AN

INAUGURAL DISSERTATION

ON

RESPIRATION.

SUBMITTED TO THE PUBLIC EXAMINATION OF THE

FACULTY OF PHYSIC

UNDER THE AUTHORITY OF THE TRUSTEES OF COLUMBIA COLLEGE, IN THE STATE OF NEW-YORK,

The Right Rev. BENJAMIN MOORE, D.D. President;

FOR THE DEGREE OF

DOCTOR OF PHYSIC,

On the 12th Day of November, 1805.

BY THOMAS COCK,

CITIZEN OF THE STATE OF NEW-YORK.

Hear, O ye sons of time! the powers of life
Arrest the elements, and stay their strife;
From wandering atoms, ethers, airs, and gas,
By combination form the organic mass!
And,—as they seize, digest, secrete,—dispense
The bliss of being to the vital ens.

DARWIN.

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1805.

TO

VALENTINE SEAMAN, M. D.

Permit me to offer you, as a mark of esteem and respect, the first fruits of that medical education which has been conducted under your patronage.

The AUTHOR.

TO

WILLIAM HAMERSLEY, M. D.

Professor of the Theory and Practice of Physic in Columbia College,

THIS DISSERTATION

Is respectfully inscribed

By his obliged humble servant

The AUTHOR.

INTRODUCTION.

WHEN we take a retrospective view of the advancements that have been made in physiological inquiries, we are fully impressed with the advantages that have resulted from a correct chemical examination of the materials operating upon the animal body, together with a more accurate investigation of its productions. Among the agents acting upon the body, and entering into it as an useful part, the air of the atmosphere demands the greatest attention; and in this chemical inquiry has been productive of extensive importance.

It is certain that the most important advantages do result from a close attention to the different functions of the animal body in a state of disease; therefore, in proportion as our knowledge of these functions is more or less correct in a state of health, so may the diseased changes of the body be inferred, and their removal understood. With an impression of this nature I have been led to the investigation of Respiration as the subject of an Inaugural Essay.

From the late experiments of some ingenious chemists who have directed their attention particularly to this subject, many important facts have been discovered. Among these experimenters may be reckoned Dr. Beddoes and Mr. Davy; the latter of whom has exposed, with great clearness, the fallacy of preceding opinions, and has given more extensive experiments upon the nature of different airs, with their effects upon the body when respired. These experiments have not only been made upon himself, but upon others with the greatest attention.

However clear and decisive the experiments of Dr. Goodwin upon respiration may have been considered, Mr. Davy has pointed out their errors and imperfections, and has deduced from his own discoveries a more correct explanation of the phenomena of this function.

In the plan of this dissertation each particular division is briefly considered. In the first place a short sketch is given of the parts concerned in the performance of respiration.

2d. The importance of air in the support of life, and its chemical properties are considered.

3d. The influence of different airs upon blood out of the body, and the changes that are effected upon this in its passage through the lungs of animals during life.

4th. The application of these different phenomena to the explanation of animal heat.

In the explanation of many subjects in physiology great error has arisen from too general conclusions by analogical reasoning, and this by facts drawn from the operation of matter upon inanimate substances. Hence the reasoning has been fallacious, as the laws of inanimate matter are far different in their operations, subject to great variety from the actions of the machine itself, and changed by the influence of mind upon matter, which is primarily operated on by a variety of external as well as internal causes. How far these objections are applicable to the present opinions on the subject of respiration, time will alone determine, as error shall give way to truth, and the absurdity of hypothesis be corrected by the power of just experiments and correct reasoning.

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RESPIRATION.

BY Respiration is understood the taking in and expelling air from the lungs. The importance of this function has rendered it synonimous with life. We are all sensible of the great inconvenience of its being suspended only for a short time, or of any imperfection in its performance, as takes place in many diseases of the chest; such as asthma, hydrothorax, &c. in which a free action of the parts concerned cannot take place.

Respiration is a function of a mixed kind, that is, both voluntary and involuntary. We can increase its frequency, and can take in a larger quantity of air at will; but in this case the operation becomes fatiguing, the same as when any motion is performed by voluntary muscles in other parts of the body.* As an involuntary action, it is rendered far more important to us, as our existence is so immediately connected with its regular performance and continuance; and whenever we make it a voluntary action, its frequency or force is always increased.

The principal parts concerned in respiration are, the trachea, lungs, and diaphragm, to which

* In the singular instance of Mr. John Hunter, his respiration was a complete voluntary action for some time; he found it unnecessary to respire except when he would speak.

may be added, the intercostal and abdominal muscles; and when it becomes forced or laboured from any cause, other muscles are called into action.

The trachea is a cartilaginous tube, extending from the larynx to the bronchia, which are its divisions, and whose more extreme ramifications terminate in the air cells of the lungs. This tube is lined throughout its whole extent with a delicate membrane of extreme sensibility to all matters excepting air, and highly susceptible of inflammation. The lungs are organs of considerable size that completely fill up the two larger cavities of the thorax; they possess little specific gravity in animals that have breathed, being made up of cells extremely numerous and minute, upon which the branches of the pulmonary artery spread out: they always contain air in greater or less quantity, according as they are more or less distended or collapsed. The lungs (contrary to the ancient opinion) are considered as passive in the function of respiration; they only fill up the increased cavity of the thorax, which is produced by the actions of the intercostal muscles elevating the ribs; while the diaphragm encroaches upon the abdomen, which it effects by bringing itself nearer to a plane; and the lungs are enabled to fill up what would otherwise be a vacuum by air rushing into them through the trachea. These actions constitute inspiration. The air is again expelled from the lungs by the actions of the abdominal muscles which are attached to the ribs, and are excited into action by their elevation and by the protrusion of the abdominal viscera produced by the descent of the diaphragm. The expulsion of the air is also assisted by the elasticity of the cartilages connected with the ribs; by which power, after the intercostal muscles cease to act, they restore themselves to their former situation, which diminishes the cavity of the chest and empty the lungs. Although these combined actions produce respiration, yet it may be performed with a less number, under certain circumstances, as where the ribs are fractured, or in inflammations of the pleura, where motion is rendered painful: respiration takes place principally by the actions of the diaphragm, in which it is an essential part. The use of thus taking in and discharging air from the lungs was little understood until the time of Dr. Priestley, although many hints had been thrown out by his predecessors of its probable effects. It was with this, as with many other important discoveries, that when its nature was understood, the discovery itself explained the mysterious opinions found in the writings of former ages, which before were entirely inexplicable. Something of this is apparent in the observations of Dr. Beddoes upon the writings of Mayow, where he says, " he not only understood the composition of the atmosphere, but was also aware of the increased weight of metallic bodies, and that certain bases are rendered acid by combination with vital air. He also asserted, that the air was diminished in respiration, and that a certain portion was conveyed to the blood. If this be an accurate analysis of his writings, he appears to have understood almost the whole doctrine of respiration and combustion as determined by modern chemists. The mysterious manner in which the opinions of Mayow are expressed, has given rise to a difference of opinion as respects the merit which he deserves as a discoverer of the nature of the atmosphere. The celebrated experiments of Hook (who was the predecessor of Mayow) before the Royal Society, appear to contain some knowledge of the uses of air in respiration. He laid open the thorax of a dog, and kept the animal alive for some time by blowing air into his lungs. These experiments and facts could not have come within the knowledge of Dr. Hunter, or he considered them as not having in any degree developed the nature of this function, as we should infer from his introductory lecture published in 1784, where he says, " respiration we cannot explain, we only know that it is in fact essential and necessary to life. Notwithstanding this, when we see all the other parts of the body and their functions so well accounted for, we need not doubt that respiration is so likewise. And if ever we should be happy enough to find out clearly the object of this function, we shall doubtless as clearly see that this organ is as wisely adapted for an important office, as we now see the purpose and importance of the heart and vascular system; which till the circulation of the blood was discovered was totally concealed from us." This has since been realized by the discoveries of Priestley, Scheele, and Lavoisier, in modern chemistry, which have thrown great light not only upon this, but upon many other functions of the human body. "The establishment of this truth alone is almost sufficient to subvert the old and to erect a new system of physiology. And if no other benefit than this had arisen from all the brilliant discoveries which chemistry offers to the world, it would have sufficed to rescue that science from neglect, and to assign it an elevated rank among the objects of human knowledge." Perhaps one of the most mysterious operations of the human body yet remains to be explained by it, namely, secretion.

The importance of respiration to animal life consists in a frequent change of air. When animals are deprived of this, they soon cease to exist, as when confined under the receiver of an air-pump, where life is terminated by convulsions as the air becomes vitiated. Life becomes painful and imperfect where the same air is breathed by a number of persons, as in large assemblies; or produces great destruction, as was particularly exemplified in the distressing instance of Mr. Holwell and his companions in the black hole at Calcutta; where, in consequence of a considerable number of persons being crowded together in a place illy ventilated, great mortality ensued; and among those who survived the most serious form of disease was produced. The instance related by Dr. Trotter, of the fatal effects arising from a large number of Africans being closely crowded together on board of the slave ships, also strongly illustrates this fact. He says, "I have often observed the slaves drawing their breath, with all the laborious and anxious efforts for life which are observed in expiring animals subjected to foul air, or under the receiver of an air-pump." In instances similar to these, though not under circumstances so afflicting, the great Lavoisier instituted experiments to ascertain the changes effected upon the purity of the air. This was done at the principal theatre in the city of Paris during the play, and after the conclusion, in which the house was much crowded. He here found, as the purity of the air was diminished, the effect upon the audience was very perceptible in producing great languor and inattention. Similar changes resulted from experiments made upon the air of the closed wards in the principal hospital of France. In order to understand more particularly the nature of these changes, it will be necessary to trace those experiments which have been made upon the chemical properties of our atmosphere as connected with animal life.

After the mechanical effects of the atmosphere had been investigated by philosophers, chemists were led to examine more particularly into its nature. "It had been considered by them heretofore as an homogeneous fluid, and little notice was taken of it in their operations; for when their materials vanished in air, they considered the experiment at an end, and stopped at that part when only their analysis became interesting."* Several phenomena had been observed,

* Bell's Anatomy, vol. ii.

which led to a more particular examination of its nature, such as the increased weight of metallic bodies, which, when burned in atmospheric air, became altered in their properties from a mild substance to a caustic drug;—the support given to animal life and flame was limited according to the quantity of air and the formation of acids by combustion. For an explanation of these phenomena, we are greatly indebted to the investigations of the celebrated Priestley. He, from extensive experiments upon aërial fluids, was led to a particular examination of the atmosphere, and proved by accurate analysis, that it was made up of two separate airs, to which he gave names expressive of their different natures. The larger and impurer part he called phlogisticated air; the second or smaller portion, which possessed directly opposite effects, he denominated dephlogisticated, or an air deprived of phlogiston.

Scheele was led to the same conclusion by a different course of experiments, in which he was engaged at nearly the same time, but applied different names to the result of his inquiries. He called the phlogisticated air of Priestley foul air; to the dephlogisticated he gave the name of empyreal air, or an air pure in the extreme. Lavoisier, extensively engaged in experiments upon almost all substances, and without a knowledge of what had been done by the other discoverers, was led to an investigation of the same subject, and drew the same conclusions from them, but applied also different names, as more particularly expressive of their different effects and properties. The phlogisticated air he called *azotic gas*, from its noxious effects upon animal life and combustion; to the dephlogisticated he gave the name of *oxygen gas*.* These two airs he found, from accurate experiments, to exist in the proportion of seventy-three parts of azote to twenty-seven of oxygen in the hundred of all uncontaminated atmospheric air. Later chemists have added another gas as a constituent part, which, however, forms only a small proportion; but its strong tendency to combine with various substances whenever it is generated in any considerable quantity, is the probable cause of its not being reckoned a constituent part by some chemists. This air is called carbonic acid gas, from its having carbon as its base, and from the uniform disposition which that substance possesses to combine with oxygen. It exists in the state of an acid, possessing greater specific gravity than either of the other gasses, and for that reason is supposed to be found only near the surface of the earth.†

Hydrogen gas, so called from its being the base of water, is formed from numerous sources, and often exists in the air we breathe; from its

* Oxygen gas is thus denominated from its base being necessary in the formation of all acids.

† Sassure found it at the top of mount Blanc, the highest point of the old continent; a point covered with eternal snow, and not exposed to the influence of vegetables or animals. Lime-water, diluted with its own weight of distilled water, formed a pellicle on its surface after an hour and three quarters exposure to the air on the top of that mountain; and slips of paper acquired the property of effervescing with acid after being exposed for half an hour in the same place. *Thompson's Chemistry*, vol. iii. p. 284.

possessing less specific gravity than the other airs, it occupies the higher regions of the atmosphere.

Oxygen exists in the state of gas by being combined with caloric, or the matter of heat which is separated in the combustion of inflammable bodies,* while its base enters into combination with the combustible substance forming (if the union be complete) an acid, as with sulphur; but if imperfect or partial, a calx or oxyd. All bodies, when burned in this gas, are rapidly consumed, and give out a bright flame that is painful to the sight. *Azotic gas* is also united with caloric; it is lighter than common air, enters largely into animal bodies as a constituent part, and being chemically united with oxygen, forms nitric acid. The necessity of these airs, or some one of them in particular, in respiration, is an obvious fact, and is best ascertained from experiments made upon animals when breathed in an uncombined state.

If an animal be confined in azotic air, its life is suddenly destroyed, and the effect is almost as sudden from hydrogen gas. This, however, appears to be contradicted from the experiments of Scheele: he found he could breathe it for some time without much difficulty. The same experiment was also made by Pilatre de Rosier, and nearly with fatal consequences upon his first respiring it; but afterwards he was enabled to continue the experiment without much inconve-

* This is denied by Mr. Davy from some experiments of his. See *Beddoes' Observations*.

nience for some time. This experiment was repeated by Fontana: he ascertained that the ability to breathe this gas arose from the common air contained in his lungs when he began to breathe. Mr. Davy was unable to breathe hydrogen, but with the greatest difficulty, after a complete voluntary exhaustion of his lungs. It produced an uneasy feeling in his chest, momentary loss of muscular power, and sometimes a transient giddiness. The probability therefore is, that this air is respirable only till the common air contained in the lungs becomes vitiated, for they always contain it in considerable quantities. Forty cubic inches of air is the quantity usually taken in at each inspiration ; by a forced expiration much more can be expelled: hence the lungs are supposed to contain, at their utmost fulness, not less than two hundred and twenty cubic inches of air, and it is not in our power to empty them completely.

The fatality of carbonic acid gas to animal life is proved from numerous instances; as that of holding animals over the tubs of fermenting beer, where we know this gas is generated, or over springs from which it is thrown off. The instances of people going into wine cellars that have been long shut up, by which they are instantly suffocated, and the experiments made at the celebrated Grotto del Cani in Italy, to satisfy the idle curiosity of travellers, are sufficient evidences of its fatal properties.

These gasses then being evidently proved noxious to animal life, oxygen is that part alone that remains which appears essential and necessary; this, in an increased or diminished quantity, renders a certain portion of atmospheric air respirable for a longer or shorter time, the life of the animal always being proportioned to the quantity of oxygen. And in these particulars the same facts are true as respects combustion: as the quantity of oxygen, in a limited proportion of air, is diminished, the flame begins to decay, and is, at length, entirely extinguished: on examination this air is found to be entirely consumed, while, in some instances, other substances are generated. It is from a similarity of results in the experiments upon animal life and combustion, that this process has been concluded to be the same, which, however, is contradicted from some known facts hereafter to be enumerated.

It is presumable, from the facts and experiments that have been detailed, that the air answers some important purpose in the animal body; and from its coming nearly in contact with the blood while it circulates through the lungs, separated only by a delicate membrane, it may be inferred, that this becomes the medium through which the necessary changes are answered. Some sensible effect may therefore be rendered evident upon this fluid, as so frequent a change becomes necessary for the support of life. These effects may be judged of by exposing blood to the influence of each gas out of the body, from which we may probably infer the importance of the oxygenous portion.

1st. If we expose a quantity of venous blood, which is of a dark colour, to a certain quantity of atmospheric air, it becomes of a bright colour, and the air is diminished in quantity. This change of colour is effected not only by an immediate contact of air with the blood, but the same effect is produced through the thick coats of a bladder, which fact was first noticed by Dr. Priestley.

2d. If venous blood be exposed to oxygen gas alone, the change in colour is the same, but the diminution not so sensible; and in this experiment, agreeable to Girtanner, a quantity of hydrogen and carbon are given out, which form water and carbonic acid.

3d. Venous blood exposed to azotic gas undergoes no change in its colour, neither is the gas diminished in quantity; but if arterial blood be exposed to its influence, it becomes of the colour of venous blood, and after being exposed for a short time, the air contained in the bottle in which the experiment was made, was found capable of supporting animal life and combustion.*

4th. Venous blood exposed to carbonic acid gas becomes of a brownish-red colour, and the gas is slightly diminished in quantity.

5th. Venous blood exposed to hydrogen gas renders the colour darker, but its action upon arterial blood is to render it suddenly of a dark colour.

These experiments, with others that have been made, show that the principal apparent change

* Venous blood possesses the power of decomposing the oxyd of azote, which heightens its colour.

wrought upon the blood is in the colour, and that by the absorption of oxygen it is also capable of giving off this air when exposed to other matters which have a stronger attraction for it, as is also proved by the experiments mentioned above.

If these changes are effected upon blood out of the body by the influence of air, it becomes necessary to ascertain whether the same effect is produced upon the mass of venous blood while passing through the lungs of animals during life; for a confirmation of which, we must refer to the experiments of Hook, Goodwyn, and Hunter. They took a dog, opened the chest, removed the pericardium, and kept the animal alive by an artificial respiration. Here it was found that the blood carried to the lungs by the pulmonary artery was of a dark purple hue, answering in all its appearances to that of venous blood in other parts of the body, while that returned to the heart by the pulmonary veins became of a bright vermillion colour: if they ceased to throw in air this change did not take place; the blood returned by the veins was as dark as that brought by the artery; a diminution of the pulsations of the heart and arteries took place, and finally ceased. These were all renewed upon air being again thrown into the lungs; and life was in this way suspended and renewed at pleasure.

From the similarity of change effected upon the blood both in and out of the body, and from the immediate connection that exists between it and its vital actions, we may justly conclude that oxygen is that part of our atmosphere which, when combined with the blood, gives the vital spring, as it is immediately applied to the most irritable muscular organ of the human body, and which from its earliest formation is highly susceptible of every stimulating impression, and capable of maintaining its irritability longer than any other. This principle of the heart is more accumulated upon the internal surface than in any other part.*

If the air of expiration be examined, it will be found to differ materially in its properties from that of inspiration. The oxygen, and a small portion of the azote, have disappeared; a quantity of carbonic acid, and water in the state of vapour, has been generated. In respect to the quantity of air that disappears during each inspiration, the experiments of different chemists vary: Lavoisier and Dr. Menzies made it one-twentieth of the air inspired, while others have made the quantity greater or less, according to the perfection of the apparatus with which the experiments have been made, and the accuracy of observation. These chemists confined the diminution only to the oxygenous portion of the atmosphere, while the later experiments of Mr. Davy have confirmed the supposition of Dr. Priestley, that a certain portion of azote as well as oxygen was absorbed by the venous blood. He found by repeated experiments, the average quantity of air that disappears to be 1.4 of a cubic inch, of which 0.2 are

* It is a position that has been considerably contended for, whether the heart derived its principle of irritability from the oxygen of the air; whether it was a principle derived from another source, or resident within itself. The former position has been strongly contended for by Girtanner and other pneumatic physiologists.

azote and 1.2 oxygen. This, allowing twenty-six respirations per minute, which is about the average number, amounts, in twenty-four hours, to rather more than thirty-eight ounces of air, or precisely 4.68 of azote, and 33.54 of oxygen.*

That carbonic acid gas exists in the air of expiration, is proved from the simple experiment of breathing through lime-water, which renders it turbid by the new combination that is formed: the carbonic acid unites with the lime that is suspended in the water, and forms a carbonate of lime that is insoluble.

That water is also continually passing off from the lungs in the state of vapour, is rendered evident to every one that breathes in a cold atmosphere, or upon the surface of a polished body, by the condensation that takes place. Whether these substances are formed in the lungs by the combination of the oxygen with the hydrocarbon that is thrown off from the blood, or, whether they are formed during its circulation through the body, remains a question not satisfactorily determined from experiments. As far however as experiments have been directed to the particular investigation of this subject, their results favour the latter opinion. From a collection of these facts, it follows to investigate how far they may tend toward an explanation of the phenomena of animal heat.

It is a singular property which animals possess of supporting a standard degree of temperature

* Thompson's Chemistry.

in every vicissitude of climate.* Thus we find that the degree of temperature is the same in the coldest regions of the earth where man can exist, and where even mercury may become solid, as well as in the higher ranges of temperature up to that of boiling water, as was proved from the experiment of Dr. Fordyce and others. In this extreme degree of heat, they found the body supported its standard degree of temperature, that of 98 deg. And it is even said, that man, by habit, may become able to bear a much greater extreme.

In the different classes of animals, there is a considerable variety in the heat of their bodies. This variety is dependant upon the perfection of their respiratory organs, and their capability to take in a large proportion of air. As for example, in birds, where, from the particular structure of their lungs, the blood is exposed to the extensive influence of air, their temperature exceeds an hundred degrees of Fahrenheit's thermometer.

In the lower classes of animals, or what are called the cold-blooded, their heat exceeds very little the medium in which they live. In these animals, the process of respiration is slow, and the quantity of air that is absorbed is small. They retain their irritability longer than the more perfect animals, and suffer less from any injury which they receive. Their power of generating heat is not sufficient to prevent them from be-

* This power, from experiments, appears to extend also to vegetables in a very considerable degree. Their standard temperature does not exceed 56 deg.

coming torpid during the severities of winter, but are soon renovated from the warmth of spring.

The standard heat of animal bodies is regulated not only by the nature of the air taken in, but by a function of its own, the *cutaneous perspiration:* for, in the extremes of cold, we not only take in a larger proportion of vital air, by a condensation from a diminished temperature, but the perspiration is in less quantity, and a portion of heat is retained. When respiration becomes quickened from any cause, the heat of the body is increased, and continues so until a proportional increase of perspiration subducts the superabundant heat from the system. As it is an established law, that in proportion as aqueous fluids are converted into insensible vapour, caloric, or the matter of heat is absorbed. These facts are particularly exemplified in walking more rapidly than usual, or in any other species of exercise which calls a number of muscles into considerable and continual action; and in fever, where the perspiration becomes obstructed; while the actions of the heart and vessels are increased, and the respiration proportionably quickened, the heat will be more continued, and is diminished only by a free discharge of perspirable matter. In high degrees of temperature, the air we breathe is much rarified, and a much less quantity of vital gas respired in an equal volume of air; while, at the same time, the cutaneous perspiration is much more increased, and its vicarious discharge, that by the kidneys, diminished. We are hence enabled to live under every vicissitude of climate and season. The different opinions which have been offered to explain this property of animal bodies, admit of considerable diversity, even after the importance and influence of air was understood from experiments. Dr. Priestley made respiration to consist in an elimination of a noxious principle from the blood, which is thrown off from that brought to the lungs by the pulmonary artery, for which the air of inspiration has a stronger affinity than the blood, and when separated renders it of a bright colour. This principle is denominated *phlogiston.* It was this theory that was adopted and improved upon by Crawford and Elliot, by means of which they attempted the explanation of the different phenomena of animal heat; saying that in proportion as the blood parted with phlogiston its capacity for containing fire became increased, which it absorbed from the air, and distributed to every part of the body. The exceptions to this doctrine are obvious; for the explanation is entirely dependant upon an assumed principle, of whose evidence we have no certainty, and, of course, are incapable to judge of its properties. The theory of Lavoisier is similar to that of Priestley, differing only in terms. His opinion was, that the quantity of oxygen was diminished by its combining with hydrogen and carbon, to form water and carbonic acid gas; at the same time a portion of caloric was given to the blood. This theory is incorrect, inasmuch as it asserts the combination of hydrogen and carbon at a lower temperature than is evident from experiments out of the body, where the decomposition does not take place in any instance without the production of flame. Lavoisier, however, did not prove this theory from experiments; it was the subject in which he was engaged when cut off by the tyrannical hand of *Robespierre*. The theory of Le Grange differs somewhat from that of Lavoisier. He has asserted that a portion of oxygen is taken up by the blood in the lungs, and at the same instant a quantity of water and carbonic acid are given out. This, however, makes the lungs still the fire-place of the system, and besides allows only the oxygenous portion of the atmosphere to be absorbed, which is contradicted by the experiments of Mr. Davy, as mentioned above, whose theory appears liable to the least objections. He considers the blood, while passing through the lungs, to absorb air in an undecomposed state, which it carries through the blood vessels. In the course of the circulation this air is gradually decomposed, the oxygen of the azote entering into new combinations, while a portion of azote and carbonic acid are evolved. On returning to the lungs, the blood receives a fresh supply of air, and, at the same time, discharges the azotic gas, carbonic acid gas, and watery vapour formed during the circulation.

From the experiments of Mr. Davy, respecting a diminution of a portion of the azotic part of the atmosphere, some new reasoning upon the process of respiration may be introduced: for, before these experiments, the writers upon this subject confined themselves to an investigation of those substances in the blood that should account for the strong affinity that existed between it and oxygen. Accordingly iron, whose presence is universally proved to exist in all animals that possess red blood, was considered, from its readiness to combine with oxygen, as best calculated to explain the change produced. "But as the temperature at which this oxydation takes place is not sufficiently great to account for that instantaneous change which the blood undergoes in the lungs, or when exposed to the influence of oxygen out of the body, it is therefore necessary to call in some other of the component part of the blood; and as phosphorus is always found in the blood of animals, and its attraction for oxygen is very strong, and that at a low temperature, it explains more satisfactorily the effect produced."* If these then are the substances with which the oxygen combines, to what is the azote united? We are told by Mr. Davy, that the blood becomes completely animalized in the lungs. If this be the fact, it may be explained why so small a portion of the azote disappears, for the discharge of chyle into the subclavian vein is slow and gradual, and this absorption must be in that proportion; and as azote is a constituent part in all animal bodies, whether their food be taken from the animal or vegetable kingdom, its appearance upon their decomposition, in con-

* Youle on Respiration.

siderable quantities, and its production as the result of chemical experiments, are facts that lead us to conclude, that azote enters into combination with the animal fibre, as derived from the air through the lungs.* These discoveries show that what is fatal to animal life in an uncombined state, is necessary to it when combined, and demonstrates the economy of nature in the regular preservation and support of life.

Oxygen gas, when breathed in a pure state, gives new vigour to animal life, quickens the circulation, increases the heat of the system, promotes digestion, and is said to produce the most pleasurable sensations. The sense of heat in these instances has been said to begin in the lungs as a centre, and to be diffused from thence more generally over the body. These experiments were however closely connected with the establishment of a favourite hypothesis, and the sensations were felt more evidently by the authors than by disinterested persons. That oxygen is however a powerful stimulus is an acknowledged fact, and like all other powerful stimuli, when continued for some time, destroys the animal machine. Azote may therefore answer a further purpose in the animal economy, that of properly tempering the air, be-

* From some late experiments that have been made by Dr. J. Leymerie, of France, he has found that ammonia is one of the essential parts in the formation of red blood. Now, as the component parts of this substance are *azote* and *hydrogen*, we are again shown the necessity of a supply of the former material in order to answer the essential properties of an animal fluid. He has succeeded in converting milk into blood by the addition of pure ammonia in certain adjusted proportions within a given time. A more full account of his experiments will probably soon be given to the public.

sides allowing of a more extensive exposure of blood in the lungs, to the influence of that quantity of oxygen that is necessary to the support of life, by inflating them with a gas whose stimulant properties are not so powerful, but whose presence is at the same time equally necessary. This position, therefore, appears consistent, inasmuch as it explains many of the phenomena connected with animal life.

The following conclusions may then be drawn from the facts and experiments detailed: 1st. That respiration is of use, by imparting oxygen to the system through the medium of the blood circulated in the lungs, for the principal purpose of giving heat to the body by the new combinations that are formed. Of this we are convinced directly from experiments. Mr. Davy took blood from the carotid artery of a calf, enclosed it in a phial, to which was affixed a pneumatic apparatus; it was then exposed in a sand bath to a temperature of 96 deg. gradually increased to 108 deg. The blood now began to coagulate, some globules of gas were emitted; the temperature of the bath was raised, and the blood became of a dark colour. On examining the nature of the air disengaged, it was found to be oxygen, with a small quantity of carbonic acid.* We are also convinced that oxygen is absorbed by the blood from its presence in many of the secretions and excretions formed from this fluid; as in the urine, where it is discovered passing off as excrementi-

* Beddoes' Observations.

tious in the form of an acid. In the bones it has entered into union with calcareous matter when combined with phosphorus. In the fat of animals a particular acid is also discoverable. The formation of acids in these different secretions depend upon the presence of oxygen, as it is an acknowledged principle in chemistry, without it no acid can be formed. If oxygen then be maintained in its gaseous state by means of caloric, its decomposition and new union must have set it free. It is therefore probable that oxygen is decomposed in the extreme vessels; for, as far as we have yet become acquainted with secretion from the ultimate structure of glands, the process appears to be effected in the extreme arteries. And further, while a partial action of the minute ramifications of arteries become excited, as in local inflammation, a preternatural heat is accumulated without an increase of respiration: but this effect cannot be produced to any considerable extent without an increase of arterial action, which produces a disease of the whole body. This fact is more particularly exemplified where the principal arterial trunk of a limb is tied up, and the circulation is to be carried on by the small anastamosing branches. Here at first the limb is cold, until the blood begins to find its way by the minute vessels which are excited into great action, the heat becomes preternaturally accumulated, and continues so until some of the branches are sufficiently dilated to transmit the former quantity of blood.

2d. The union which has taken place between the chyle and azote, as a constituent part, and which has now become of the nature of blood, in all respects fit to answer its purposes in the body, of forming new secretions, generating new parts, and effecting every property which is necessary in the maintenance of the animal body.

It is a fact admitted by physiologists, in which they have been aided by the experiments of the chemist, that the coagulable lymph is that portion of the blood approaching the nearest to the nature of the animal fibre; and from this property the inference is consistent, that it is more particularly calculated to answer every purpose of nutrition to the body, the wastes of the machine are continually going on, and it is necessary that they should be as continually repaired. From these different changes, is it not probable that the animal heat is in some degree assisted in its regular maintenance? It must also be admitted, that as *azotic gas* enters into union with the coagulable lymph to render it of the nature of the animal fibre, it also parts with its caloric in the same manner as the oxygen. And it is an established law, that as gaseous substances assume the solid form, their caloric is set free; this heat being disengaged from its base, which has formed a union, assists itself also in answering a useful purpose.

Animal heat may therefore not be dependant upon the respiration of oxygen alone, but upon the absorption of azote also, which two gasses are so changed by means of vascular action, that their bases enter into union with the body to answer useful purposes in the animal economy. And it is by means of these changes that the regular maintenance of animal heat is kept up, subject to irregularities from increased respiration and diminished perspiration, as in fevers and active exercise; regulated also in colder climates by the volume of air being more condensed and perspiration lessened. These facts may be considered fully evident, yet the chemical changes that occur in the animal body are so obscure, that it will require a number of well conducted experiments before every objection can be answered that may be urged against the opinions advanced, which the genius for improvement appears to be rapidly investigating.

THE END.