atmospheric air becomes the <u>main-spring</u> of all its actions & functions. When the air rushes into its nostrils, the child opens its mouth & cries, the Lungs are expanded; and that action closes up forever the foramen ovale. The blood which had hitherto passed through this opening, now takes a wider circuit,

*. Hence appears the pernicious custom of wrapping up the heads and of new-born infants in blankets.

and the Lungs, which had untill ~~now~~ this time been inactive, now first begin their functions; & they cease not their motion as long as life continue. They began their motion by Inspiration, and they cease their motion by Expiration.

But in order that an infant should grow in size ~~as well~~, as well as receive the vital principle from the air, to oxygenate its blood, & animate its frame, it must have likewise a supply of more solid food; which being received into its stomach from the breast of its mother in the form of milk, is therefore prepared for its nourishment by digestion; taken up from thence by absorption, distributed by circulation; assimilated to its nature by the wonderful process of nutrition; & all its various fluids & juices perfected by secretion; while the whole is kept up by respiration, which being free & easy, requires neither conscious exertion, nor even a thought; but carries on the circulation, at the rate of about 105 pulsations in a minute, when duly modulated by perspiration.

The growth of the young animal depends on the extension of the arterial system; & this depends upon the quantity of fluid accumulated in it from the organs of digestion; and upon the force of the heart being such, as to keep the arteries constantly in a state of distention. This depends on the "vis contractilis insita"; which depends on the conjoint energy of the digestive & respiratory functions.

Dr Priestley has thrown out an idea, that phlogiston was attracted by plants in their growth; & that it became fixed in their substance; & that when the plants were taken into the stomach, and there decomposed by digestion, the phlogiston, or inflam-

inflammatory principle, recovered its fluidity, & after an-
-swering its vivifying purposes in the system, was thrown
out again by means of the blood in the Lungs, by which opera-
-tion it vitiated, or as he called it phlogisticated the air ex-
-pired. Priestley conceived that the chyle, which is in-
-cessantly entering our system, beside distending the vessels
and conveying fresh supply of matter to repair the daily
waste of the body, conveyed also a portion of that subtle
fiery principle, which the ancients called the pabu-
-ulum, the flame, or provender of life; or in other words
a portion of that expansive fire, or "anima mundi," which
gives motion to the Universe, & life to Nature. This idea
does honor to Dr Priestley, who though not a medical man,
was a philosopher of the very first class.

To conclude; our idea is explicitly this—

"And the Lord God formed man of the dust
"of the ground; and breathed into his nostrils the
"breath of life; and man became a living
"soul."

Genesis 2d. Chap. 7th Verse

This comes next

To conclude, our ideas respecting ~~respecting~~ the re-
-ciprocal changes of the blood & of the air in the
process of respiration are these,

There are within us two important organs performing, at the same time, two different kinds of digestion, viz. the Stomach & the Lungs; for while the former is digesting solid substances, the latter is digesting air. The digestion of solid substances by the stomach, is the conversion of food into chyle; and of chyle into blood. A regular supply of this milky fluid is necessary to recruit & repair those parts of the animal machine, that are incessantly wearing down, & passing off, by the very actions re-
-quisite to life. When this function is impaired, & much de-
-ranged, the patient languishes, becomes emaciated, faints & at length dies. If digestion be well performed, that is, com-
-pleted within three or four hours, the chyle is proper, be the food ever so various. The blood formed from this chyle is natural; the secretions & excretions are regular, and health, strength, activity, & cheerfulness ensue. But if the function of digestion languish, the contrary of all this will happen, be the food whatever it may*

There is however a remarkable sympathy between the function of digestion, & the function of respiration. When we inhale atmospheric air, the Lungs in the action of breath-
-ing seperate a portion of that inspired mass, called oxygeneous (or vital air, or empyreal air, or dephlogisticated air, for all these names have been used to designate that so often mentioned spirit of the air) which entering the blood, vivifies & animates the whole ~~frame~~ frame, giving that fluid a bright vermilion colour; which oxygen actually becomes one

(* Dr Waterhouse's printed Lecture "On the evil tendency of the use of Tobacco in young persons &c.)

one of the constituent principles of our bodies. Between this oxygenation of the blood from the air, through the Lungs, and the digestion of the more solid food by the stomach, there exists an inseperable sympathy. When the stomach is loaded with a superabundance of food, we labour for breath; but when we breathe the oxygenated air of the mountains, or of the equally oxygenated air of the open & deepest ocean, we feel not merely an encreased alacrity & keener appetite, but a greater portion of food than ordinary can be digested without any oppression of the stomack, or labour of the Lungs.†

Respiration, beside occasioning an equable continuation of animal heat, is a most powerful agent in the circulation of the blood. Azotic air, or the fumes of burning sulphur will stop respiration, & the heart will cease to beat, unless you allow your patient immediately to inspire the pure atmospheric air, when he will directly revive, & his heart beat as before. This is not owing to the mechanical destention of the Lungs, but to the oxygen in the air.

This law in our natures affords a very important practical rule to the Physician in forming his judgement from the pulse, where he should always take into consideration the state of the air the patient breaths. If a sick man, in a confined place, receive the mephetic or azotic air of his own foul body, his ~~pulse pulse~~ pulse becomes depressed, & fluttering; its beatings become slower & slower; & the cause continuing, by degrees, all his vital functions labour, and at length appear to be suspended; the artery is nearly ceasing its motion, & death appears fast approaching. In this alarming

† ibid.

state, if you allow your ~~patient~~ expiring patient, to inspire the oxygen gas, properly diluted with common air, his pulse will begin to tremble, & then beat; he will fetch a deep sigh, which effort serves to heave round, if we may so speak, the wheel of life, & his pulse will beat as before, when warmth sensation, & cogitation will again return. And this refuge ~~species of resurrection to life~~ is effected by the simple inspiration of that principle in the air which turns the black, venal blood to a bright vermilion co-lour!

This wonderful principle, which some have called the univer-acid; others phlogiston; others impenial air, & which the French chymists have called Oxygen, when in com-bination with calovic, or the fluid matter of heat, is the grand, efficacious, & necessary instrument, which nature principally makes use of in all her operations. The fishes in the depths of the ocean cannot exist if deprived of it. So necessary is this vital air to the ex-istence of every animal, & every vegetable, that the eggs of animals, and even the seeds of vegetables, be they ever so ripe & perfect, will never bring forth the em-bryo contained in them, but will remain inactive & die, if cut off from this vivifying principle.

Of what importance this doctrine of oxygen & azotic air must be in asthmatic & consumptive disorders, phi-sicians of more experience than myself can best determine.

From what has been said, it appears that during res-piration the blood imbibes the vital part of the air, called

oxygen, through the membranes of the vessels of the Lungs; and hence the resemblance between this function & combustion. How this is performed we know not. The conjecture oppressed with the fewest difficulties is that which supposes that something from the inspired air pervades the coats of the pulmonary vessels by the power of chemical attraction. It is not to be expected that we should give an opinion, in the tone of decision. Nothing but probability can be expected in our present state of knowledge. Some future Franklin, Priestley, Lavoisier, or Davy may unfold this mys-tery of nature, so long hidden from the prying eyes of philosophers. It has been conjectured, that the oxygene of the air unites with the inflammable, or phlogistic part of the blood pro-ducing ammonia, or phosphoric-acid; & that it is this, which changes the colour of the blood from black to a bright vermillion, or scarlet; & that caloric was, at the same time, thrown out from the system through the Lungs.

It should be constantly borne in mind, in all our disquisitions on the vital functions, that the Lungs is by far the most complicated organ; & performs the most compounded function of all others in animal nature. Beside circu-lation & respiration, the Lungs is a sanguifying, or blood per-fecting organ. It is in the origin of the pulmonary vein, (where the blood is perfected, & prepared & fitted to answer the purposes of nourishment) that the "punctum saliens" of the blood exists: and it is at the extremity of the pulmonary artery, where it parts with its azotic, or carbonaceous properties, after it has gone through the course of the system, which constitutes the punctum ultimum of the whole.* We then

* See Sarmazzi

see that there is a set of vessels in the Lungs that receives the blood in its purest state; and another that returns it in its worst. That portion of the blood which is brought back by the returning veins, from all parts of the body can answer no purpose in the system for which blood is intended; as it constitutes the residuary matter only, or refuse of the whole, being too grofs, and too azotic to afford nourishment for dying parts, & too impure to be acted upon by the living. Its impurity is marked by its blackness, and its corrected state by a bright vermilion, or scarlet colour. Its black state carbonates, or azotifies the inspired air; while the oxygen received, animates & perfects the blood, by the process of oxygenation.

The probability that we are every moment receiving a spark of fire from "the Father of Light", through the instrumentality of the air, is an animating thought!

It is probable that, if our bodies were transparent like glass, so that we might see all that was going forward within us, in the Lungs & heart, during respiration; and if this transparent body were placed in a dark room; & the breathing stopped, for a few moments, so as to turn the blood in the lungs black, and then allow the air to be inspired, should we not see a flash of fire in the lungs & heart, at the very moment when the pulmonic blood assumed its high scarlet colour? We probably should. That this glow of scarlet is a flash of fire (similar to electricity, or galvanism)

none can doubt, who have attended to the subject.

I know not how it strikes others; but I confess that the idea of our receiving, every moment a spark of celestial fire to ~~animate~~ keep up life, ~~an~~ animate our bodies, and light up our souls, has in it an air of grandeur inexpressibly impressive, and consoling, while travelling through some of the dark and dismal scenes of this world! and must inspire a veneration for that Divine power, which "breathed into man's nostrils the breath of life", in consequence of which "he became a living Soul".

Let there be at least half a blank leaf, or a whole one between Thy & Dr Pp's paper

Appendix —

We did not wish to deviate from the strait road of our discussion into any of the byepaths of theory; & have therefore thought it best to reserve such desultory matter for an appendix.

After Harvey demonstrated the circulation of the blood, this puzzling question forced itself upon the minds of the physiologists - What is the use of the Lungs? It was not untill a century & an half afterwards, that Priestley & Lavosier revived by their experiments, the antient idea, that the air in respiration undewent a change similar to what it did in combustion. It was found that the same quantity of air was expired as was inspired; but that a portion of it was materially altered; & that not negatively but positively, & becoming absolutely deleterious. They found that this portion was a carbonic acid gas.

As a considerable quantity of water was observed to be expired in the form of vapour; & this has been attempted to be accounted for by the Hydrogen secreted from the Lungs being united with the atmospheric oxygen, & so forming water. But when we consider that it requires some of the most powerful reagents to produce this effect out of the body, we can hardly believe that an operation so inconsistent with the simplicity of nature, takes place within us.

Hydrogen, which is a constituent both of the animal solids, & fluids, & exists in them as a fluid, & as a solid also, may be secreted through some organic structure that is unknown to us, & may be thrown out in a fluid form, and may be brought into contact with the oxygen of the atmosphere, & uniting with it form water. But why ~~should~~ need we have recourse to this

complex operation to account for the water emitted from the Lungs in form of vapour, when it can be explained on the easiest & most palpable operation? This savours too much of the doctrine of the effervescence of acids & alkalies; & of intestine fermentations in the blood causing the cold fit, & hot fit of fevers, & as taught Sylvius de la Boe, than of the simplicity of nature. It is too much like the mathematical physicians, who imagined they saw all the mechanical powers in the human body, not even excepting the screw. The works of man are marked by a very complicated machinery to produce a simple effect; but the works of Nature, like the obliquity of the axis of the Earth, are dignified by a simple contrivance, producing manifold effects & con-veniences.

We know full well that every circumscribed cavity in our bodies is replete with water, which is taken up & modulated by the Absorbents; ~~as is the case of the urine, of the~~ or else is thrown out of the system as an excrement; as is the case in the urine, in the perspiration, & in the vapour from the Lungs. This operation is simple & palpable. Why then have recourse to chemical hy-potheses?

As air once respired looses its power of supporting life, the great question is what is that change whereby it looses this power of animation? Whatever be the comparative proportions of oxy-gen & azote in atmospheric air, the quantity of the latter is thought to be the same when expired, as inspired; but this is not the case with the two other ingredients, viz the oxygen & the carbonic acid. They are found to vary in their proportions; the oxygen almost en-tirely disappears, while the carbonic acid gas is increased in proportion to the diminution of the oxygen. Quick silver becomes red by com-bining

combining with a maximum of oxygen; so does iron, copper, manganese & chrome. The blood changes from a dark colour to a beautiful bright vermilion, by exposure to the atmospheric air; & the presumption was, that as the changes were analagous, the cause must be the same.

That the oxygen disappears, & the carbonic acid gas is generated, we find proved by breathing through lime water. Carbon is a constituent part of the blood; but we have no proof of the existence in our bodies as carbonic acid. The carbon therefore must have absorbed the oxygen, & united with it, and been given out again; & thus becoming a gas, & requiring a certain quantity of caloric to sustain it as a gas. But as it is a dense gas, it will require a less quantity of latent caloric

A gain. — An 100 cubic inches of oxygen weighs, according to Davy 35.09 grains, at 55° of Fahrenheit; & 34.70 at 60° Fahren, and 30 inches of the Barom; and according to Allen & Pepys 33.82 Therm. 60° Barom. 30.

An 100 cubic inches of carbonic acid gas weighs, according to Davy 47.5 grains, Therm. Fah 55°. Barom 30 inches & 47 Therm. 60° Bar. same presume. — According to Allen & Pepys 47.26 grs Therm 60°. Bar. 30 inches. — Thus, by calculation, we have an average difference of 13.03 grs nearly; and as the capacity of any body for caloric, or its specific latent caloric, is inversely as its density, nearly, the union of the carbon of the blood with oxygen will extricate a portion of the latent caloric, & make it sensible. As the average difference between the carbonic acid gas & oxygen is 13.03, or nearly, is to the average quantity of oxygen 34.53, so is the caloric evolved, to the quantity of oxygen which has disappeared. Here we account for the oxygen disappearing, & for the generation of carbonic acid gas; and shew likewise that caloric

must be evolved, since it is ascertained that the augmentation of the temperature of the blood by its passage through the Lungs is only one degree; which must have been greater, were there not some other way & means by which the heat should be carried off.

The next question is where does the carbon, which is found in the expired air, come from? We have said that carbon was a constituent part of the blood. Is the blood then decomposed in the Lungs, so as to yield its elements to the all powerful oxygen of our atmosphere? We suppose that that portion of the blood which is animalized, or just converting into the living fibre, as well as every live part & point of our bodies, is constantly oxygenating; and that by this process a portion of carbon is separated from the blood, & brought successively, & alternately to the Lungs; and while it marches out of the citadel of Life with its dark colours, the vital principle, or oxygen marches in with his scarlet ones. And we would beg leave to insinuate by this flourish of colours, that if we have not completly succeeded in our enterprize, we hope it may appear that we have not quitted the ground we had taken with dishonor.

Recapitulation

Our theory is explicitly this; — The oxygen in the inspired air, enters the membranes of the Lungs, by the force of an operation resembling chemical attraction; & combines with that portion of the blood, which is brought, virtually, in contact with the atmospheric air, by the pulmonary veins, & combines with the carbon, with which these vessels are surcharged. This operation takes

from the venal blood its black colour, & imparts a scarlet ~~one~~, or an intensely high vermilion one; and this is the first, effect of the process of Respiration.

The second effect of respiration is the evolution of calorie, by the condensation of the two gases, the oxygen & the carbonic; & that this compounded operations keeps up the focus of heat in the Lungs; ~~which~~ this idea is supported by the fact, that those who respire, by way of experiment, the oxygenous gas, affirm that they perceive an increased heat in the breast, & extending from thence to all the other parts of the body, together with a remarkable elevation of spirits, and energy of mind. And finally that the Lungs, in common with every other moistened part, receives its portion of water from the exhalent vessels, & not from the formation of Hydrogen.

"The Lord God formed man of the dust of the ground, and breathed into his nostrils the Breath of life, and man became a living soul."

Genesis 2d. Chap. 7. verse

This Dissertation is sent to D Hayward — with the accompanying letter bearing the motto Familiarity.

Decr. 17th. —— In this days Patriot is Rd p Wright