An essay on the lungs : ascertaining their true functions to be contrary to the present adopted opinions ; and leading to a treatment of consumptions, and other pulmonary diseases, which promises more success than has been experienced heretofore ; in a series of numbers / by John Christopher Stroebel, physician in New-York.

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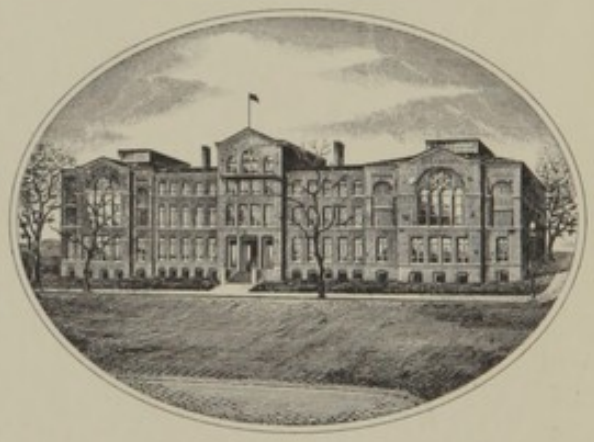

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Stroebel (J. C.)

AN

ESSAY

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IN A SERIES OF NUMBERS.

BY JOHN CHRISTOPHER STROEBEL,

PHYSICIAN IN NEW-YORK.

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1810.

TO THE

ROYAL PHILOSOPHICAL SOCIETY

IN THE CITY OF LONDON,

THESE NUMBERS

ARE MOST SUBMISSIVELY DEDICATED,

BY THEIR MOST RESPECTFUL,

MOST OBEDIENT, AND

MOST HUMBLE SERVANT,

JOHN CHRISTOPHER STROEBEL.

PREFACE.

IF there is an organ in the human frame whose particular construction is especially calculated to strike the mind with admiration, and impart a conviction of the special agency and infinite wisdom of the Creator; whose utility and economy have to this day been egregiously mistaken by physiologists; whose functions are synonymous with the life; and whose disorders are more destructive to the human species, (particularly in Great Britain and North America,) than any other class of diseases, it is that called the Lungs. To form, therefore, correct conceptions on these several relations, must be of the utmost importance to mankind.

What induced the author to the particular investigation of this subject, and the bold step of deviation from the generally adopted theory and practice in the treatment of the derangements of the lungs, and to endeavour to attain to a more correct and comprehensive view of the animal economy, as well as more efficacious means in the practice, was, that his own life was at stake, and depended on his success. Having derived a hereditary propensity to consumption from his ancestors, (they having been successively cut off in the prime and vigour of life,) and feeling early the alarming symptoms of colds affecting the pulmonary organs, he had most urgent reasons for every exertion to guard against the fate which threatened him. Flattering himself, therefore, not to have been unsuccessful in his researches, he has resolved to publish his observations for the good of mankind.

The writer, deriving the admonition from some recent instances, could not but be aware that his philanthropic efforts might have to combat, in their progress, with a host of prejudiced and critical opponents; and as that portion of the community whose scientific acquisitions, liberal minds, and philanthropic dispositions render them fit to sit in judgment on these subjects, is uncertain and small, in comparison of those whose sentiments are immoveably staked on the modern decisions of splendid and popular authority, who are apt to look upon all attempts at renovation and improvement as the mere efforts of ambition or speculation, and who cannot or will not look beyond the pale of fashionable precept: He has deemed it expedient to appeal for the higher and more honourable decision. To convince the world that he seeks not the obscure path, and shuns not the light of strict investigation; conscious of the rectitude of his design, and that nothing but a fair developement of the truth is intended, he has taken the liberty of dedicating this Essay for the inspection and decision of that great tribunal of the literary world, the Royal Philosophical Society of London, under the full conviction that the gentlemen of the medical department will honour it with their notice, and secure to mankind those important benefits which are the exclusive objects of the author's endeavours.

INTRODUCTION.

AT a period like the present, when all the other arts and sciences are far advanced towards their consummation, it may seem strange, that the healing art has lingered so much in the rear: nor has it progressed equally in all its departments. Anatomy and Chemistry have, by fine touches, careful analysis and infinite compounds, been pushed to exceeding minute developement, while physiology and pathology, have been rendered more complex and obscure by the advocates of contrary doctrines. However, the wonder will presently cease when we consider the circumstances which mark the different pursuits. The anatomist can dissect by the aid of optics, and the chemist analyze, or form compounds, by his improved laboratory, at discretion; but this is not the case with the physiologist; he is obliged to recur to various auxiliary sciences for the attainment of his knowledge, and infer from a group of indications, or well known analogies; or by certain experiments and facts direct his judgment, and he is bound by fashionable doctrines, unless he assume more substantial ground for his investigation, and weigh in a more scientific scale his propositions and his arguments; taking for his basis incontrovertible facts, and deducing from them more rational conclusions. However, it must be observed, that experimental philosophy has but very lately unveiled those requisite facts to our view, and in the important discovery has exhibited secret and powerful agents in animal economy, which were only supposed to exist aforetime, but with their real nature we had no actual acquaintance.

The late experiments made by a committee of philosophical gentlemen in Paris, by order of the national institute, on the effects of the galvanic fluid on the muscular fibres, have greatly enlightened that formerly so obscure subject, animal motion; we now know the nature of the nervous fluid, the functions of the nerves, and their connections with, and influence upon, the muscles: we can form a satisfactory conception of the causes of animal heat, agreeable to nature, reason and experience, and we can now decide the important questions:

Whether the blood is endued with life, or is a dead matter, subject to the laws of the inorganic or mineral kingdom, and always in a state of putrid fermentation?

Whether the blood receives oxygen and discharges carbonic acid gas, or whether it receives no oxygen, but discharges carbon, and carbonic acid gas?

Whether the human body gains or loses substance by respiration? and whether we receive the pabulum vitæ from the air through the lungs, or from food and drink through the stomach?

Whether the body receives the electric matter from the air, or whether the animal system generates the galvanic and electric fluids, and emits the electric matter to the air?

Whether animal heat originates in the lungs, or in the extremities of the blood vessels throughout the body? and how local heat is produced in inflammatory tumors?

Whether respiration cools or warms the lungs?

Whether oxygen acts as a stimulus or as a sedative in respiration? and whether there are any sedative medicines, or all act as stimuli?

Whether cold, being a negative quality, can do any positive harm?

And whether consumptions are curable or not?

When these and many other questions are decided contrary to the generally adopted opinions, they must cause a revolution in the theory and practice of the healing art; and it may be reasonably expected, that much opposition will be made to their establishment; but truth will sooner or later prevail, and in order to secure to the world any benefits which may be derivable from these investigations, the author has adopted the precaution of his high appeal, confident of the more certain success of his benevolent design, when supported by the approbation of that illustrious body of learned gentlemen, which constitute the Royal Philosophical Society.

AN ESSAY ON THE LUNGS.

NUMBER I.

MAN is a world in miniature; and as the study of natural history is divided into three kingdoms, agreeable to the laws by which they are governed, so also is the study of the human body to be divided in like manner; the animal fluids being subjected to the laws of the mineral kingdom, or to the laws of inanimate matter; the hair and the nails to those of the vegetable kingdom; and the nerves and muscles are governed by the laws of vitality.

Before we proceed, however, to the consideration of that complicated and animated machine, the human frame, it may be proper to observe, first, what is to be understood, at this time, by the terms of simple and compound matter.

The component or elementary principles of all the solid and fluid substances of this globe, seem to be light and air, the solar and terrestrial, or rather, aërial bases, uniting together in different proportions, form the three gases, which in the new nomenclature are called oxygen, hydrogen and carbon; these again uniting in different modifications form azote, carbonic acid gas, and water.

Professor Davy has found oxygen to be combined with light. (Vid. Dr. Beddoes' Western Contributions.) The same gentleman has also very

lately investigated nitrogen or azote, and shown before the Royal Society, that when azote disappears, nothing can be obtained in its place but oxygen and hydrogen; and when azote is formed, its elementary matter is furnished by water.

It has been maintained during the last fifteen years, that oxygen and hydrogen uniting form water. This combination is now again disputed. Its decomposition has always been doubtful to me, because in Bergman's tables of chemical attraction, pure air and phlogiston occupy the first stations, that is, they have the strongest attractions for each other; at least, at the time when these tables were formed, no decomponent was known, and no especial one has been pointed out since. And the doctrine of the decomposition of water during a solution of iron in contact with diluted vitriolic acid, had no good foundation, as long as the neutral salt produced was vitriol of iron. However, whether water be composed of hydrogen and oxygen or not, it will cause no difference in the arguments of this Essay; it is sufficient that it is universally allowed, that carbon and oxygen form carbonic acid gas; and I consider carbon to be a species of phlogiston or inflammable air.

In the specimen of an arrangement of bodies, according to their principles, Mr. Davy has expressed his opinion, that all metals, salts and earths, are compounds of oxygen, hydrogen, azote and carbon. (Vid. Dr. Beddoes' Western Contributions.)

That light and air should be the bases of all solid bodies, even of rocks and metals, might at first seem a paradox; but it is a fact which has been ascertained innumerable times, that the hardest substance in nature, which is the diamond, has, by the addition of heat and pure air, been convert-

ed into an invisible vapour, viz. carbonic acid gas, without even leaving any ashes behind. This experiment gives to the diamond very much the appearance of concentrated light; and we may with great certainty conclude, that all bodies which can be converted into air, may have been originally formed from air.

Water is continually evaporating, not only in the state of steam, but also in that of a more diffusible vapour, which is not condensable by cold, as ice evaporates. Inflammable gases are also constantly ascending from fermenting and putrefying vegetable and animal matter. These and other gases may, by chemical attraction, form, in the higher regions of the atmosphere, such compounds, as frequently come to our view under the appearances of different meteors; they are particularly discernible in the night on account of the red or white heat, or light, which they emit, and which they have contracted by the condensation of that large space which they occupied before their formation, and which disappears by their concentration to that small space and heavy state in which airolithos descend to the surface of the earth. For it has been demonstrated before the Manchester Philosophical Society, that all air, when condensed chemically, or compressed mechanically, emits sensible heat; and all air when rarified, at that time absorbs heat, or generates cold.

The mineral world would be a dreary desert, did not a certain principle, which is the cause of vitality, act upon inert matter, and form organized bodies, vegetable and animal. This principle is capable of forming bodies by an increased combination of simples, and double compounds, constituting variously multiplied combinations. Many of

these are formed and retained in their organic and animated state, by the agency of the vital principle, contrary to the laws of chemical attraction. As soon, therefore, as life has abandoned them, they undergo the chemical process of fermentation and putrefaction, which is that arrangement of matter, which chemical attraction effects, when the ingredients of bodies are under favourable circumstances, accompanied with certain degrees of heat and moisture.

This fermentative process, which decomposes organic bodies, is also necessary to the formation, growth and support of vegetables and animals. For as the brewer, in making malt, to cause the barley to grow, adds moisture and warmth to it, which sets it in fermentation, causes spontaneous heat, and the sprouts, and the roots to come forth: so also does the same fermentation take place in the seed grain in the ground; and when the sprouts and roots have consumed the body of the fermented grain, the leaves draw nourishment, not only from the sun, but also from the vapours which ascend from fermenting and putrefying substances, as has been shewn by Dr. Priestly, and many other experimentalists.

Animals are also supported by this fermentation. Notwithstanding digestion is, properly speaking, a solution of food in the stomach, by means of the gastric juice, which is the foremost agent in this work, yet the natural fermentation and putrefaction also takes place, according to the laws which govern organic bodies, when life has abandoned them, and as long as they retain life the gastric juice cannot dissolve them. That this fermentation of the food does take place, may be inferred from the air which is formed in the intestines. This is not only carbonic acid gas, but also a quantity of inflamma-

ble air. Here it is to be observed, that this fermentation continues after digestion, in the receptaculum chyli, but particularly in the blood vessels, as well in the veins, as the arteries.

As all inorganic matter is governed by chemical attraction, aggregation and gravitation; and as by elective attraction the different gases unite and form solid matter, which accumulates by aggregation and increases in bulk, and then by gravitation descends towards the surface of the globe, and by the condensation of rarified vapours, bodies become heated: in the same manner are the fluids of the world in miniature governed. The salutary and the morbid combinations of the ingredients of the blood, are effected by the laws of affinity or chemical attraction. Calculi, incrustations, mucous concretions, and polypi, are formed by the law of aggregation; upon this law also depends the coagulation of the blood, when it either moves too slow or stands totally still. The gravitation of the animal fluids is proved in the vascular system by the provision of valves, which nature has instituted in all cases where the fluids have an ascending motion; and the heat of the animal fluids is derived from the condensation of part of the air which is inspired by respiration.

Seeing then that the blood is governed by the laws which rule inanimate and inorganic matter, we have no reason to consider it as being endued with life, or the vital principle, as has been suggested and advocated by Mr. John Hunter, and others.

To distinguish the vital agency from those changes which are produced by the laws which govern inanimate matter, it is necessary to form more correct conceptions of the vital actions, than those which have been assumed before: for this purpose

we have to consider the agents of life, under the denomination of the vital powers.

The FIRST vital power is the vital principle. The origin and the pabulum of this remains yet unknown. Its propagation in vegetables and animals is conducted by the union of the male semen with the female ovum. The Lynnæan sexual system of botany is founded on the variety of the generative parts of this principle. Although the Creator has determined that it should be generally propagated by male and female connection, yet the mode of executing this, he has so much diversified, that in the many thousand different species of vegetables, there are not two in which the flowering, and fructification are conducted exactly alike.

No seed grain can grow which has not been fructified by the vital principle, or in which that power has become extinct. Its extinction may be caused in seeds by age, e. g. being more than one or two years old, or by boiling-water heat, or by immersion into caustic substances, e. g. lie, lime, &c.

The vegetable vital principle, as well as that in animals is endued with instinct; that is, it possesses that mental power to act wisely, for the preservation of the body, according to circumstances. In vegetables it sends forth roots, in such directions only, from whence nourishment and support can be drawn. In the fœtus of man it causes the heart to beat, before the brains and the nervous system are formed, and in the case of diseases it is the vis medicatrix naturæ.

The SECOND vital power on which vegetable and animal life depends is heat. In a temperature below 35 degrees, vegetables may live, but cannot thrive, and the vital principle cannot act at the freezing point.

The first supply of heat, which is necessary to warm-blooded animals, for their formation, and growth to perfect animals, is derived from their parents, either in or out of the body; they are either matured in the womb, or they are hatched; and in their tender age are frequently in need of auxiliary heat, either from the sun, or from fire or parent bodies. Man in particular requires, in his infant state, to be carefully guarded against the noxious influence of a cold atmosphere on his tender frame.

All cold-blooded animals, and even some of those which have hot blood, are capable of going into a torpid state in winter. What this torpidity is cannot be explained, unless we admit, as an established truth, the constant fermentation of the blood in active animals. When, under certain degrees of low temperature, fermentation cannot be maintained, all action ceases, respiration cannot be supported, and the thorax, which has before been a perpetuum mobile, must now stand still.

Animals in a torpid state are to all appearance dead; but, as the vital principle does not leave them, their bodies undergo no kind of change, and they are resuscitable in an atmosphere of higher degrees of temperature, although active life may have been suspended some hundred or thousand years; as we have experience of toads and frogs having been found in blocks of timber and of marble, or in clay of a considerable depth, which have been restored to active life.

The THIRD vital power is the galvanic fluid. This is a particular modification of matter, with which, till lately, philosophers have been totally unacquainted. This is the nervous fluid which anatomists and physiologists have been so long in

quest of. The mechanism and chemical combination of the nerves are principally constructed to convey it. In vain have anatomists been always searching for a tubular form in the nervous construction, without which they supposed no fluid could be conducted. However, as it is now understood that the electric fluid can be conveyed by solid metallic rods, so it is also found, that the galvanic or nervous fluid can be conveyed by the solid nerves from the brains to the muscles.

In reference to its degree of rarefaction : the nervous fluid is less rarefied than the electric matter, for the latter can pass through the meninges of the brains, and their elongations, which serve as sheets to the nerves ; but the galvanic fluid cannot penetrate these membranes; they therefore confine the nervous fluid, and cause it to follow the particular course of the nerves. Even the tunica adiposa or cellulosa is impermeable to the galvanic fluid, and by these means is its operation confined to the particular muscles, to which the nerves serve as conductors. In order to obtain a full and comprehensive view of the effects of the galvanic fluid on the muscles, we have to take notice of the FOURTH vital power, which is the susceptibility of the muscles.

This susceptibility is a certain capacity in the muscular fibres (depending on the presence of the vital principle) to contract upon the influx of the galvanic fluid. This contractive power is strengthened by alternate exercise and rest ; and weakened by too long and too strong contractions ; by narcotics, by distilled spirits ; and is totally exhausted or destroyed by alcohol.

The FIFTH vital power consists in the nerves. They have two functions, first to carry sensation to the brains, by the means of their sensibility ;

and, secondly, to convey the galvanic fluid from the brains to the muscles.

The three last mentioned powers, viz. the galvanic fluid, the muscles and the nerves, are the three agents of motion, and constitute the moving system. Motion is performed, when the sensations of the nerves are carried to the brains, as quick as lightning; and the galvanic fluid is sent from the brains to the muscles with equal velocity, and the muscles contract, which brings those parts nearer together into which the heads and tails of the muscles are inserted.

Every set of nerves is endued with a particular sensibility. The optic nerves are sensible of light, the olfactory nerves of odours, and those of the ear are sensible of sound. The mouths of the absorbing vessels, and the openings of the secretories, must be endued with nerves whose sensibility is affected only by those fluids which they are destined to select from the mass. Thus is absorption, secretion and excretion conducted by the especial sensibility of the nerves of the vessels. How extremely delicate the perceptions of the nerves can be, is proved by the olfactory nerves of a dog, which can follow the footsteps of his game and of his master. It must be a very small quantity of matter which can be emitted at each step, and a much smaller quantity which adheres to the earth, stones or wood, with which the foot has been in contact; and of this there is some continually evaporating: therefore it is admirable to consider, how very subtile and rarefied that vapour must be, which is continually ascending from a footstep, and yet is capable of being perceived by the olfactory nerves. How very fine then must be the capacity of these nerves, which not only perceive

it, but also distinguish it from any other nearly similar vapour, even in a running course?

Whatever diminishes this sensibility of the nerves and the susceptibility of the moving fibres, impedes absorptions, secretions and excretions. This is effected by narcotics, particularly by opium, and also by a fever paroxysm; at which time the vis medicatrix naturæ nauseates tobacco, which is a narcotic.

The ideas which were formerly expressed by the terms excitability and excitement, are now to be viewed under the three distinct capacities which form the moving system; and excitability may be excessive or defective, from too much or too little sensibility of the nerves, from too much or too little susceptibility of the muscular fibres, and from too much or too little of the galvanic fluid.

The commissioners, who were appointed at Paris for the examination of the effects of the galvanic fluid upon the muscles, have observed, that when the atmosphere is dry and cold, or the body charged with electric matter, and insulated, the muscles are much more susceptible than under such circumstances which favour the escape of the electric fluid. This shows the influence which damp and warm air has to diminish the agency of the moving powers; and it seems that in a state of good health the body is filled with electric fluid, which is continually carried off, according as the atmosphere is a good or bad conductor.

The SIXTH vital power consists in those substances which the body takes as nourishment. There are four ingredients of food continually wasting and discharging from the animal frame; these must, therefore, be repeatedly replenished, else either a high degree of putrefaction and a

morbid fermentation will take place in the blood, or a consumption and death will follow.

The first ingredient which is continually discharging from the body is water. This is the base of the animal fluids, and passes off by perspiration, respiration and urine. The second substance constantly emitted from the body is the fat. This is the abulum of animal heat, and is discharged through the lungs in the state of inflammable air.

The third ingredient of food which is continually changing and discharging from the body, is a variety of salts. These are the substances employed by the vital principle to stimulate the nerves in the acts of secretions and excretions; they undergo various decompositions, they become animalized and volatile, and are discharged by urine and perspiration.

The fourth ingredient of food which is constantly liable to diminution, is the animal gluten or mucilage. This is the base of the muscles; it lines numerous mucous membranes, and in consumptions is wasted by too frequent and excessive expectorations.

The SEVENTH vital power consists in the action of some stimuli. When Dr. Rush wrote his treatise on animal life, in which he declared life to be a forced state, depending merely on the actions of stimuli, and that there was no such thing as a vital principle, he did not notice any of the preceding powers; and particularly those three on which muscular motion depends, were at that time buried in obscurity. Although not one stimulus was mentioned as absolutely necessary to life, yet we have, at this time, to take particular notice of one upon which the life of man exclusively depends; that is, that inflammable air, which is generated by the fermentation of the blood, and which acts on the

nerves of the lungs as a stimulus, producing that perpetuum mobile called respiration.

The doctrine of inflammable air being discharged from the blood in the lungs, in the act of respiration, is contrary to the report of experiments which has lately been made by Messrs. Allen and Pepys, and which has been laid before the Royal Society. However, this report cannot deter me from pursuing the road I have entered, and which I hope to clear of all impediments, so that others may easily follow; and I flatter myself, that even these identical experiments will confirm my doctrine, and prove what those gentlemen were not aware of, or what has come to pass without their noticing it.

The report says, "that the quantity of carbonic acid gas emitted is exactly equal, bulk for bulk, to the oxygen consumed;" and they conclude, that "therefore there is not any reason to conjecture that any water is formed by a union of oxygen and hydrogen in the lungs."

If no water, but carbonic acid gas is formed, then there is no great difference in the gases which are generated in the blood by the putrid fermentation of that fluid, and discharged in the lungs. Whether it is hydrogen or carbon, they both are inflammable airs, and can be produced and discharged by the decomposition of dense inflammable substances. And there are various reasons from which it becomes conclusive, that only a part of the carbonic acid gas which is discharged in respiration, has in that state come from the blood; the remaining and greater part will be proved to have been formed in the lungs by the union and decomposition of oxygen and carbon.

That the oxygen which disappeared has not been absorbed by the blood in the lungs, and that

all the carbonic acid gas has not been emitted from the same fluid, is plain from this circumstance, that it is contrary to the nature of these gases to be exchanged in this manner; for carbonic acid gas is ten times more miscible with blood, water and other fluids, than oxygen gas. If it were asserted that oxygen was first discharged from any fluid, and afterwards the same quantity of carbonic acid gas absorbed, this might be considered as practicable, but the reverse is totally impossible; and that fluid which cannot retain a certain quantity of carbonic acid gas, cannot, immediately after, receive the same quantity of oxygen.

What becomes of the oxygen which disappears in respiration, and whence arises the carbonic acid gas, will be presently shown. We have to consider, first, that all liquors which undergo the fermentative process, discharge carbonic acid gas and inflammable air. This latter is sometimes called hydrogen, and at other times carbon. As they are the same substance, merely with some small variation, both modifications may be discharged in the fermentation of different liquors, and also in that of the blood. It has been generally believed, that the union of hydrogen with oxygen forms water, and the union of carbon with oxygen forms carbonic acid gas. This carbon or hydrogen is always discharged in fermentation in greater quantity than the carbonic acid gas. If, then, the lungs discharge this latter gas from the blood, we have to suppose a fermentation in that fluid; and, if this is the case, inflammable air must also be disengaged; but the latter is not to be found in the expired air, because it has met in the lungs with oxygen, which has decomposed it. The same is the case with fermenting liquors; let a tub thereof be exposed to the atmosphere, and

presently a large quantity of carbonic acid gas will be found floating upon the top of it. I attempted, twenty years ago, to impregnate a quantity of pure water with fixed air, which was to be discharged from fermenting sugar, from which the atmospheric air was excluded; but I could not procure one half of the quantity which I expected, because the greater part of the gas generated was inflammable air; and I found that by the free communication with the atmosphere only, this carbon was converted into carbonic acid gas. The same circumstances and discharge of vapours take place in the lungs. The carbonic acid gas discharged in respiration cannot all come from the blood, without a great quantity of inflammable air being generated and emitted also; but the latter uniting with the oxygen in the lungs, forms the greater quantity of the carbonic acid gas which is discharged in respiration.

If carbonic acid gas be a compound of inflammable air or carbon with oxygen, and if 79 grains of oxygen unite with 21 grains of carbon, it follows, that if oxygen disappears, and it cannot be accounted for, and carbonic acid gas appears, which also cannot be accounted for, then oxygen must have united with carbon.

Carbonic acid gas is double the weight of oxygen, and more than twenty times heavier than inflammable air. If, then, the same measure of carbonic acid gas be discharged, bulk for bulk, compared with the measure of oxygen, which disappears in respiration, then it follows, that double the quantity of matter is discharged to that which has been retained; for the quantity of matter in different substances is not to be calculated by measure, but by weight.

If eight measures of oxygen disappear, it takes twenty measures of carbon to form the union, and both can produce only five measures of carbonic acid gas. If, then, eight measures of this gas are discharged at the same time, it must follow, that only three measures of this latter gas came from the blood, and twenty measures of carbon or inflammable air from the same source, and these united with eight measures of oxygen, altogether form eight measures of carbonic acid gas.

Messrs. Allen and Pepys have also stated, "that a larger proportion of carbonic acid gas is formed by the human subject from oxygen than from atmospheric air."

This can only be accounted for by allowing oxygen to be decomposed in the lungs; for if more oxygen is introduced into the air-cells than ordinary, a greater quantity of carbon, which is in these cells, is decomposed, and more carbonic acid gas formed. If this latter gas, completely formed, were all derived immediately from the blood, a greater discharge of it could not be caused by a few inspirations of oxygen.

As by the union of eight measures of oxygen with twenty of carbon, so great a condensation and reduction in bulk takes place as to leave only five measures of aërial fluid out of twenty-eight, which space they occupied before, it follows, that sensible heat must consequently be produced, according to the laws of condensation and rarefaction.

This production of sensible heat I consider as the sole cause of animal heat. On this subject I flatter myself to have been the first who, in the year 1787, had formed a systematic arrangement, which I laid before the Philosophical Society at

Philadelphia, who honoured it with their public approbation, and declared that it contained " new and valuable observations," although it could not claim the first Magellane premium, as discoveries in natural history were excluded from that reward.

Not long before that time had Dr. Rigby published his theory on animal heat, ascribing it unsuccessfully to mere intestinal fermentation. At the same time came also Dr. Crawford's experiments and theory of animal heat to America; but, as he maintained that sensible heat was produced throughout the body, I could not coincide with it. Dr. Priestley's first two volumes of experiments on air and respiration had also arrived then in America, from which I learned that fire was required in the rarefaction of substances, and that it absorbed heat, and that mixtures of two airs produced sensible heat, when a reduction in the bulk of the gases took place. From these circumstances I had formed my theory of animal heat, the general principles of which had, by that time, induced many in Europe to draw similar conclusions from the various labours of the experimental philosophers. However, this theory of animal heat, founded on the union of pure air and inflammable air in the lungs, was, soon after its adoption, again abandoned.

For, when Mr. Lavoisier and his followers, maintained, that the calcination of metals was merely an absorption of oxygen, and that no phlogiston was present in that process, it was soon concluded, that the calcination of metals, combustion and respiration were similar processes, in which no phlogiston or inflammable air is present, but that all depends upon the absorption of oxygen, which change is called oxydation. However, as long as Dr. Priestley did not subscribe to that

opinion, I was not ashamed to hold to the first theory; and every year in the twenty-two since has given new proofs of its correctness; but particularly during the last two years, the experiments made by the means of galvanic electricity, have thrown so much light upon many subjects, which were in total obscurity before, that we may now proceed in many of our investigations, as by the break of day.

It is not to be denied, that the calces of metals are heavier than the metals were before calcination; it is therefore admitted, that a material substance has been added to it, and we agree that this substance is oxygen. However, as in the combustion of wood, the heat expels inflammable air; and, as I have seen iron so heated that it burned in a flame, I can form no other conception than that the inflammable air of the iron, uniting with oxygen, formed the flame of blazing iron, exactly similar to the burning of fuel. In the latter, both gases uniting, form water or carbonic acid gas; but, in the case of burning metals, the calx attracts the water and carbonic acid gas, or whatever new substance is formed by the union of the phlogiston of the metal, with the oxygen; the iron forms the cinders, in which Dr. Priestly has discovered water. Other metals form calces, which gain an additional weight, probably by attracting the carbonic acid gas.

There are various species of combustions, some proceed with rapidity, and produce great heat and strong light; others, like the phosphorus, burn very slow, with very little light, and little heat; but all combustions are a union of inflammable air with oxygen. The fermentation of vegetable substances, when they have lost the greatest part of their moisture, very much resemble combustion; inflammable gas is discharged, which unites with

oxygen, and produces heat, but generally not so great as to show any light; and similar to the fermentation of a stack of hay, is that evolution of inflammable air in the lungs which produces the animal heat.

When the grass has been cut down, and is drying in the sun, it loses its vital principle, and becomes a dead matter. When this is collected together into a large stack, or is stowed away in the barn, and a small degree of moisture is yet retained in it, the moist parts undergo a fermentation. In this process hydrogen, carbon, and carbonic acid gas are discharged, and the hydrogen and carbon attract and unite with the oxygen of the air, which fills the interstices between the numerous stems and leaves. This union produces steam and carbonic acid gas, which latter gas is more than five times denser than the bulk of carbon and oxygen; and when a condensation takes place heat is emitted. The steam is attracted by the hay and converted into water by its lower temperature; this hay also receives the heat, and by these means it becomes hot and damp, even to the feelings of the hand. This the farmers call the sweating of the hay. This fermentative process would continue to putrefaction if the hay contained enough of moisture, or it would kindle in a flame if it had a sufficient supply of oxygen; but when this is exhausted in the stack, no more hydrogen and carbon can be decomposed. The gases, therefore, ascend into the atmosphere, and carry the small quantity of moisture which the hay contained with them, and all fermentation ceases for the want of moisture.

As the inflammable air, escaping from the stems and leaves of the hay, unites with the oxygen of the common air in the interstices, so does the inflammable air escaping from the capillary blood

vessels in the lungs, called the rete mirabile Malpighi, combine with the oxygen in the cells, and both gases are converted into carbonic acid gas, and probably some steam may also be formed by it. This union of gases, causing a condensation, produces sensible heat, which is immediately communicated to the lungs, and to the blood which they contain.

Thus I flatter myself that the cause of animal heat will be more easily comprehended by this familiar analogy, than by those explanations in which it is asserted that oxygen is absorbed by the blood. This supposed cause of animal heat Dr. Reid describes in his Treatise on Consumption, p. 50. in the following words: "That portion of the air which is received into the lungs at every inspiration, and rendered concrete in these organs, is to be regarded as operating in the preservation of animal temperature by virtue, not of its chemical agency, but in common with other stimuli, upon which the regular and healthy functions of the animate machine are momentarily dependent."

If light and air, the solar and the terrestrial principles, are the bases of all material bodies, and if we are to ascribe to one an active, and to the other a passive power, the question is, to which of them the preference is to be ascribed? The sun being the centre round which the planets revolve, and from which they receive the most beneficial influence, might lead us to expect the solar to be the most active principle; but those who maintain that air is absorbed by the blood in the lungs, give to the aërial base of matter the preference, and attribute to the absorption of the oxygen the motion of the heart; they also suppose the nervous fluid, and even thought and perception, to be derived from hence. Dr. Stahl, a German chemist, held the opposite

opinion; he ascribed to phlogiston, or the inflammable principle, the most active properties in matter; he attributed to that not only the glimmer and ductility of metals, but also the origin of colours, odours, and many volatile qualities of matter. Dr. Priestley believed that the purpose of respiration was the discharge of phlogiston. Although many of his conceptions have been disputed in the latter days of his life, and have been treated as totally erroneous, yet, from late experiments with the galvanic fluid, his opinions prove to have been more correct than those of his opponents; and I take the liberty of advocating that doctrine which maintains the presence of phlogiston, or inflammable air in the lungs, to be that stimulating power which causes the expansion of the lungs, or the dilatation of the thorax; and that oxygen is that sedative power which causes the relaxation of the intercostal muscles, and the collapsion of the lungs in respiration, as will be proved in the sequel.

Although the calcination of metals resembles in many instances the combustion of inflammable substances, and respiration, yet they differ very much in some particulars. The presence of oxygen is necessary to every one of these operations; but in calcination the metal absorbs and retains it; in combustion it unites with the inflammable air which the combustible discharges, and in respiration it unites with, and decomposes the inflammable air in the lungs. In all three cases oxygen is decomposed: in the first it adds substance to the calx; in the second it causes heat with light, and promotes the consumption of the combustible; and in the third it causes heat without light.

Under erroneous impressions on this subject, Dr. John Reid, in his Treatise on Consumption,

p. 27. expresses himself in the following words: "It has long since been observed, that immediately after the process of deflagration or COMBUSTION OF ANY BODY in a given quantity of air, the matter which has been the subject of experiment was considerably increased in weight; at the same time the air was rendered impure, and incapable of again supporting a similar process. Such augmentation in weight had been indecisively referred to aërial absorption." P. 29. "But by numerous experiments, both analytical and synthetic, instituted and repeated with such attention and accuracy as to obviate objection and preclude doubt, the weight acquired by the deflagrated material, was found to be in the exact ratio of what had been lost by the air during the process of deflagration."

That in the calcination of mercury and lead, and in the deflagration of antimony, weight is gained from the absorption of air, is not to be denied; but this is only the case with metals, and it is a capital error to assert, that the same change takes place "in the combustion of any body." Who ever has found his firewood increase in weight by combustion? or who has experienced the oil in the lamp to increase by feeding the flame? The combustion of neither mineral, vegetable, nor animal combustibles, admits of the least conjecture, that their bodies absorb oxygen; this gas unites with the inflammable air of the combustible, and both being decomposed, fly off into the air, either in the state of steam, or carbonic acid gas. The same is the case with respiration; the oxygen which disappears is no more absorbed by the blood, than by the fuel in combustion; it unites with the inflammable air in the lungs, steam and carbonic acid gas are formed,

and both are discharged into the atmosphere by expiration. The animal body therefore gains nothing by respiration, but constantly loses by the emission of carbon, and carbonic acid gas. And the quantity which the body daily loses may be calculated from the quantity of oxygen which disappears. For if the same quantity of carbonic acid gas is discharged bulk for bulk, and this latter is double the weight of the former, then it follows, that instead of taking the quantity of oxygen, expended in respiration, for a measure by which we might estimate the quantity the body gains by breathing, it will serve us as a measure by which we can know how much the body loses of real substance, by the process of respiration.

When we thus assert respiration to be a discharge of gases, instead of an attraction of oxygen, as has erroneously been taught in medical schools, we have also to consider the agents which conduct this vital motion in perfect animals.

As we have ascribed all muscular motion to the three moving powers, the sensibility of the nerves, the galvanic fluid, and the susceptibility of the muscular fibres, so must these three agents also be occupied in respiration, and the nerves must have their sensibility affected by a stimulating power.

The nerves of the lungs, according to Mr. Scarpa's account, follow particularly the course of the ramifications of the bronchia, and spread over their inner surface in such a manner, as to be in and near the air-cells, and thus come in contact with the air; their particular sensibility, therefore, must consist in distinguishing the difference of air or gases. Inflammable air, and carbonic acid gas in any considerable quantity, seem to operate on these nerves as stimuli; the stimulus of carbon,

in particular, seems to give to these nerves that uneasy sensation, which, when conveyed to the brains, causes the galvanic fluid to be sent to certain muscles by whose agency this uneasy sensation is to be removed.

That this is the animal economy of respiration, may be more clearly understood by taking notice of some particular facts in the experiments made by Mr. Dupuystren, at Paris. Although he had formed different conceptions on the cause and benefits of respiration, from those which are laid down here, and had therefore drawn different conclusions from the facts which I will make free to recite; yet facts, if faithfully reported, will always remain independent of themselves, although their causes and effects may be differently construed; and we are not justifiable in drawing conclusions from the appearances of one set of experiments, totally contrary to that which has been proved by a multitude of experimentalists, in a thousand different ways. That the blood assumes a high red colour, when exposed to the air, is not to be disputed, and that the nerves are instrumental to muscular motion, will not be doubted by any physiologist, notwithstanding all the appearances in Mr. Dupuystren's experiments. However, not to forestal the reader's judgment, we will proceed to the facts.

This gentleman, in detailing some experiments made on a horse, observes, "that as those nerves which the lungs receive proceed chiefly from the eighth pair, so, when one of the nerves of the eighth pair was cut, a slight indisposition ensued, and such an impediment in respiration was thereby produced, as to cause the lips of the animal to become of a light violet colour; but when both nerves were cut, close where they separate from the sympathetic nerve, the

horse appeared to be in the utmost distress; the lips, tongue, and interior of the mouth, became of a violet, and afterwards of a livid colour. The horse expired in the space of an hour and a half, amidst torments horrible to be seen."

The death of the horse seems to have been caused by the dark colour of the blood, and this change to have been brought about by the impeded or diminished motion of the intercostal muscles and diaphragm, owing to the section of those nerves whose office it is to convey the information to the brains, of a necessity of removing a certain stimulus. That this is the case, and how this purpose is effected, all men experience in the act of sneezing.

The nerves which spread over the mucous membrane which lines the air passage, from the nose to the smallest ramifications of the bronchia, gives to that membrane that extreme sensibility as to cause a concussion of the whole thorax, or a cough, when an uneasiness is perceived from any foreign matter coming in contact with it. The Sneiderian membrane, in particular, which contains the olfactory nerves, may, by strong odours, by dust, or even the motion of a hair over it, be so stimulated, that, although its nerves are derived from the medulla oblongata, the galvanic fluid is sent through the six pairs of dorsal nerves, which are the intercostal and diaphragmatic nerves, and causes their muscles to contract forcibly, and produce a deep inspiration, which is followed by a rapid expiration, and effects the act of sneezing, which is capable of removing the foreign substance that has caused the irritation of the membrane.

As it would be impossible to sneeze, if the nerves of the Sneiderian membrane were cut or insensible: so is it also impossible to breathe, when

the nerves of the lungs are destroyed or compressed. The Author of Nature has supplied the lungs with nerves, which are ramifications of various origin, for this purpose, that in case any one trunk of the nerves should happen to be destroyed, respiration should not be interrupted thereby, as life depends upon it. On that account is the section of one of the eighth pair not materially injurious as to the life and health of an animal; even the cutting of the other nerve half or two-thirds through, is not a mortal wound, and even a sixth part remaining is sufficient to support life, when it can be maintained by a weak or small expansion of the thorax, by which a less quantity of air is introduced than what is necessary on extraordinary occasions. Mr. Dupuystren reports, that the animals which retained only one-seventh of the two nerves of the eighth pair, were at ease and appeared in health, only when they were at rest. Medical Repository, 2d Hexade, vol. 5. p. 380. "Those of which we cut the nerve of the eighth pair of one side and a half, or two-thirds of that of the other, at first experienced all the consequences which ensue from a complete section of the two nerves, but after some hours the pains abate, and, if the animals are not disturbed, or compelled to run, they are healed; and we see, with surprise, that the sixth, and sometimes a small portion of the eighth pair of nerves, is sufficient to support respiration. As often as we compel the horse to gallop, even for some minutes only, the symptom arising from the section of the nerves are immediately aggravated, and often terminate in the death of the animal submitted to the experiment. We made this remark particularly on a horse in which we left no more than a seventh of the nerves of the eighth pair. A month after the experiment, he showed all the signs of good health; and then, when we forced him to run

the distance of two hundred metres, he began to blow, respiring by the nose and mouth; he lay down and rolled on the earth; his body was covered with sweat; his blood became black, and it was not before half an hour that these appearances went off. They were afterwards renewed as often as we forced him to gallop."

"The section of the two nerves made at once on the same horse occasions greater sufferings, and it becomes fatal in a space of time which is never less than half an hour, and never more than two hours."

Some of the usual phenomena of this section of the eighth pair are: "the mouth is open; the nostrils dilated; a plaintive sound is emitted, like that of wind-broken horses, and the arterial blood becomes black—a colour which is always stronger in the veins than in the arteries."

Here it is to be observed, that when animals are at rest and at ease, not half the quantity of blood passes through the lungs, which circulates through them in time of hard exercise, or when running. At the time of rest, and of a slow circulation of the blood, weak and small inspirations serve all the purposes of respiration. On this account are wind-broken horses at ease when at rest, and come in danger of suffocation, under exercise. For when these animals are compelled to hard exercise, the forcible contractions of large muscles send a greater quantity of blood through the lungs; and as thus more of carbon is to be decomposed, more oxygen and atmospheric air is necessary; to introduce this into the lungs, not only deeper inspirations are required, but they are also more frequently to be repeated. A more forcible contraction of the muscles, and a motion of greater velocity, are alone capable of introducing as much air as is necessary to dephlogisticate the blood

during severe exercise. But when only one-seventh part of the nerves is left which have before been instrumental to this motion, we may reasonably expect that a smaller degree of action will be produced, an insufficient quantity of air will be introduced, and will not be capable of decomposing the greater quantity of hydrogen; the blood therefore cannot be dephlogisticated, and cannot get rid of its excess of colouring matter, which rather accumulates, and renders it more black. This state of the blood continues to increase by the exercise, until it has attained that degree of noxious influence upon the nerves and muscles, particularly the heart, which is destructive to life.

Although the report says, that the horse "began to blow, respiring by the nose and mouth," these appearances may be deceptive; for the horses which had both nerves cut, had, when they stood still, "the mouths open and the nostrils dilated." It is not to be supposed that these animals made deeper inspirations, although more forcible expirations, after they had received these mortal wounds, than they did before. The section of the pulmonary nerves could not promote the dilatation of the lungs, as the appearances were. But because they felt a sensation like suffocation, they made every exertion to overcome this painful feeling; and as long practice had habituated them to the opening of the mouth and nostrils, to admit air, so did they move every part for that purpose which could contribute towards it, and which was not directed by the influence of the pulmonary nerves. But the motion of the diaphragm and of the intercostal muscles, which act under the direct influence of the nerves which have been cut, must be greatly impaired thereby, and therefore full inspirations could not take place, notwithstanding all

the appearances and efforts of the animals, in opening their mouths and distending the nostrils, and sometimes blowing.

If this explanation of the consequences of cutting the eighth pair of nerves is correct, then we have to draw conclusions from the experiments of Mr. Dupuystren very different from those which he has laid down, and which he considers as invincible proofs of his proposition. He says, "While the asphyxia lasts, the air does not cease for a moment to penetrate the lungs, nor the blood to circulate through them; which establishes, in an invincible manner, that this disease is not induced by a suspension of the motion of the breast, nor by that of the motion of the heart, but by a suspension of the action of the lungs." The error in this conclusion seems to be founded on an inattention to measure, the experimentalist noticing the quality without distinguishing the quantity. It is not enough, for the support of life by respiration, that air is introduced into the lungs; this is but one point: the other is, that a sufficient quantity of it is passing and repassing in a given time. If the animals appeared well and in good health, as long as they were at rest, notwithstanding the communication between the brains and the lungs was very much interrupted, yet a sufficiency was left to answer the purpose for a weak respiration, but a strong respiration could not be effected, notwithstanding all the efforts of the animal for that purpose, when its life depended upon it; the dilatation of the thorax could not be made to such extent as to give room for a sufficiency of air, to change the dark colour of all the blood, which passed through the lungs during laborious exercise. If any person would assert, that there was not only air, but also a sufficient quantity of it in-

troduced into the lungs of the horses on which these experiments were made, then we must observe, that they assert facts which militate against more than one established truth. It would prove, 1. That the nerves were not necessary to accomplish the contraction of the muscles. 2. That by cutting the nerves, the muscular motions are increased; as the horse breathed through open mouth and dilated nostrils, although it stood still, and had not breathed in that manner before the communication of the nerves was intersected. 3. That the blood does not change colour by mere exposure to the air, which is contrary to daily experience. 4. It is contrary to Dr. Hook's experiment, made by fixing the nose of a pair of bellows in the windpipe of a dog, which has been innumerable times repeated.

That the life, the nutrition, and the health of the lungs, are not impaired by cutting one and a half of the eighth pair of nerves, Mr. Dupuystren has proved by the experiments made on different animals. On opening their bodies one month after, he says, "We found no traces of atrophy, leanness, or any change whatever on the lungs." Yet if these animals had been compelled to run, the same suffocating symptoms would undoubtedly have appeared, which have been observable in others.

Hence we have to conclude, that the animals who had only one-seventh of the eighth pair of nerves remaining, and which died on account of being compelled to run, lost their life, not by the death of the lungs, but from want of a sufficiency of common air in that organ; and they blowed sometimes to expel the carbon.

The different conclusions which Mr. Dupuystren has drawn from his experiments, compared to those which have been laid down here, may be

easily accounted for, when we observe the different sentiments he holds concerning respiration, and the utility of the lungs, when compared with those which are held forth in this number. He says, " The function depends on the intimate and reciprocal action of the air on the blood of animals: it has for its object to render this last liquid proper to excite and nourish their parts." When I take the liberty to differ in opinion from the Principal of the anatomical labours of the college of medicine at Paris, and maintain, that when the air enters the lungs, and the venous blood has been carried there by the vessels, the action of chemical affinities is sufficient to produce the change of colour in the blood, from dark to light red. Mr. Dupuystren is of opinion, " that life is as necessary to the exercise of respiration, as to that of all the other vital functions: in vain would the air penetrate into the chest, and be put in contact with the blood, if the lungs did not maintain vitality." To prove this point these experiments were made. However, they have proved to me the reverse of that which was intended; and the instance of the hay-stack becoming warm without vitality, settles the point of animal heat. As to the change of colour in the blood, this will be noticed in its proper place. Here we have only to remark, that the nerves of the lungs carry the sensation of a stimulus to the brains, in consequence of which muscular contractions cause inspiration. This last is plainly demonstrated by Mr. Dupuystren's experiments.

What may have given cause to the erroneous opinion, that the vital principle causes the animal heat throughout the body in an unaccountable manner, may be the local heat, which is to be observed, when any part of the body is affected with an inflammatory tumour. This increase of heat,

which occurs, even at the extremities of the body, is supposed to be inconsistent with that theory which maintains the blood to be warmed in the lungs only, and no where else. This appears certainly to be an important objection against it; but it will be found not more difficult to remove than any of the others. If we avail ourselves of the present state of medical knowledge, and the advancement of the healing art, and take notice of Mr. Wintrel's experiments on brutes; (Vid. Wintrel's Inflammationis Theoria Nova;) the truth of which is confirmed in Kratzenstein's Dissertatio Sistens Theoriam Inflammationis, where it is shown, that when any part of the animal body is irritated, the small ramifications of the arterial vessels become enlarged or widened, and those of the veins contracted. The absolute consequence must be, that much more arterial blood enters an inflamed or irritated part, than any other; this causes a light or high redness, and this change is called inflammation; and as the arterial blood is hotter than the venous, an increase of heat, in the inflamed part, must become perceptible; and as the contracted veins prevent the blood from returning as rapidly as the arteries bring it there, a swelling and tumour must arise from this circumstance. This impediment to the free course of the arterial blood, is also the reason why the patient can feel the pulsations in the inflamed, against the obstructed parts.

Thus, instead of the local heat of an inflamed tumour being a test against the origin of heat in the lungs, it gives an additional proof of the truth of it. For if any part is more sensible of the pulsations, and of a higher red colour, at one time than at another, it is to be concluded, that at that time there is a greater influx of the arterial

blood in that part, than there is any where else. And if at the same time the part is warmer than others, it follows, that the arterial blood is hotter than the venous. And if the arterial blood has more heat, it must acquire it in the heart or in the lungs which surround the heart. Thus we maintain, that, excepting the lungs, the left chamber of the heart is the hottest part of the body.

The lungs being the fire-place of the system, and all the other parts of the body deriving their warmth from thence, has not only been warmly disputed, but the reverse has been attempted to be inculcated, viz. that the lungs are more cool than the other parts, and that they absorb that heat which the decomposition of oxygen has caused. Dr. John Reid, in a note to his Treatise on Consumption, says, " The pulmonary vaporous exhalation has lately been supposed to be a species of perspiration. By this constant evaporation from the surface of the lungs, the heat extricated from the condensation of oxygen, may, perhaps, in a great measure, if not entirely, be absorbed."

If the discharge of steam from the lungs causes such a degree of cold, as to absorb, in a great measure, the heat produced by the decomposition of oxygen; and if the latter change or decomposition takes place " throughout the whole frame," (as the same author asserts,) " in consequence of the appropriate operation of the various exciting powers on the irritable principle," then the lungs must be considered as the coldest part of the human frame, and so would the heart be, which they surround. But the arterial blood being found hotter than the venous, contradicts this assertion; and the arm-pits being warmer than any other exterior of the body, proves a greater heat in the thorax than any where else.

That respiration should be the cause of animal heat, has been contended by Dr. John Reid, on various grounds. In his late Treatise on Consumption, p. 47, he makes this remark: "The varied phenomena which are displayed in the different stages of pyrexial fever, appear to oppose themselves forcibly to the admission of Dr. Crawford's principles. In the course of a febrile paroxysm, there is an alternation of cold and heat, apparently independent of the respiratory organ. During the first and cold stage of an intermittent, the salutary functions of the general frame are considerably impeded, the usual motions of the system are interrupted and partially suspended, and cold is generated. In the succeeding period of the paroxysm, every thing is reversed. Morbid action succeeds to temporary suspension, and the temperature of the frame is now augmented in a degree proportionate to its previous reduction. The spasmodic or oppressed breathing which occurred in the first, shall, however, be continued, if not increased, during the second stage, and shall only be subdued with the subtraction of part of the heat generated by the disordered actions that had constituted fever."

If these objections of Dr. Reid were correct, they would powerfully operate against the adoption of that theory which maintains animal heat to depend on respiration. But it seems this gentleman is misled by those appearances, which, as they deceive the patient, may also impose upon the physician. But as this deception has been detected and exposed, above fifty years ago, by Dr. Home, in his medical facts and experiments, I have no more to do, than to quote that author, when the question is started, whether, in the cold stage of an intermittent, the circulation of the blood

and " the usual motions of the system are interrupted or partially suspended, and cold is generated;" or whether the reverse are the true facts; this has been decided by Dr. Home's sixth experiment on that very subject, p. 221.

	Velocity of the pulse in a minute.	Heat of the body.	Heat of my room.
" Haliday shaking greatly in the cold fit of an ague,	112	104	60
In the hot fit,	104	104 1-2	60
In the sweat,	112	101	60
Next morning feels himself well,	104	100	62

" Here again," says Dr. Home, " is an increase of heat during the cold fit, and a deception from the patient's feelings."

Here it is to be observed, that Dr. Home has always found that the cold fit, in its duration, increases the heat of the body, and never generates cold to the test of the thermometer.

To explain the cause of this deception, we have to consider the effects which cold has on the surface of the human body. When a limb is exposed to cold air or water, the blood-vessels contract to such a degree as almost to disappear, and the same vessels swell to very great size by an immersion in warm water; on this account the foot is immersed in warm water before bleeding, for the purpose of relaxing and raising the veins. When the blood disappears suddenly from the surface of the body, and is sent in greater quantity to the heart, a reaction and increased motion of that organ takes place, and this is indicated by harder and quicker pulsations. The repulsion of the blood from the surface is produced by a spasmodic contraction of the skin and its blood-vessels;

hence we have to conclude that, as cold always causes this contraction in and near the skin, it may be produced in one part of the body, when the rest of it has its veins filled and swollen with blood.

By simultaneous sensations, and an association of ideas, man feels the contraction of the muscular fibres in the same instant that he feels the cold, and he does not know whether the fibres contract or not, at least it is none of his concern; it is enough for him that he feels cold, and always, whenever this change in and near the skin takes place, he imagines he feels cold, when his skin may in reality be much warmer than that of a healthy person. To shake with cold is the common expression, yet, this motion being produced by the alternate spasmodic contractions of a number of muscles and their antagonists, this shaking is caused in the intermittent fever, not from real coldness of the air, nor of the human body, but from the muscular constriction on the surface, which has been called by Dr. Cullen the proximate cause of fevers; which, however, we may with more propriety call the first stage of fever.

This spasmodic constriction in fevers has been disputed by many who wished to introduce new opinions and found new systems, which, if adopted, instead of giving more light, would lead us more into the dark.

The blood is reduced to the lowest temperature in the intermittent fever patient, not by what is called the cold fit, but by that state of languor, when, one or two hours before the fever, the body is invested with a lentor, or a disposition to yawning and stretching. It is then that the circulation of the blood is too slow, and its temperature too low, because a smaller quantity of it is carried

through the lungs in a given space of time. Respiration is then the most easily performed, because it requires no great exertions in the intercostal and diaphragmatic muscles to produce that small dilatation of the thorax which can introduce into the lungs a sufficiency of air to dephlogisticate all the blood they contain. On this account the body then is in the lowest state of temperature, and the hands and feet feel cold.

But as soon as the first stage of fever begins, (which is erroneously called the cold stage,) and muscular contraction on the surface takes place, then do the nerves send notice of this change to the brains, and to the mind, under the influence of that high degree of affection which causes disagreeable and even painful sensations, which the patient justly compares with those which he feels when he is exposed to severe cold, and, therefore, either sets himself in the sun or near the fire, or covers himself with bed-clothes, to get rid of the disagreeable sensation; however, this feeling continues, although the body begins to grow warm, and even acquires a morbid heat, for the circulation of the blood progresses in a cold fit with more velocity than before; and as more of this fluid passes through the lungs, more vapours of fermentation are also discharged; more stimulus excites the pulmonary nerves; deeper and more frequently repeated inspirations take place; more oxygen is decomposed, and more heat produced and imparted to the blood.

Notwithstanding this sensible increase of animal heat, which is ascertained by the thermometer, the patient may complain of a continuance of cold, and may give to the bystanders (who may have felt his skin warmer than their own) a proof of his

feelings, by shaking, as with cold, and yet deceive himself and them.

At this time the patient may also appear to labour under an oppressed or impeded respiration, when, to a more accurate observer, it will be plain, that it is a hurried and quickened respiration; for, exactly as in the case after running, the inspirations are deeper, and more frequently repeated than when the patient was at rest, or before the fever paroxysm commenced; therefore, instead of considering in this instance the motion of the blood as "interrupted and partially suspended, and cold thereby generated," it becomes certain that the motion of the blood is quickened, and the heat of the body morbidly increased.

If, at this time, any usual motions of the system are interrupted and partially suspended, they are the usual secretions and excretions, which cause the fauces to be dry; but this interruption is not only during the cold, but also in the hot stage of fever; and this is caused by the particular effect which a fever paroxysm has on the sensibility of the nerves, and the susceptibility of the muscular fibres, both of which are greatly diminished during the fever.

The patient becomes sensible of a morbid heat only then, when the muscular constriction on the surface of the body has subsided. At this time the rapid circulation of the blood may continue through the lungs, and the thorax may be hurried to deep and more frequent inspirations; but they never can be considered as oppressed and impeded breathings; and when the excess of this pectoral motion subsides, it cannot be ascribed to a "subtraction of part of the heat:" this would be mistaking the effect for the cause; but it is the gradual diminution of the deep and rapid inspira-

tions, which no longer generate so much heat, the evaporation of steam from the lungs, and also the relaxation of the perspiratory pores of the skin, discharging their contents, which are converted into steam; these are the causes of the diminution of heat.

The alternate changes of cold and heat in the different stages of fever depend, therefore, totally on the increased or diminished circulation of the blood, and on the agency of the respiratory organs; and this explanation will be more satisfactory to the inquisitive mind than those inferences which Dr. Reid has drawn from the preceding facts, when he says, p. 49, "that the alterations which the blood undergoes in the course of its circulation through the lungs is rather to be regarded as an indirect than immediate source of the result in question; and that the cause of constancy and equality, in the respective temperature of different animate bodies, is to be sought for in the incessant actions that characterize vitality, and which are generated immediately and through the whole frame, in consequence of the appropriate operation of the various exciting powers on the irritable principle, of which the process of respiration is incalculably the most important and indispensable. When such exciting powers exert their influence in an undue degree, being either deficient or in excess, a species of vibratory motion is generated in place of the regular and appropriate actions which constitute health, and preserve an equably diffused heat. Of such irregular motions, febrile or inordinate heat is the consequence."

"That portion, then, of the air which is received in the lungs at every inspiration, and rendered concrete in these organs, is to be regarded as operating in the preservation of animal temperature, by

virtue not of its chemical agency, but in common with other stimuli, upon which the healthy and regular functions of the animate machine are momentarily dependent; all of which are similar in kind, but extensively varied in power, and likewise in their mode of operation."

The principal objections which have been made against the theory of inflammable air combining with oxygen in the lungs, and thus producing heat by the decomposition of both gases, are those of Professor Davy, in Dr. Beddoes' Western Contributions, p. 129, where he observes, "that oxygen gas is never decomposed by carbon at so low a temperature as 98 degrees, and is never decomposed without combustion;" and p. 130, "there is never a decomposition of phosoxygen by hydrogen at so low a temperature; and it is well known that this process does not take place without flame."

These objections have startled many who had adopted the phlogistic theory of respiration, and believed hydrogen, uniting with oxygen in the lungs, to be the cause of animal heat; and when they considered the flame which this union produces in common experiments, they abandoned the idea of the lungs being the stove of the system, from an apprehension of their being exposed to a scorching heat.

However, in defence of the theory of the lungs being in reality the stove of the system, we have that force of argument on our side, that circumstances alter cases; and now, at this present time, we have obtained so much experience, that it will be easy to show those circumstances which will completely remove these objections.

It is first to be observed, that when chemical experiments are made with hydrogen gas, it is

generally obtained by pouring diluted vitriolic acid upon iron. This gas, thus procured, it is true, cannot combine with the oxygen contained in the common air, when a quantity of both are poured together in the temperature of 98; but when a candle is brought so near as to inflame it, it explodes with violence. However, the hydrogen which is discharged during a putrid fermentation of animal fluids is not of that nature; it is combined with sulphur and phosphorus; and the former article alone, when united with hydrogen, renders it so much the more inflammable that it burns in any temperature, when it is exposed to the atmospheric air; but, when the phosphorus is added to sulphurated hydrogen, it increases so much more its inflammability, that it resembles, in that respect, the substance which is contained in phosphoric match-bottles, which causes heat, when its vapours unite with some atmospheric air, which heat rapidly increases, on account of the great quantity of vapour discharging from the solid matter, and soon sets it in a blaze.

As to the danger of the lungs being scorched by the union of carbon and oxygen in the lungs, we have to consider the quantity of both gases which come in contact, and the size and construction of the air-cells. Suppose each to be the size of a pea, which is covered inside with moisture or mucous, and every inspiration introduces so much air as 1-20 to be occupied by oxygen; this is gradually decomposed as it comes in contact with the hydrogen, which oozes through its sides, and with which it combines in its nascent state, when extricating itself from the admirable net-work of Malpighi; and this change takes place in the space of four or five seconds of time. This

certainly is such a slow combustion that it can emit no light or red heat, although it gives more heat than the mere burning of pure phosphorus in common air, yet not so much as to scorch the moist air-cells, nor the small ramifications of the bronchia in a healthy body.

However, there are morbid and mortal cases, in which the scorching and burning of the lungs really takes place, and soon destroys the life of the unfortunate sufferer. This is another proof of the correctness of this theory of respiration.

"Dr. Kopp has made interesting inquiries on the spontaneous combustion of the human body. It was formerly an almost general opinion that the combustion only took place in drunkards; and it was believed that their whole frame was impregnated with the spirituous liquor; but, on comparing the different cases which Dr. Kopp has had an opportunity to collect, it appears that the combustion chiefly takes place in elderly people, and mostly in women. In general, in all these instances, the victims were very fat or very lean, which proves a weak state of the constitution; and they were accustomed to drink spirituous liquors. The combustion penetrated rapidly the whole body, but the trunk was the most injured. Almost in all cases a fire was at hand. In several instances the patients complained that they perceived something like an electrical stroke in some part of the body. The accident mostly happened when the atmosphere was dry and clear, and an empyreumatic smell surrounded the persons. It is therefore probable that an asthenic state of the lymphatic system may be considered as a predisposing cause, in consequence of which inflammable air might be collected in the cellular membrane, and other cavities of the body; in the same manner as a watery fluid is

collected in the cellular system in the dropsy, it may contain, when such an accident takes place, a collection of inflammable gas. It is very probable that electricity has some influence, as, in several instances, the combustion began with an electrical phenomenon. The flame is like the inflammable gas, and spreads, in general, so rapidly, that it has been impossible to give assistance to the victims of this horrible disease." Med. Reposit. vol. iii. 2d Hexade.

These so remarkable deaths, prove, not only to a certainty, that in living and healthy bodies inflammable air is emanated from the blood, but, also, that, in certain diseased states, so much of this gas can be generated that it cannot be discharged with that degree of rapidity with which it is produced; that it may be accumulated out of the blood vessels, and be collected in reservoirs, and may kindle and burn to a blaze when escaping from its confinement.

How it happens that drunkards are particularly liable to this unfortunate accident may be easily comprehended, if we take into consideration the experiments which Dr. Priestley has made on alcohol, and which he published in the Philosophical Transactions at Philadelphia. There he has shown that distilled liquors are easily convertible into inflammable air, by a heat less than that of the human temperature, and even merely by removing the pressure of the atmosphere by means of an air-pump. Hence it becomes conclusive, that all the inflammable part of distilled liquors is converted to hydrogen in the human body, and is again discharged through the lungs in respiration. This will form a practicable rule in the healing art, by showing the modus operandi of fermented and distilled fluids.

There are certain chemical processes in which mixtures maintain an effervescence, while there is a constant addition of some one or other of the ingredients to keep up the heterogenuity of the mixture; and when that new infusion ceases, either a morbid putrefaction will arise, or the intestine motion and the discharge of gases cease also. This latter is particularly the case in those who die of consumption; when several ingredients in the blood, which are absolutely necessary to the support of life, have been so much consumed or exhausted that the process of respiration can no longer be continued; with this the circulation of the blood ceases, and all other vital operations are suspended, as has been hinted when speaking of the vital powers.

Next to water there is no ingredient of the blood which is so much consumed, and which requires so constant replenishment, as that substance which formerly went by the name of phlogiston, meaning the inflammable matter or the base of fat. That next to water this is a principal necessary of life, is proved by that wise provision with which the author of nature has supplied the camel, by the means of which it is capable of undergoing a long journey, for several weeks, without taking much or any food or drink. Besides the water bag, in which this animal carries pure water for many days in his body, it is provided with a hunch, or large lump of fat on its back, which increases as long as the animal is at rest and supplied with plenty of food, but diminishes and dissolves when the camel undergoes fatiguing exercise and takes little food. This fat is necessary to supply the blood with that fermentative principle which produces the hydrogen or carbon, and which causes respiration, and yields the base of the galvanic

fluid. That this is the principal use of the fat in animals may be inferred, not only from its chemical properties, but also from this circumstance, that no other and better use has ever been pointed out for it by any body, and that it has been considered in that light by ingenious ancient anatomists, whose opinions have remained undisputed to this present day.

Malpighius did believe "that the fat was intended for a nobler use than only to fill up the interstices of the glands and muscles, so as to make the beast round and plump, or to smoothen the wrinkles in the skin of man;" he thinks "the principal use of fat, whilst it is mixed with the blood, is to be a continual pabulum of the natural heat, whereby the vital flame is perpetuated."

Thus did Malpighius comprehend the truth of the use of the fat, and anticipated the present discoveries, although he knew nothing of the inflammable air which is continually discharging from the lungs, and was unacquainted with the light which pneumatic chemistry has thrown on this subject. So, also, has Mr. Mayo anticipated the errors into which our present antiphlogistians have fallen, although he knew nothing of the disappearance of oxygen in respiration, when he says "that a double benefit chiefly accrues by respiration: first, that the blood, by the admixture of the nitro aërial particles of the air, is fermented and freed from coagulation; and, secondly, that the same nitro aërial particles, being received in the blood, are carried to the brain for the refection and supply of the animal spirits."

That fat, taken as nourishment, is the pabulum of animal heat, and the base of the galvanic or nervous fluid, may be also concluded from this circumstance, that when American hunters in the back

settlements take a winter hunting excursion, at a time when the deer are lean, and the men attempt to live on the venison alone, they soon become weak, and with difficulty can keep themselves warm, until they meet with a bear, racoon, or other fat animal, by the eating of which they find themselves strengthened and warmed.

It is on this account that the whales are provided with so much oil and fat, that they may be able to keep their blood warm, in their cold and dense element. All food, therefore, we may consider as being fit for nutriment in proportion to the quantity of inflammable matter which it possesses. The vegetables which contain the most saccharine matter, and the animals which have most fat, are the most nourishing bodies, and may be called rich food.

While thus the followers of Stahl ascribe to phlogiston the superior agency in matter, the antiphlogistians maintain that the aërial substance of matter, appearing in the state of oxygen, deserves the preference; that it is absorbed by the blood in the lungs, and is "the true Promethean fire; that it stimulates the left ventricle of the heart to contract, and thus causes the circulation of the blood;" when they ought to consider that the right ventricle contracts likewise, and that the heart did beat and the blood circulate in the fœtus, long before respiration takes place.

It is not only asserted by the antiphlogistians, that oxygen gas acts as a stimulus, but it is also considered by them to be the base of the nervous fluid, and of the vital principle, and to be the cause of action in body and mind; and not only do they suppose that animal heat flows solely from the concretion of oxygen, but also that the acids in the body, and even electricity, come from that

source. They further assert, that as some azote likewise disappears in respiration, it is absorbed by the blood, and that it enters into combination with the animal fibres, azote being a constituent part of all animals, therefore they believe it must be derived from respiration. Animal bodies are also supposed capable of decomposing water, and of converting its hydrogen into fat; and, totally forgetting food and other necessaries of life, their experiments have led them to conclude, "that organized beings, both animal and vegetable, can subsist upon air and water." (Dr. Beddoes' Western Contributions, p. 219.)

Instead of admitting respiration to answer any of these purposes, we contend that no air is absorbed by respiration, and we even deny to oxygen that stimulating quality which the antiphlogistians ascribe to it, and to which they attribute the most important actions in animal economy.

That oxygen possesses no stimulating power is proved by the very act of breathing. Inspiration is an action, and expiration a remission or relaxation of those muscles, which have caused by their contraction the inspiration. When an action is produced, we may with propriety inquire after the stimulus which has caused it, and this we shall find to be the inflammable air, which is constantly entering the air-cells, when extricated from the blood; this impresses the nerves of the lungs with a stimulating sensation, somewhat similar to that which irritates the Sneiderian membrane before sneezing, and a similar effect takes place, which is an inspiration. This action brings azote and oxygen into the lungs, and oxygen combining with the inflammable air, destroys its stimulating quality. That substance which destroys or counteracts a stimulus, or removes a stimulating effect,

cannot itself be considered as a stimulus; it must be the very reverse, for it acts as a sedative. The presence or introduction of oxygen no where causes an action or contraction of the muscles, but it produces a relaxation of the intercostal and diaphragmatic muscles; it is therefore not only to be considered as a sedative, but also, if we admit that oxygen is the base of all acids, we have to consider it as the base of all sedatives.

A most important property has been ascribed to the presence of oxygen, that is, the change of colour of the blood in the lungs, from dark to high red. It is not to be denied, that mixing oxygen with dark coloured blood will make it more bright; but how this change comes about, is a question to be decided. The dark blood contains much inflammable air, and when oxygen unites with this air, both are decomposed; it is therefore the absence of carbon or inflammable air, and not the presence of the oxygen, which gives the high colour; for both are the same as absent when they are decomposed, and neither can act with their former powers.

Instead of the blood gaining the colouring matter by respiration, it loses it. For any person who is acquainted with colouring or painting, knows, that the more body and colouring matter any mixture contains, the deeper is that colour. The blood changing from dark to bright red, is no indication of its having acquired more colour, but is a proof of its having lost it; and in its high red state it is nearer approaching to chyle than in its dark state.

Whether the change of colour in the blood, during its passage through the lungs, is to be attributed to a gain or loss of the colouring matter, may be ascertained by noticing the vessels in

which this change takes place. It is a universal rule in animal economy, that the arterial vessels perform all secretions, and the venous vessels all absorptions. If, therefore, this change of colour takes place in the arterial vessels, it is to be attributed to some secretions, and, if the change takes place in the venous vessels, it must be effected by absorptions.

Dr. Winslow, in his Anatomical Expositions, takes notice of the great difference there is between the arterial and the venous blood-vessels of the lungs. He says, it must be observed, that the capillary ramifications of the arteries are more numerous and larger than those of the veins, which, in all other parts of the body, exceed the arteries both in number and in size. This plainly proves, that the arteries of the lungs, but more particularly their capillary ramifications, are destined for other purposes than those of merely conveying the blood through that organ; for to answer this latter purpose, they need not to have been larger and more numerous than the veins. The absolute consequence of this difference in size and number must be, that the blood passes much slower through the arteries than through the veins. For if number, length and thickness is doubled in one class of vessels, the same fluids must pass eight times slower through them than through the other class. The arteries have, therefore, a very appropriate construction, to give time to the blood to undergo some change, viz. to part with carbonic acid gas, and inflammable air, both of which are to be extricated from the blood, through the very fine texture of these capillary ramifications. By this discharge of inflammable air the blood loses its deep red colour, and assumes that nearly resembling scarlet.

That the blood changes its colour in the arteries and not in the veins, may be plainly proved by one particular circumstance. The blood, when discharged in hæmoptysis is of a high red colour. In all cases of this kind, which do not arise from external violence, the blood proceeds from ruptured arteries. However, the larger branches of the pulmonary arteries carry dark blood, and if it is high red in the capillary ramifications, the change must have taken place in those very vessels. Hence follows the conclusion, that the variation of the blood's colour is produced by secretion, and not by absorption. For the venous vessels being so much smaller, and less numerous, are properly constructed to convey the blood, which has acquired an addition of heat, rapidly to the heart, which organ is to distribute it over all the body. The short time in which the blood passes through the veins, and the rapidity with which it moves, renders it impossible that the same quantity of air, bulk for bulk, should enter the venous vessels, and combine with the blood, compared with that which has been discharged from the arteries; when, at the same time, the latter air, which is said to be absorbed, is ten times less miscible with fluids, than that which escaped.

Innumerable experiments have been made with blood out of the body, to observe its change of colour, by the addition or subtraction of oxygen and hydrogen.

If venous blood, immediately on its discharge from the vein, be exposed to hydrogen gas, dark as it is, it will become darker still by this contact. This certainly proves, that the presence or addition of hydrogen deepens the colour of the blood.

Let arterial blood, which is of a high red colour, be exposed to hydrogen gas, and it will suddenly become as dark as the venous blood.

The antiphlogistians will account for this latter change by saying, that the hydrogen has attracted the oxygen from the arterial blood. However, here it ought to be observed, that the same opponents have disputed the union of oxygen and hydrogen, at so low a temperature.

Let venous blood be put into a thin bladder, and tied up, and the bladder exposed to the atmospheric air, its contents, which have been dark before, soon become of a bright colour. Here is the question, whether some hydrogen has escaped through the bladder from the blood, or whether some oxygen has penetrated the bladder, and combined with the blood. This question is decided by Dr. Priestley's report of experiments, when he states, that he could not retain hydrogen gas in a thin bladder, for any length of time; but the same bladder is very capable of retaining oxygen without any loss.

This will also show how much more likely it is, that inflammable air should escape from the blood through fine vessels, than that oxygen should be absorbed by the blood.

Attempts have been made to prove that oxygen is absorbed in the lungs, from experiments made by Doctors Home, Keil, and Hales. These gentlemen have ascertained, that under certain circumstances, people have gained weight in the night during their sleep. That people who have gone hungry to bed, and who have been much fatigued by the exercise of the preceding day, may have gained from two to ten ounces of weight, is granted: however, this does not prove that oxygen has been absorbed; for if that was the case, this weight would always be gained by every body; but since it happens but seldom, and the reverse is more

generally the case, it is a stronger proof against the absorption of oxygen than for it.

There are chemical processes in which mixtures will not effervesce, without being shaken, or some how moved; this is the case with the blood; it is a mixture of various matters in a viscid or glutinous fluid, which, if standing still, the laws of aggregation soon show their influence upon it; the glutinous parts cohere, and, on account of their levity, ascend through the lymph, and form a viscid covering, through which no gases can penetrate. It is on this account that it is so difficult to extract from the blood its several gases. As soon as it is out of circulation its agglutination arrests and confines them, and renders an analyzation by distillation impossible. Therefore, that the fermentative putrefaction of the blood may go on prosperously, and the carbonic acid gas and inflammable air be continually discharged from it in the lungs, it is spread over a very large surface in the capillary blood vessels, and exposed to the air in the cells of the lungs; and for this purpose a constant circulation is necessary as an indispensable condition, without which the discharge of those vapours which have become noxious, could not be effected.

As the circulation of the blood depends upon the agency of the heart, the antiphlogistians have considered oxygen as being the stimulus of the heart. To this opinion they have been led by the effects which are observable in breathing more oxygen than the common air contains. An increase of the pulsations of the heart in number and strength is the consequence; and it has always been observed, that breathing a certain quantity of nitrous oxyde (as it is called) causes a

greater sensibility of the nerves, and a greater mobility in the muscles. These facts have led to the conclusion, that oxygen must be a stimulus in a superlative degree, and must consequently be absorbed by the blood, and carried to the brains, to produce on the nerves such an exalted state of sensibility. However, these conclusions are far from correct, and the effects which follow appear to me not to be owing to the operation and presence of oxygen, but to a subtraction of inflammable air from the blood, in a greater quantity than is ordained in the regular course of nature.

The nerves seem to me to be endued with a greater degree of sensibility than is absolutely necessary to be continually employed in the common course of life. If the full powers of the nerves and the muscular fibres were constantly exercised, they would both be very soon totally exhausted. The Author of Nature has therefore set a moderator, which is to balance this sensibility and susceptibility, and guard these capacities against being too high, or, by exhaustion, becoming too low; and this check is the inflammable air in the blood. If, from any cause, too much carbon is withdrawn from the blood e. g. by breathing nitrous oxyde, or too small a quantity is generated, either from a deficient supply of its base, the fat, or from a morbid fermentation, then too high a colour in the blood, and too great sensibility and irritability is produced. This state of the nerves and muscles generally accompany consumptions; it may be derived from inanition, and it has a great tendency to increase the evil, acting reciprocally, and exhausting the vital powers.

When, on the reverse, from any cause, too much inflammable air is introduced into the blood, as is the case in drunkenness, or too small a quantity is

discharged in the lungs, from impeded respiration, and the blood becomes too dark, and the lips blue, then the sensibility of the nerves and the susceptibility of the muscles are depressed; such persons stagger like the horses in Mr. Dupuystren's experiments, from which he drew the conclusions, "that men whose hearts are badly organized, and which permit the black to mingle and circulate with the red blood, teach us that this description of people remain constantly in a state of muscular weakness, and an oppression of strength analogous to that which we have seen in animals."

Those people, therefore, who have inspired nitrous oxyde, have their blood more dephlogisticated, and, according to Messrs. Allen and Pepys' experiments, they discharge more carbonic acid gas, and their blood has parted with more carbon, and their sensibility and excitability is more accumulated than is consistent with good health; or the moving powers are permitted to act with a morbid or excessive force. Dr. Reid has remarked, in his Treatise on Consumptions, p. 32, 33, that "this oxygen gas, when inspired pure, increases the action and general heat of the system, and has been known to produce an inflammation in the lungs." Of this particular state of the blood, as deprived of too much carbon, we shall have to take particular notice, when we come to consider the causes of consumptions.

A third substance which is discharged from vegetable and animal bodies which have parted with life and undergo putrid fermentation, is SEPTON. This is also emitted and passes constantly from the fermenting blood through the lungs, in the act of respiration. The necessity for the discharge of this substance is one of the principal causes why the functions of the lungs cannot be, for any con-

siderable length of time, with safety interrupted, as long as the fermentation of the blood continues.

This septon is not a compound of oxygen and azote, as one of our professors of chemistry has laboured hard, above ten years, to inculcate: for each of these two gases has been long the subject of chemical experiment; and, combined in any proportion, they do not escape the hands of an able experimentalist; but this is not the case with septon, nobody has made any experiments upon it, when detached from the gases of putrid fermentation. It is too fine to be arrested, confined, and submitted to chemical analysis and other investigations. We know it only from its noxious effects on the human system, when either accumulated in the body, or inspired with the atmospheric air, after it has been discharged from putrefying vegetable or animal matter.

It was this septon which brought death and destruction upon many of the citizens of Philadelphia, when, in the summer of 1793, it arose from a quantity of putrid coffee, lying in the sun on a dock.

It is this septon which ascends from putrid animal bodies and fills the air with nauseating exhalations, and causes putrid fevers in those who are not accustomed to it by long habit.

It was this volatile poison, escaping from heated putrid oysters, which imparted, in 1803, to the people of Alexandria, in Virginia, a typhus gravior, equal in malignity to that experienced in Philadelphia ten years before.

It is this septon which renders the air of a crowded room unfit for respiration, even before one-half of the oxygen is decomposed or missing.

It is this poison, possessing certain specific qualities, which is capable of conveying contagious diseases, and communicating particularly that very disease with which the body is affected from which it ascends.

The poisonous quality of this very subtile substance, is not a mere acid, for it is destroyed by frost. For small-pox matter loses its communicating quality by freezing; as plague and yellow fever ceases in frosty weather. Fumigation seems also capable of decomposing this septon. To comprehend its nature we have to observe that smoke, when collected, forms soot, and this is a species of coal. All coaly matter has been found capable of decomposing odours in fluids, and of arresting putrefaction in animal substances: on this account, also, from time immemorial, have fish and meat been smoked, to preserve them for wholesome food; with much propriety, therefore, we may ascribe to fumigations the destruction of septon.

Late medical writers, when treating on the subject of animal heat, are very prolix in ascribing to the vital principle a power, by the means of oxygen, to effect "the regular preservation of heat, in a due and equal degree, throughout every part of the animate frame."

That the vital principle is not capable, by any means in its power, of preserving a more regular heat through every part of the animate frame, than what is derived from that heat which the blood has acquired in the lungs, and which is distributed by the circulation of that fluid, has repeatedly been proved to every person's own feelings, when, in winter weather, they complain of cold feet. Here is not a "due and equal degree of heat through-

out every part of the animate frame;" and the reason is obvious; the sensation of cold contracts the muscular fibres so much, that the blood-vessels do not contain one-quarter of that blood, which they hold when the limb has its due degree of temperature, and the bulk of the blood in a cold limb is not one-thirtieth part, compared to that of the solids, upon which the cold air, which surrounds them, has a greater influence, and cools them more than the blood can warm them. Instead of speaking, therefore, of this "regular preservation of heat in a due and equal degree through every part of the frame," as a proof against the doctrine which maintains the lungs to be the source of heat, whence it is distributed over the body; it serves as a strong proof in favour of it, because we are all sensible that those parts of the animate frame which are most distant from the lungs, are most liable to suffer from the want of the influence of its heat.

As thus the due and regular preservation of heat throughout every part of the body has no existence, so it is, also, with that singular property which is ascribed to animate beings, of supporting a standard degree of temperature in every vicissitude of climate. A writer on this subject says, "Thus we find, that the degree of temperature is the same in the coldest regions of the earth where men can exist, and where even mercury may become solid, as well as in those higher ranges of temperature up to that of boiling water, as was proved from the experiments of Dr. Fordyce and others." This property may in some degree be applicable to the brute creature; for sheep will have wool in a cold country, and hair in a hot climate; and many other animals may have similar but less degrees of changes in their coverings, ac-

cording to seasons and latitudes. But to the human species this property cannot be ascribed. Nature does not support this standard degree of temperature. This doctrine is far from being correct, and the reverse is often experienced, not only in the same climate and the same season, but also in the same place and day. I am therefore frequently under the necessity of admonishing my consumptive patients, not to trust to nature for the support of a salutary temperature, but to be attentive and employ art, and shift their dress two, or even three times a day, according to circumstances; e. g. if a patient is recommended to take an early walk or ride for the sake of exercise: the morning may happen to be cool, he therefore ought to be so dressed as to feel comfortable; at noon it may be warm or sultry, he ought to dress again in garments more thin and light; a thunder-storm may arise in the afternoon, and in the evening a north-west wind may blow: on this change it would be very imprudent not to change his dress.

It is true we are enabled to live under a variety of climates, and pass through the vicissitudes of seasons; but not without the support which art gives, can we enjoy life, health and comfort. It is by means of houses, fires, clothes and bedding, that the standard of healthy temperature can be maintained.

The inspiration of cold air, it was supposed by many, would produce more heat than the inspiration of warm air, because cold air, containing more matter, holds also more oxygen in a certain bulk. This conclusion is not applicable to respiration; for by the time the air arrives in the cells, it is of the temperature of the lungs, whether it may have been hot or cold when it passed the fauces. It requires several inspirations, to propel the air to the

cells after it has passed the mouth, and the small ramifications of the bronchia, possessing the temperature of the lungs, warm the air before it enters the cells. Therefore, instead of air giving more heat when cold than when warm, it rather subtracts from the heat of the lungs, when cold air is warmed in that organ.

Among the many vague conjectures concerning respiration, which have been started, and communicated to the world by writers on physiology, that remarkable assertion is not to be passed unnoticed, which maintains, that the utility of the lungs consists in the reception of the electric fluid from the common air, and its conveyance to the heart, from whence it is supposed to be transmitted to the brains, where it is to constitute the base of the animal spirits.

How erroneous this opinion is, will be quickly perceived, when we observe, that so highly rarefied is the state in which the electric fluid always exists, that it cannot be confined by the blood-vessels; for in the application of medical electricity, it is well known, that this fluid diffuses itself over all the human frame, and it can be sent across the vessels, in any direction the operator pleases. To conjecture, therefore, that the lungs collect the electric matter, is a supposition contrary to the nature of that subtile fluid.

After having noticed the effects which an excess or a deficiency of oxygen in the atmosphere can have on respiration, and on the health and vigour of the body, it remains yet to be shown what are the effects which irrespirable airs have on the lungs and the animal economy.

As all those who maintain the absorption of oxygen by the blood, cannot give a comprehensive view of the process by which animal heat is

produced, so neither can they assign plain and intelligible reasons why death should be caused by a few inspirations of carbonic acid gas, which is considered as the most salutary medicine, when introduced into the stomach; and people travel great distances, and collect in a great concourse at the Ballston and Spa Springs, and Pyrmont Wells, every year, for the purpose of reaping the benefit of the mineral waters, whose principal medicinal quality consists in being richly impregnated with this carbonic acid gas. It is even generally admitted, that the blood contains a considerable quantity of this gas, and that it is constantly emitted in respiration. It can therefore not act as a poison when absorbed by the blood, from three or four inspirations of it.

That theory of respiration which cannot solve this problem, but leaves it involved in as much mystery as it always has been, cannot claim the preference over those fundamental principles, which easily explain this, and every other phenomenon, which mark the breathing of what are called irrespirable airs. It has been shown, that oxygen acts in respiration, not by any stimulating, but by its sedative powers; that oxygen decomposes the stimulus of carbon and hydrogen; that inflammable air causes the expansion of the lungs, which is an action, and that the introduction of oxygen causes the collapsion of the lungs, which is a relaxation of the muscles. It has also been shown, that this inflammable air is continually evolving from the blood in the lungs, and acts by its stimulating power. When, then, no sedative is introduced, and particularly no oxygen, which is the only substance which can decompose hydrogen and carbon; but when, on the contrary, carbonic gas enters the lungs and the air-cells, this being likewise

a stimulus, no relaxation of the intercostal muscles and of the diaphragm can take place, but the dilatation of the breast and expansion of the lungs must remain, and respiration become interrupted for the want of expiration. The consequence must be, that although the blood can pass freely through the lungs, yet it cannot be dephlogisticated, because no oxygen is introduced; therefore the blood not only retains its dark colour, but also becomes more and more dark, and in that state it is sent to the brains, where it causes a sense of intoxication, the nerves lose their sensibility, and the heart stands still. This latter effect may also be caused by the quantity of septon which the blood retains, when respiration is interrupted, and expiration fails.

Carbonic acid gas is the foremost among the irrespirable gases, in showing these suffocating effects, and three or four inspirations are sufficient to endanger a man's life, when ten inspirations of hydrogen gas cause but slight inconveniences, viz. a giddiness. The reason of this difference lies in the difference of the specific gravity in the two gases, carbonic acid gas being above twenty times heavier than hydrogen and carbon, and above double the weight of common atmospheric air, it descends by its own gravity into the lungs and air-cells, and displaces that quantity of common air, which has not been fully contaminated by respiration. But hydrogen gas, being above eleven times lighter than the air in the lungs, it remains therefore in the trachea and bronchia a considerable time, till all the oxygen of the air in the lungs is decomposed; and then neither can hydrogen gas enter into the air-cells through the small ramifications of the bronchia, because these are occupied by an air of more gravity, viz. the azote of the

atmospheric air, and the carbonic acid gas which is formed in the lungs.

By thus noticing the difference which is to be observed in the deleterious quality of the heaviest and the lightest of the irrespirable gases, it will be easy to form an opinion on the rapid effect of the noxious power of the others, which depends entirely on their respective gravity; otherwise they are all equally deleterious, for none are capable of removing the stimulus of the lungs, which causes in spiration.

How the breathing of a mixture of these irrespirable gases with common air can have a salutary effect on diseased lungs, and which of the irrespirable gases is most convenient for that purpose, will be noticed when we treat on pneumatic medicines in consumptions.

We have observed that animal heat is produced by means arising from the fermentation of the blood, and that the same fermentation is promoted by heat. These two agents, acting thus reciprocally on each other, would soon raise the heat of the body above the healthy standard, and become the cause of disease and destruction to the animate machine, had not the Author of Nature provided certain conductors, by which the excess of heat is diminished and conveyed from the body. The first is the cold air which is inspired, which generally is of so much lower temperature than the lungs, that it is warmed in its passage to the air-cells, in the bronchia, and therefore subtracts heat from the lungs. On this account we see animals, when overheated, breathe with open mouths, to bring more cool air in contact with the heated fauces, which also promotes the effect of the second conductor, which is the evaporation of moisture from the air passage. It is supposed that the

lungs expose nearly as much inside to the air as the skin of the whole body covers of its outside; and this air passage being always moist, it evaporates a great quantity of steam. The third conductor is the cold atmosphere which surrounds the body, and which would carry off the heat too rapidly, if we did not guard against it by the clothes we wear. The fourth and principal conductor of heat which, with much propriety, may be called the regulator, is perspiration; this is either increased or diminished, according to the exigences of the body, from which it subtracts the superfluous heat, by the rarefaction of steam.

Thus may we flatter ourselves with having attained to the two great desiderata in physiology, viz. the causes of muscular motion and animal heat; the two objects on which Dr. Young expresses his opinion, Medical Repos. No. 42, p. 140, viz. that "those physicians, who are ignorant of the physical or generative cause of heat and motion in the human body, have yet to learn two of the most important lessons in the medical science;" and, p. 143, "Until this discovery is made, almost every phenomenon in nature will continue to be an inscrutable mystery, and the opinions and systems of philosophers continue to be founded on mere conjecture, and defined in terms which have no determinate meaning." And Mr. Davy also expressed, in Dr. Beddoes' Western Contributions, that, until we become better acquainted with the functions of the nerves and muscles, the medical science will continue to be a mere chimera.

Thus, instead of considering the lungs as "the organ in which the blood acquires vitality, and receives the pabulum vitæ, and of being rendered by respiration proper to excite and nourish the parts of animals," we find respiration is a dis-

charge of putrid vapours, which would become highly noxious if longer retained in the body, and cause death within a few minutes, as is proved by the inspiration of irrespirable airs, and by other cases of suffocation.

Thus, instead of the blood being endued with life, we find it to be a dead matter, subjected to the laws of inorganic and mineral substances, or of such vegetable and animal bodies as have parted with life, and are in a state of fermentation and putrefaction.

Instead of oxygen being absorbed by the blood in the lungs, and the body gaining substance by that means, as has been taught in the medical schools, we find that the body loses daily exactly as much substance, by the discharge of carbon and carbonic acid gas, as it was supposed to gain by the absorption of oxygen.

Instead of resorting to a mysterious agency of the vital principle, for the explanation of the generation of animal heat, we find that dunghills and hay-stacks can generate heat and moist vapours, without the assistance of the vital principle.

Instead of attributing to oxygen a stimulating power, we find it to act as a sedative in respiration; and oxygen being the base of all acids, we may, with so much the more propriety, consider it as the base of all sedatives.

Instead of ascribing the increased sensibility of the nerves, and a greater mobility of the muscular fibres, to an absorption of a greater proportion of oxygen in the respiration of nitrous oxyde, we find these effects are to be attributed to a greater subtraction of carbon from the blood; and when the blood in the arteries assumes a dark red colour, from the retention of too much carbon, nervous and muscular weakness is produced.

Instead of local heat in inflammatory tumors being considered a proof against the origin of heat in the lungs, it gives an additional confirmation of the truth of it, according to Kratzenstein's Theory of Irritation and Inflammation, which shows the greater heat of the blood in the arterial, than in the venous vessels.

Instead of considering fever heat as being independent of the respiratory organs, we find, by the test of the thermometer, that the heat in fevers is solely produced by an augmented respiration, discharging more carbon and decomposing more oxygen gas at that time.

Instead of hydrogen and carbon being incombustible with oxygen, in the temperature of the body, as has been supposed, we find that phosphorated and sulphurated hydrogen, such as is formed by putrid fermentation, enter into slow combustion with atmospheric air, even in the temperature of the common atmosphere; and, when the quantity of inflammable air is morbidly increased in the body, it can produce a spontaneous combustion, and destruction of life.

Instead of the blood acquiring the colouring matter by respiration, it loses it by passing through the lungs; and the change of colour, from deep to high red takes place in the secerning vessels by the secretion of carbon from the blood, and not in the absorbing vessels from the absorption of oxygen.

Instead of contending about the chemical properties of septon, and considering it as the product of elective attraction, we have to observe, that it is solely met with in organic bodies, and is discharged from them only; therefore its formation is a product of the vital principle, and chemistry is totally incapable of developing and estimating the specific properties of its combination.

Instead of trusting to the agency of the vital principle for the regulation of the standard heat in our bodies, according to the circumstances of emigration to the northern or southern temperatures, we find it necessary, by the means of art, to guard the body against the noxious influence of heat and cold; and, although the constitution may in time become habituated to a climate, it would be very imprudent to adventure on the notion, that a seasoning to any certain latitude would render the body insensible to the influence of a change of seasons.

Instead of the utility of oxygen in respiration, depending on its stimulating power, we find that all stimulating gases are totally unfit for respiration, and that their mephitic property depends upon their stimulating quality.

When these truths shall have become adopted they will have a powerful influence in improving the treatment of various disorders, but particularly those of the lungs, of which pulmonary consumption is the most important.

When it is considered that respiration does not nourish, but subtract from the substance of the body, and that the increased action of the lungs increases this subtraction, we learn what becomes of the fat and the flesh which so rapidly disappears in proportion to the degree of fever the body sustains. To preserve it therefore from destruction by consumption, we have to learn how to diminish the agency of the lungs agreeably to health; and when this organ becomes irritated by a catarrh, which stimulates the heart to a febrile motion, and more blood passes through the lungs than before, and greater heat and hectic fever are produced, we have to learn, also, how to remedy these direful effects; and this will be the subject of the succeeding numbers.