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ORIGINAL COMMUNICATIONS.

ART. I.—*A Valedictory Address delivered in the Chapel of Transylvania University, to the Medical Graduates at the Commencement on the* 12*th of March*, 1828. By CHARLES WILKINS SHORT, M. D. Dean of the Medical Faculty.

(Published by request of the Class.*)

GENTLEMEN GRADUATES,

You have now received through that official source,† designated by the proper authorities for the purpose, the highest honour which the Trustees and Medical Faculty of Transylvania University have it in their power to bestow; and having reaped that reward in the field of Science to which your la-

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*Dear Sir, In compliance with the wish of the Medical Class, we would request of you, a copy of the Valedictory Address to the Graduates, for insertion in the Transylvania Journal of Medicine &c.

Respectfully,

N. N. SMITH, of Georgia,
W. M. GWIN, of Tennessee, } Committee.
D. H. MASON, of Alabama,

PROFESSOR SHORT,

MARCH 13th, 1828.

† The Presidency of the Institution being at the time vacant, Professor Dudley was appointed by the board of Trustees to preside on this occasion.

ART. IV.—*On the Chemical changes that take place in the Blood, during Respiration, and the causes of Animal Heat.* By JAMES BLYTHE, D. D. Professor of Chemistry in Transylvania University.

IN a former paper* we endeavoured to trace some of the effects produced upon the atmospheric air by *respiration.* In this paper we shall endeavour to trace some of the effects produced upon the animated system in general by the same process.

It cannot be too frequently repeated in the ear of the student of nature, *that nature is her own interpreter;* that is, she always gives some information as to her ultimate and occult purposes, by what she renders *visible* and *palpable.* Where she does nothing to indicate her purposes, to say the least it is idle to speculate. We therefore call the attention to this known fact. The blood passes from the heart to the lungs, and circulates through the vessels of those organs, and during that circulation is exposed to the influence of the atmospheric air, which the animal is constantly drawing into the lungs. Now here is a grand indication. Science would say, some great good is to be effected upon the blood, and probably through the blood upon the whole system by the constant approximation of blood and atmospheric air.

Another fact is also worthy of observation here—the *rapidity* of this circulation. Nature, or rather the God of nature does nothing in vain. There is still another thought no less worthy of our notice, viz. the *uniformity* of this circulation. This uniformity is so great that it is a measure of health, and the absence of it an indication of disease.

Certain changes are produced upon the blood by its passage through the lungs. These changes have been traced with great accuracy by Priestly, Fourcroy and, among other philosophers,

*Trans. Jour. Vol. 1, p. 227.

by Davy. These changes so far as we are acquainted with them are the following.

1. It acquires a florid red colour and loses a portion of its carbon. 2. Its capacity for caloric, is increased, and therefore, agreeably to a well known chemical principle, it becomes more thin and fluid.

It has long been known that the blood that flows in the veins is of a dark reddish purple colour, whereas the arterial blood is of a florid scarlet colour. To this subject Lavoisier paid great attention. The result of his investigations was, that the colour of the blood is changed by the combination of oxygen. His theory on this subject has been denominated the *oxygenation* of the blood. This theory it is known has been laid aside. Has it not been laid aside too hastily? I believe it has: and for this I have two reasons. That venous blood, whether during the circulation or immediately after it has been drawn from the veins, is changed to a florid scarlet colour, by coming in contact with oxygen gas, is too well established by experiment to be doubted. Now can any fluid be changed in its colour unless something be added to it, or subtracted from it. I know the present theory is that the change of colour is owing to the abstraction of carbon. If this were the *only* cause, would the change of colour always be the same as observed in the living animal? I apprehend not; because the quantity of carbonic acid emitted at each expiration, varies at different periods of the same day, and probably in different individuals: It appears at its maximum during digestion, and at its minimum in the morning, when the stomach is empty, and when no chyle is flowing into the blood. Now is it agreeable to philosophy, to say that this uniformity of effect can be produced by a cause which operates with so little uniformity?

But I have another reason for not throwing away entirely the theory of the oxygenation of the blood. If, as I have endeavoured to show in my former paper and as I have no doubt will ultimately prove to be true, a portion of oxygen, equal to at least two per cent. disappears at every expiration, we may ask what becomes of it, if it is not employed in oxygenating the blood. It will not be said that two per cent. is by far too small a quantity of oxygen to produce any effect. This objection will vanish by making a very small calculation. If we suppose twenty-five cubic inches of atmospheric air to be taken in at every inspiration, (which I am convinced is below the truth, with a man of ordinary size,) this multiplied by the ordinary number of inspirations, viz. twenty in a minute, will give five hundred cubic inches of atmospheric air passing through the lungs every minute. This five hundred divided by five (and more than one fifth of the atmosphere is oxygen,) will give one hundred cubic inches of oxygen passing through the lungs of a man of ordinary size every minute, two cubic inches of which goes into the circulation. Now inasmuch as blood newly drawn from a vein, and brought into contact with oxygen gas, uniformly changes its colour, and, if the experiment be performed over mercury, the mercury perceptibly rises in the receiver, is it not fair to draw the following conclusions? that a portion of the oxygen has combined with the blood, and has aided in the change of colour. If this reasoning be correct the old abandoned theory of Lavoisier ought to be revived. *The blood is oxygenated in the act of respiration.*

But the oxygenation of the blood is not the only change that is produced upon this fluid by respiration. The blood is also *decarbonized*. The change of the colour of the blood is partly owing to the action of the air, which takes place through the thin coats of the circulating vessels; and the end thus attained, is the removal of a portion of carbon from the venous blood. It can scarcely be doubted that the presence of carbon obscures the colouring matter of the blood, and consequently the venous blood is of a black or dark colour. That this blood is decarbonized by coming into proximity with atmospheric air, we think can be doubted by no person, except under the influence of a love of theory in the face of fact. When on the subject of the black colour of the venous blood, the chemist has been asked if carbon is *black*. We answer no; *pure* carbon is not black; but impure carbon is always black, or approaching to black. From this remark I do not now recollect a single exception. These two chemical differences, therefore, between venous and arterial blood, are we think well established; viz. that arterial blood is oxygenized, and the oxygen imbibed, in part, affects its colour. The venous blood is decarbonized, and by this process in part, it is converted into arterial blood. The blood is by this twofold process reconverted, and is fitted for the renovation of parts of the body, for the formation of secretions, and for the sustenance of life, by its action on the cerebral system. It is worthy of remark, that although the heart does not refuse to circulate venous blood, paralysis and stupor never fail to be produced, when blood not aerated, passes into the brain.

I have only farther to remark upon this part of the subject; that when oxygen is changed into carbonic acid, it does not materially change its bulk; and that the blood from the best experiments, in a man of ordinary size, must emit carbon in or through the lungs, to the extent of three fourths of a pound in one day. Now we lay it down as a fact which cannot be controverted, that no compound substance in a fluid state, can be exposed to the constant action of the atmospheric air without undergoing a greater or less change by that exposure. Water itself, between the ultimate elements of which there is the most perfect balance, and consequently the most intimate union, loses some of its properties by being excluded from the action of the atmosphere, and regains them by its readmission. It would therefore be miraculous indeed, if the blood did not undergo constant changes by its constant exposure to so great a quantity of atmospheric air, as five hundred cubic inches in a minute. The fact is, it is impossible for these two fluids, the blood and atmospheric air, to come in contact with each other, or if not into absolute contact, into such a state of proximity as they do, without mutually decomposing each other, when we take into consideration their constituents. Now this decomposition is constantly going on by the agency of living organs, the lungs, upon dead matter, the atmosphere.

Perhaps the atmosphere is vital too; and then the chemical actions of which we have been speaking, are nothing more than the agency of two vital principles upon each other, and of course the whole of them are without the legitimate field of chemistry, according to some philosophers: and after all that has been written about the vitality of the blood, I would as soon suppose that the *air* was vital as that the blood was. Whether the blood be vital or no, or whether it be or be not partially decomposed by the action of the atmosphere, we know that it is a very compound body and subject to perpetual decomposition by some means.

Blood usually consists, according to Dr. Ure, of about three parts serum to one of cruor: and according to Berzelius, 1000 parts of the serum of bullock's blood consists of 905 water, 79.99 albumen, 6.175 carbonate of soda, and extractive matter, 2.565 muriate of potash and soda and animal matter, and 4.75 loss. One thousand parts of the serum of human blood consists of 905 water, 80 albumen, 6 muriate of potash and soda, 4 carbonate of soda with animal matter, and 4.1 of soda and phosphate of soda, with animal matter. But suppose it should be said that none of these substances are found in the blood in a *free* or *formal* state. On this supposition I should like to know how we are to account for the two following experiments; viz. that the serum of blood changes the syrup of violets to a green, if blood does not contain *free* soda or some alkali. If there be not free carbonic acid in blood, how can we account for the fact that newly drawn blood under an exhausted receiver, gives it out in considerable quantities. If blood be thus compounded, can we for a moment resist the belief that the presence of the atmosphere must necessarily decompose it.

Before we progress farther into this curious and certainly chemical investigation we ought carefully to note two things.

A great many experiments have been made by different chemists to ascertain which of the two fluids venous or arterial blood, has the greatest capacity for caloric. Dr. Crawford makes the capacity of arterial blood for caloric to exceed that of venous blood as 1.0300 does 0.8928; Mr. Davy, who, I believe, makes it less than any other philosopher whose works I have examined makes it as .913 to .903. All agree that there is a considerable difference.

A second fact equally well established by experiment, is, that the specific capacity of oxygen and carbonic acid gas for caloric, is also considerably different; oxygen having a greater capacity for caloric than carbonic acid. According to Crawford, the capacity of oxygen for caloric, is to the capacity of carbonic acid for caloric as 4.794 to 1.333; and according to Dalton as 1.333 to 0.2361. That is if the capacity of a portion of water for caloric be represented by 1000, the capacity of a similar portion of oxygen for the same, is 4.794, and that of carbonic acid 1.333 according to Crawford.

But there is another circumstance which would lead us to conclude that arterial blood has a greater capacity for caloric: It is I believe universally admitted that arterial blood is thinner and more fluid than venous blood. It is a law of nature, from which I do not now recollect any exception, that all fluids under the influence of an increased capacity for caloric are thinner or more fluid. I am aware that this increased fluidity is said to be owing to an increased *vitality*. Now if vitality be the cause of fluidity in one animal fluid, we cannot see why it must not be the cause of fluidity in other animal fluids. In other words, if fluidity be the effect of vitality in one instance, it would be but reasonable to suppose that it would be the effect of vitality in every other instance; and consequently that fluidity in any animal fluid is a measure of its vitality; and therefore the urine or the milk, or any other secretion is more vital than the blood. This will not be contended for by any one; nor ought it ever to be contended for that the fluidity of the arterial blood is owing to its *greater vitality*. I imagine it is merely owing to its greater capacity for caloric.

We think that the above facts and indications have been abundantly established by the experiments of the ablest philosophers; nor ought they to be called in question, but by a similar set of equally well conducted experiments and inductions. From them we obtain the two following important uses of respiration.

1. The change of the chyle into blood. Indeed the blood is a fluid which is constantly running through a suit of changes; and it is preserved in a similar state only by the constant influx of new materials, which are constantly converted into blood. It appears from the most accurate experiments hitherto made, that neither chyle nor lymph contains fibrin. This fibrin is em-

ployed to supply the waste of the muscles, the most active part of the body, and therefore in all probability requiring the most frequent supply. The quantity of fibrin in the blood, must then constantly be diminishing, and therefore new fibrin must constantly be formed. But the only substances out of which it can be formed, are the lymph and chyle, neither of which contain it. There must therefore be a continual decomposition of the chyle and the lymph going on in the blood vessels, and a continual formation of fibrin. Other substances may be formed, but we are certain this *must* be formed there, for it did not exist previously. Now one great end of respiration must undoubtedly be, to assist this decomposition of chyle, and complete the formation of blood.

In what manner chyle or a part of it is converted into fibrin, is perhaps impossible to say: we are not sufficiently well acqnainted with the subject to explain the process; but we can see at least, that carbon must be extracted from that part of the chyle, which is to be formed into fibrin. Hence, as the process of blood-making advances, there must be a greater and greater redundancy of carbon in the blood. Unless this redundancy were removed, the process could not go on, and probably the whole would run into putrefaction. We conclude then that one great end of respiration is to abstract the carbon, by forming carbonic acid.

2. But the abstraction of carbon is not the only advantage gained by respiration. The temperature of all animals, depends in a measure upon it.

It has long been known that those animals which do not breathe, have a temperature but little superior to the medium in which they live. This is the case with fishes and many insects. Man on the contrary and quadrupeds which breathe, have a temperature considerably higher than the atmosphere: that of man is 98°, and in all latitudes the temperature of the human body is the same. Birds who breathe in proportion to their size a still greater quantity of air, have a temperature equal to 103° or 104°. It has been proved that the temperature of all animals is in proportion to the quantity of air which they breathe in a given time.

These facts seem sufficient to prove that the heat of animals depends at least in some measure upon respiration. But it was not till Dr. Black's theory of latent heat became known to the world, that an exposition of the cause of the temperature of breathing animals was attempted.

According to him, part of the latent heat inspired becomes sensible; and of course the temperature of the lungs, and the blood that passes through them, must be raised; and this blood thus heated, communicates its heat to the body. This opinion was ingenious, but was liable to an insuperable objection; for if it were true, the temperature of the blood ought to be greatest in the lungs, and diminish gradually, as the distance from the lungs increases; which is not true, to any great extent. The theory was consequently abandoned even by Dr. Black himself.

Dr. Crawford who considered all the changes operated by respiration, as taking place in the lungs, accounted for the origin of animal heat almost precisely in the same way with Dr. Black. According to him the oxygen gas of the atmosphere, combines in the lungs with the carbon emitted by the blood. During this combination, the oxygen gives out a great quantity of caloric, with which it had been combined; and this caloric is not only sufficient to support the temperature of the body, but also to carry off the newly formed water in the state of vapour. According to this philosopher then, the whole of the caloric which supports the temperature of the body is evolved in the lungs. This theory accordingly was liable to the same objection with Dr. Black's; but Dr. Crawford obviated it in the following way. He found that the specific capacity of arterial blood for caloric, was 1.0300, while that of venous blood was 0.8928. Hence he concluded that the instant venous blood is changed into arterial blood, its capacity for caloric increases; consequently it requires an additional quantity of caloric to preserve its temperature as high as it had been while it was venous blood. This addition is so great, that the whole new caloric evolved is employed; and therefore the temperature of the lungs must necessarily remain the same as that of the rest of the body. During circulation arterial blood is gradually converted into venous blood, consequently its specific caloric diminishes, and it must give out heat. This is the reason that the temperature of the extreme parts of the body does not diminish.* If we add to the above remark a fact, to a greater or less extent admitted by all philosophers, that the capacity of carbonic acid gas for caloric is considerably less than that of oxygen gas, and reflect that the portion of carbonic acid emitted in respiration is nearly equal to the quantity of oxygen consumed, we have a copious source of animal heat; for all the extra portion of caloric which was necessary to preserve the oxygen in a gaseous state, above what was necessary to preserve the carbon in that state, must go into the general circulation.

Let any philosopher put together the following facts and candidly admit the inductions.

1. The astonishing rapidity of the circulation, even if we assume that calculation which is the lowest. Why this perpetual rushing of the blood "to kiss" the atmosphere so often in an hour?

2. Why expose twenty cubic inches of the atmospheric air to the blood, sixteen or twenty times renewed every minute? Shall I be told "to vitalize it?" Very well: and in what does this vitalization consist, if not in imparting to the blood a small portion of that gas without which the lamp of life would be extinguished, and subducting from it another gas, the abundance of which induces death? If any thing else be meant by vitalizing the blood, I should like to know what is meant. I am afraid the terms vitality and vitalization, have a strong resemblance to Aristotle's occult qualities.

3. A third and to me a beautiful coincidence of causes presents itself when we reflect that at the moment when the inspired oxygen of the atmosphere necessarily parts with a portion of its caloric when converted into carbonic acid, the venous blood has its capacity for caloric increased, by being converted into arterial blood, and the system is thus supplied with caloric, regularly emitted as the arterial blood changes into venous blood.

I do not know that I should contend for respiration, or the oxygenation and decarbonization of the blood, as being the only source of animal heat, although it seems to me a sufficient source.

*In order to do the above named philosophers justice, we have nearly quoted their own words.

It is known to those conversant with chemico-physiological books, that the following sentiment dropped from the pen of Dr. Cooper (now of South Carolina) a few years ago. "I see no material difficulty in accounting for the production of animal heat from the doctrine of latent heat. The fluids of the body are incessantly employed to renew the solids; whenever a fluid is converted into a solid, heat or caloric is evolved, this takes place every moment very gradually in every part of the animal body."

It is said a gentleman of great philosophical pretensions, caused Dr. Cooper to abandon his ground, by suggesting, that the absorbents are constantly employed, in converting the old and worn out solids into fluid and carrying them off; and that consequently as much caloric is employed in reconverting the solids into fluids, as had been received by the system, when the fluids which had been employed in nutrition, had been converted into solids.

This objection to Dr. Cooper's hypothesis is certainly plausible, but not sound. Is it certain that this old worn out rubbish of the system, when it passes off in some of the gaseous or liquid forms, has the same *specific capacity* for caloric, which the comparatively living materials have, which present themselves to us in the forms of chyme and chyle, and fibrin, out of which, nature is about to repair her waste. This is, as far as I know, a new subject, and one on which no direct experiments have been made. But we would venture to pronounce that all the analogies and probabilities are in favour of the opinion, that the *calorific capacities* of the fluids, as we receive them into our system, far, very far exceeds the calorific capacities of those dead matters, which are momently carried off from the system. We have proof positive, that oxygen which we are constantly receiving for the sustainment of life, has a much greater *capacity* for caloric than carbonic acid, which, as we have seen, is constantly casting off. I therefore think Dr. Cooper's ground perfectly tenable, and if he has abandoned it, we should like to see him resume it. Thus we have a second source of animal heat. But we have no doubt respiration is the main source, and the constant supply of that fluid to the body is one of the chief objects of respiration. Says Dr.

Thompson, "the fact that all animals which respire regularly, are hot-blooded, while amphibious animals and fishes are cold-blooded, seems to me to establish a connexion between respiration and animal heat."

Nature is not more beautiful than she is simple; all her indications may be relied upon. Every where we see the wisdom, power and œconomy of the great architect of the universe.

> "When air's pure essence joins the vital flood,
> And from carbonic acid frees the blood,
> Contractile tubes the transient heat dispart,
> And lead the soft combustion round the heart."

Art. V.—*An Essay on Autumnal Diseases.* By John Esten Cooke, M. D. Professor of the Theory and Practice of Medicine in Transylvania University.

In a former number of the Transylvania Journal of Medicine &c. I have endeavoured to give an outline of an attempt, since published,* to investigate the connexion between the remote causes and the symptoms of fever and of some other diseases, by inquiring into the effects of those causes on the body; next into the effects of those effects, or new causes, and so on descending to the ultimate effects, the symptoms in question. In the present paper it is proposed to take a view of the origin of that cause which produces the autumnal diseases, of its effects on the system, and of the best mode of obviating them.

Most of the remote causes of fever do not produce epidemic disease. Excessive fatigue, violent emotions of the mind, excessive stimulants, &c. do not operate upon such numbers as are affected during the prevalence of epidemics, nor are they confined in their operation to particular seasons of the year. Famine is capable of producing epidemic disease, but it is comparatively a rare occurrence; whereas epidemics are annual in many parts of

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*A Treatise of Pathology and Therapeutics, by John E. Cooke, M. D. &c.