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On Resuscitation and Animal Heat

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On Respiration and Animal Heat

Respiration is a function of such importance to animal life that it has always claimed the attention of the Physiologist. It shall be the object of this Essay to treat of the chemical changes induced by it upon the atmosphere and to consider what powers there are for ascribing to it the origin of animal heat.
The ancients appear to have had crude and imperfect ideas upon the subject of Respiration. Hippocrates considered air to be an alimentary substance, the "Nabulum vitæ." Galen, who was aware of the fact that arteries and veins contain blood, thought that the air received into the lungs engendered the heat by uniting with the impurities of venous blood, which was the cause of its conversion into arterial, and he considered the trachea as nothing but a species of chimney to let out the suliginous vapors which arose from the combustion within. A very common opinion entertained by them seems to have
been, that it served to cool the blood which having been heated in the different processes carried on in the body was tempered in the Lungs. Expired air being observed to be warmer than that which is inspired seemed to be a strong proof in favor of this idea. It was also asserted in support of it that the quantity of blood in the pulmonary veins was much less than that in the correspond- ing arteries; the reason assigned for the blood being condensed by the escape of too much heat. An assumption, however, which is quite erroneous.

In more recent times, and with the
Progressive advancement of the sciences, since Anatomy has unfolded the structure of animal organs and Chemistry made known the elements of matter, a more correct theory has prevailed and Respiration is now generally defined to be the reciprocal action of the air and the nutrient fluid upon one another.

The organs in different animals subordinated to this surface vary according to circumstances, but in all the same design is manifest by the intimate contact of the air with this fluid. The higher animals, which breathe in air possess organs denominated the Lungs. In these, the branchial of fishes correspond, one or two animal organs, of which the Snan is an example. Insects both feel and lungs. Insects inhale the air by stig-
mata, the openings of tracheae which transmit it throughout the body. Polypi absorb the air by their whole external surface along with their nourishment, and plants act upon the air by their leaves.

To all animals and also to vegetables, the influence of the air is essentially requisite for the sustenance of life. Without it, the higher animals speedily perish. Fish cannot live in a vessel, the mouth of which is stopped so as to exclude the air, and hence it is a common practice to make holes in the ice of ponds, if the fish are to be preserved, to prevent them perishing in the water of the orifices of the tracheae of insects or the leaves.
of plants be immersed with oil they die. Even zooplankter cannot live without air.

The action of atmospheric air, says B. Roget, is equally necessary for the maintenance of vegetable as of animal life; and as the ascending sap of the one cannot be perfected unless exposed to the chemical agency of air in the leaves, in like manner the blood of animals requires the perpetual renovation of its vital properties by the purifying influence of Respiration. The great importance of this function is evinced by the constant provision which has been made by nature in every class of animals for bringing each portion of their nutritive juices in contact with air. Even the circulation of their juices is an object of inferior importance compared with their respiration, for we find that insects which have but an imperfect and partial circulation of their
blood, still require the introduction of air into every part of the system. The necessity for air is more urgent than their demand for food. Many animals being capable of subsisting for a considerable time without nourishment, but all speedily, perishing when deprived of air.

As the Lungs are the organs of Respiration, I venture to hope that a few remarks upon the structure of the human Lungs, for which Rushes, is my chief authority, will not be out of place. The Lungs, then, are a pair of light, elastic, spongy organs, enveloped in a serous membrane, and suspended by the trachea. The trachea is an extremely smooth, fine, thick mucous membrane, which continues from the throat forms a short tube, from which in its further course new branches are always given off which become pro-
portionally finer and more numerous till they end in the last branch or a blind end or cul-de-sac.

From this it appears that every vessel or circuit which we observe on the surface of the lungs is nothing but the blind end of a tube, and that the extremely numerous divisions of these terminations constitutes the crenitating substance which, is considered cellular tissue. The following experiment may serve as a proof of this.

Let the lobe of a calf's lung be prepared, the branches distributed to it being bare in the middle of its course, and after inflation a ligature applied to it there. The part under the ligature will remain inflated, but the part above will soon be emptied of air and collapse. Here the texture of the lungs seems cellular tissue, each cell having communication with another; the air would gradually penetrate from the part under the ligature to that above it, and
the inflated part would also be evacuated. Even when the cellular tissue is separated from the trachea, the part that will remain inflated. This morphyni proved by inflating a lung at a light; the flame of the light not being affected by it.

In order plainly to discover the true structure of the termination of the trachea, the following experiments were made by Rüksen. Mercury was forced into the branches of a lung, and gradually pushed forward with the handle of a scalpel till it projected at the edge of the lung. Under a simple microscope the mercury was plainly seen to form regular cylindrical tubes which gradually became more numerous till it at last remained at the border of the lungs and projected in semi-spheres under the pleura.
If we put such a piece of lung, filled with mercury, between two glass plates, and bring it under the microscope, by gently compressing these plates so that the mercury, which is always refilled by the residual air reaches the extreme terminations of the bronchi, it will be observed that the regular ramification continues to the end, that the decrease of the diameter of the bronchi is proportional, that the divisions that last become extremely numerous, that from every point of a bronchus new ones arise, which when they are not filled with quicksilver appear like small knots and that the final ones become so short as to appear only like semi-spheres sitting close upon each other, like the inflorescence of the cauliflower.

These experiments show satisfactorily that the bronchi of the lungs consist of cylindrical tubes, that at the end and formed of an opaque, mucous membrane.
But that the trachea may be always ready for the egress and ingress of air and follow with entire every motion of the chest, it must have supports to keep it always extended, to elongate and shorten it, to dilate and contract its diameter. These demands are satisfied by three different structures.

The support is given by cartilaginous rings not closed behind. These are impacted in a ligamentous tissue extremely thick and firm which completes the tube behind. In this tissue are situated the mucous glands. As the trachea buries itself in the lungs these cartilages cease to be hooped. They now form irregular laminae which revolve the tube so that it is impossible totally to compress it, nay, the more it is contracted the laminae fix themselves more firmly into each other and make the tube more rigid. At the mouths of every new branch an annular
cartilage is placed to keep this mouth always open.

As the bronchi become narrower and finer, the laminae also become narrower and finer, and are at least only visible at the offset of the branches as half rings. These also vanish, since they are no longer necessary, as the air which never wholly leaves the lungs keeps these small tubes always distended.

As far as the cartilaginous hoops continue, transverse muscular fibers, which are fixed to the ends of every cartilage, fill up the space which these hoops leave and form a muscular layer, upon the fibrous tissue which completes the rings behind. As the cartilages cease to be hooped and become laminated, these fibers encompass the whole circumference of the tube and pass over the laminae; they are continued to the extremity of the bronchi. The ligamentous fibrous web in which the cartilages are imbedded is very elastic, when extended quickly, resilient. Finally, it becomes a fine cellular expansion, embracing the muscular layer.
To shorten the trachea elastic white fibres are placed longitudinally at the back part of the mucous membrane. As the cartilages cease these fibres in fasciculi are continued round the circumference of the tube, and form a part of the structure to the termination of the bronchi.

The pulmonary artery conveys the blood uninterruptedly to the pulmonary veins, which also receive the returning vessels from the bronchi, the coats of the vessels, and nerves.

The bronchial arteries are the vasa nutricia of the lungs. They supply every part of them. The bronchial veins open into the pulmonary veins. One at the root of the lungs or the place of entrance of the first vessel to which they unite into a trunk, the bronchial vein which enters the aorta azygos or nearest systemic vein.

The absorptive system of the lungs is very extensive.
as Hewson, Muscagni have shown. The lungs are beautifully supplied with nerves. Halley was in error when he said, "neque magis, neque multis pulmonum nervi". They are supplied by the vagus, intercostals, and sympathetic.

The mucous membrane of the lungs is of vast extent. By Thores Sennus, it was estimated at 440 square feet or thirty times that of the whole external surface of the body. This was necessary that all the blood in the body every particle might be duly exposed to the influence of the air, a quantity of which is always contained in the air, only being changed at each inspiration and expiration.

By an ordinary expiration 40 cubic inches of air are emitted, but after this a considerable quantity may be expelled which has been estimated at 160 to 170 cubic inches.
so as to give 200-210 cubic inches as the difference between the states of ordinary inspiration and of extraordinary expiration. As it is impossible to empty the lungs completely, many calculations have been made of the residual air and this most probably amounts to 120 cubic inches. From which it is clear that after an ordinary expiration 280-290 cubic inches of air remain in the lungs.

The average number of respirations in a minute is 20 although this varies, there being many individuals whose respirations at the same time do not exceed 11 or 12 and some on the other hand in whom they are more than 20.

The air inspired suffers a diminution of volume. This has been calculated by Hales at \( \frac{1}{3} - \frac{1}{3} \), by Lavaisie at \( \frac{1}{6} \) by Bostock at \( \frac{1}{5} \). Some however have denied that it undergoes any diminution whatever as Allen and Pope.
As it is the blood and air which act upon each other in Respiration, in order to understand its chemistry, a knowledge of the constituents of each of them is requisite. The constitution of atmospheric air is well known; it consists of nearly 79 per cent. Azote, 21 Oxygen, and a minute quantity of Carbonic acid; but the blood is far more complicated in its composition, and the difficulty of its nice analysis must be referred the want of a chemical theory of Respiration altogether satisfactory.

Boyle and Mayow were the first who had any chemical ideas of Respiration at all tenable. The former supposed the air to lose its spiry or elasticity, as he expressed it, after the process. The latter thought the air communicated volatile nitro-sulphuric particle, to the blood, which imparted
to it, the scarlet color it assumes. This analogy he drew from the effect fixed nitre had upon the blood. The followers of Stahl imagined this change of color in the blood to depend upon the evolution of a principle from it, which they called phlogiston, and the air with which it united was said to be phlogisticated. After the discovery of oxygen by Priestley, it was ascertained by heat that a certain quantity of it always disappears in respiration. The warm-blooded animals deoxidate the air with less facility than the cold-blooded. According to Gallauzani, birds and quadrupeds die when they have consumed about one fifth of the atmospheric oxygen; Vaquerius first observed that animals low in the scale of life, live till they have abstracted all of it.

Menzie estimated the quantity of oxygen that
that disappears in human respiration in 24 hours at 57,480 cubic inches, Davy at 45,180, Laenec and Seguin at 46,037, and Allee and Pepys at 59,600.

At the same time that oxygen disappears from the inspired air, carbonic acid appears in that which is expired, a fact first observed by Girtanner and which is simply proved by the turbidity produced in theatened by breathing through it.

The source of this acid, the manner in which it is formed, whether it be generated in the different living processes or is merely formed by chemical combinations in the lungs are questions upon which there has been much discrepancies among Physiologists.

That carbonic acid is formed in the course of the circulation, and only eliminated in the lungs and is not the product of the union of its constituents in them several arguments have been.
added to prove.

1. The inequality in volume between the oxygen of the inspired air, and the acid of the expired air. Saurisier and Seguin, Gouley, Davy, Berthollet, D'Esprez, Humboldt, and Provençal found an excess of oxygen to be inhaled. T. Edwards found the reverse to be the case in some instances and the reverse in others. T. Priest made some interesting experiments upon this. He observed the quantity of carbonic acid exhaled to vary at different times of the day. It was at its maximum between 11 a.m. and 1 p.m., at its minimum between 8½ p.m. and 3½ a.m. It was reduced by alcohol, nitric acid, mercury, the depressing passions as anxiety, grief.

2. Carbonic acid has been detected in a free state in blood. Döpel remarked that venous blood placed under the influence of an air pump became very
frothy, that a gas was divengaged which when transmitted through lime water formed Carbonate of lime. Barthelemy says he drew blood from a vein in the arm and whilst still warm placed it under the receiver of an air-pump. During the exhaustion of the receiver there was a considerable escape of gas from the blood so that it had the appearance of effervescing. He afterwards ascertained that this gas was Carbonic acid. Two cubic inches were extracted from every ounce of blood. Saussure, from his researches upon the blood, obtained it, but in minute quantity. Collard de Montigny found it both in arterial and venous blood but in a double or triple proportion in the latter. He considers this gas to be merely excreted at the lungs.

Dr. Stevens assumes that the dark color of venous blood is due to the presence of free Carbonic acid, as acids and alcalis generally darken the blood. Extraorbi
The red color of arterial blood he conceives is
effected by the serum, which returning its proper
influence after the liberation of the acid in the lungs
reddens the blood, alike saline solutions in general.

Gregory corroborates Stevens in the fact that strong
saline solutions redden the blood, even although
oxygen be excluded, but in order that serum or a
saline solution of equivalent strength might accom-
plish this, the presence of oxygen was indispensable.

Davy objects that a free alkali and acid cannot
coeexist in the blood, but Stevens does not allow of
the existence of a free alkali in it.

It is evident that if carbonic acid were formed
by the combination of its elements in the lungs.
It could not be produced in cases in which ani-
mals are excluded from air or any gas containing
oxygen.—Zallanzani, Contanoeau, Nydew, made
experiments of this kind, Plunging animals into
Hydrogen they found a greater quantity to be given off than could be accounted for by exhalation from the animal or tissues. These animals, however, were warm-blooded. Edwards made use of cold-blooded animals as frogs, taking care that the residual air in the lungs should be expelled as far as possible. Claude de Montigny confined them in azote from the consideration that its weight corresponds more nearly with that of the gases contained in the cavity, and tissues, and both with similar results.

The greater exhalation of the acid with increased vigor of the circulation favors this hypothesis. Many experiments by Freuchen demonstrated that insects at the period of their greatest vitality and energy, when the circulation is most vigorous, give out the acid in greatest quantity.

5. The intervention of the pulmonary membrane which is of extreme tenacity, one thousandth part of an inch according to Hales is no obstacle to the correlation
of Carbonic acid, as Priestley, experiments upon blood within bladders amply prove. To these Mr Ellis objects, that it was the bladder and not the blood which acted upon the air, but Dr Williams has very satisfactorily established the contrary, seeing that more Carbon escaped than can be explained by the law of weight in the bladder. Dr Williams's theory is that oxygen from its greater tendency to permeate the animal textures, displaces the Carbonic acid and unites with the blood, and the tendency which gases have to diffuse themselves through each other notwithstanding the interposition of an animal membrane is a well known fact.

6. Suppose ten ounces of blood are propelled by each pulsation of the heart - Ten pounds of blood per minute will give off its Carbonic Acid in the lungs. Now the quantity of Carbonic Acid emitted in respiration in a minute according to Allen and Spen...
is 27½ cubic inches, the Carbonic acid evolved by each ounce of blood must then be 0.23 cubic inch. A quantity not above that found in the blood by its most recent analysts as Bedamore.

On the other hand, some facts would incline us to believe that the formation of Carbonic acid is merely a chemical change effectuated in the lungs —

1. Its formation by blood in contact with air extra corpus. In 1809 Berthollet observed that fresh drawn blood exposed to the air produced a volume of the acid exactly equal to that of the oxygen which had disappeared. Professor Christian from some experiments likewise concluded that a chemical action always takes place between fresh blood and air in opposition to Sir Davy who asserted that such a change always proceeds from the putrefaction of the blood. Professor Christian
however, never used blood that had been drawn above three hours. He supposes it darry to have made use of too small a quantity of blood from which his failure proceeded. He always found an excess never a defect of oxygen compared to the acid. This fact he thinks strongly confirms this view of the question, as the inequality between the two gases may be explained away by the solvent power which serum has over carboxy acid.

It may never could find free carboxy acid in serum blood when placed under the air pump and consider its existence in it impossible. Though the serum absorbs it in great quantity. If blood and serum have the power of retaining it at the temperature of 200° F. and in the act of coagulation added at the rate of a quarter of a cubic inch to the ounce, and if this portion is not sufficient to neutralize the free alkali in the blood, is it possible, he asks, it can preserve free carboxy acid?
Neither could Gärtner and Mitscherlich discover it. Having taken venous and arterial blood from a dog, and taken care to prevent the admixture of air, they state, at first no air-bubbles were emitted under the action of the air pump from either kind of blood, nor until from the exhaustion the Barometer stood at 27.28 in. at which time a quantity of aciform fluid was evolved from both so as to depress the mercury in the jar about an inch. On readmitting the air however, the evolved fluid suddenly disappeared long before the atmospheric pressure was wholly restored, from which the experimenters inferred that it was merely water vapor generated in a Torricellian vacuum, and not a permanent gas.

The following is their theory of Respiration.
The air in the lungs permeates the coats of the vessels and comes into immediate contact with the blood. Part of the oxygen consumed unites directly with the carbon and hydrogen, producing a portion of carbonic acid and water vapour. Another fact combines with the organic constituents of the blood from both causes new products are formed in that fluid, the chief of which is lactic or acetic acid. This acid decomposes a part of the carbonate of soda, and disengages its carbonic acid. The acetate of soda formed in the lungs is freed of its acetic acid by means of the various secretions, especially the urine and sweat, the alkali again combines with carbonic acid formed by the further decomposition of the organic constituents of the blood, which takes place in its passage through the body, and arrives again at the lungs as carbonate of soda.
3. The equality between the volume of the two gases has been much insisted upon as almost quite conclusive, but the equality may exist without the production of the one being dependent upon the other.

4. The heat required for the chemical union of carbon and oxygen extra corpus has been considered one of the greatest objections to the theory, as it is not easy to explain how such an union could take place extra corpus without the combustion of the lungs.

Mr. Ellis has advocated the peculiar opinion that the oxygen of the inspired air doesn't enter into the blood, but becomes converted into carbonic acid by uniting with the carbon of the blood, which he supposes the secreted as a recrement in the form of vapor into the air-cells by the exhalants of the lungs.
He ascribe the scarlet color of the blood to its combination with carbon.

The average quantity of carbonic acid given off in 24 hours in human respiration is estimated at 10,000 cubic inches, which weigh nearly three pounds and contain eleven ounces of carbon.

From what has been said on both sides the evidence seems to preponderate in favor of the theory that carbonic acid is evolved ready formed.

Guatanner is the only chemist-related who have found free oxygen in arterial blood. It was with sheep blood he experimented. No chemist since has corroborated Guatanner so the presence of free oxygen in arterial blood is not made out.

That it is oxygen which gives to blood its scarlet color, there can be very little doubt.
Cigna of Turin observed that if he put a little oil upon a coagulum of blood, it remained dark throughout, but that when he removed the oil, the surface became red, and if he took away the red part and exposed the lower laminae, which were dark they also became suddenly red till the whole mass acquired that color. Prof. Christian universally found venous blood when agitated with air to assume a darker color easily distinguishable at a distance of thirty feet.

Bichat, after having detached the trachea of an animal and cut it across introduced into its orifice a pipe furnished with a stop cock. He could thereby either allow the air to enter the lungs or not. Another tube similar to the preceding was adapted to an opening which he made in one of the cartilages of the apparatus being so arranged. Bichat observed
that if he opened the stop-cock of the trachea
and consequently allowed the animal to
breathe, the blood issued of a crescented
by the tube in the Carotid, but if he ex-
cluded the air from the trachea by shutting
the cock and thus suspending the respiration
the blood which flowed by the Carotid pre-
served its scarlet color, only until all that
which was contained in the vessels between
the trachea and lungs had flowed past,
but immediately after, that liquid appeared
of a blackish color so much deeper, the longer
the experiment was continued. If the cock of
the trachea was opened again, after some
jets of black blood this liquid was seen
to assume its scarlet color and all its arterial
characters.

S. Davy appears to be the only Chemist who has
doubted that this change depends upon the air.
Mammalia and birds which consume most oxygen are likewise those animals whose blood is richest. Whilst the blood of reptile and fish, which don't consume so much as less red as to the nitrogen of the air is probable it remains unchanged. This has been ascertained to be the case in vegetable respiration. Henderson and Pfaff from their experiments upon man, Stellargani from his on smaller things they observed an absorption of azote. Edwards found an absorption of azote in some kinds of animals, in others an exhalation. According to Allen and Pesius it remains the same when respiration takes place in air that is constantly renewed. La骗子 thought it merely served to dilute the oxygen.

The watery vapor which proceeds from the lungs is generally supposed to be an exhalation from
the mucous membrane of the bronchi. The idea of any chemical action taking place between any of the constituents of the blood and air has long been rejected—Hales estimated it to a
rubber in 24 hours to twenty ounces. Menzie, only
to six ounces.

The principal change induced upon the atmo
sphere by Respiration appears to be the sub-
stitution of Carbonic acid for Oxygen.

Although in recent times animal heat has been supposed to have a close connection with Respiration, and its chief origin has been de-
duced from that source, yet antecedently, a variety of hypotheses were invented to account for it
borrowed probably from the science that happened to be dominant at the time.

Ever since the time of Laubler and Black it has been generally held that heat is generated
by the evolution of Carbonic acid at the lungs. Black from his discovery that when a substance is converted from a rare to a dense form, a conclusion that certain quantity of heat is evolved concluded that the Carbon and Oxygen combined occupy no greater volume than simple Carbon latent heat must become sensible which was the source of heat communicated by the Blood to the whole body.

Lavoisier and Laplace compared the heat evolved during the combustion of Carbon dioxide, to produce Carbonic acid, with that given off by its generation in the lungs, when an equal result was obtained.

According to Balz and Désiré, the heat escaping in its formation is always less than the animal heat. Dulong finds, supposing the latter equal to unity, that the former is only between 0.49 and 0.53 for the Carnivorous, and between 0.65 and 0.75 for the Herbivorous animals.
Supposing that the estimate of Savarese and Laplace were correct, Dr. Black's hypothesis does not satisfactorily explain the nearly uniform distribution of heat over the body from the four in which it originates—the lungs and why their temperature should not materially exceed that of the rest of the system. Dr. Quoy found the blood of the left cavity of the heart to be one degree warmer than that of the right, which, with the decreasing temperature of the body with increasing distance from the head, favors this hypothesis.

Dr. A. Crawford supplied this defect in Black's theory most ingeniously. According to Dr. C. arterial blood has a greater capacity for heat than venous in the proportion of 11.5 to 10.0, and the specific heat of oxygen is greater than that of carbonic acid, where he presumed that the arterial blood receives all the heat given off in the combustion of oxygen into carbonic acid (which up to its own temperature), and that when
It is again converted from arterial into venous blood, its latent heat and thus sustains the animal temperature.

Objections to this theory, however, are not wanting. Dr. Davy objects that the difference between the specific heat of arterial and venous blood is much smaller than Dr. Crawford has estimated it. He says the proportion is only 0.913 to 0.903. De la Roche and Renard have also shown that the specific heat of oxygen and carbonic acid also differs much less than Dr. Crawford supposed.

Likewise to the theories both of Black and Crawford there is this objection that they assume the acid to be formed in the lungs, which assumption as has been formerly stated does not appear to be correct.

De la Grange and Hafenzratz conceived that
Oxygen was absorbed in the lungs by the arterial blood, and that it combines with carbon gradually in the course of the circulation with the evolution of heat. This hypothesis rests upon the basis that arterial blood preserved in tubes hermetically sealed gradually becomes venous as also shown the observation of Hunter that blood which is rendered stagnant from obstruction of the vessels assumes a darker aspect.

There were the views entertained with regard to animal heat till experiments were made to prove that it was derived from another source—the nervous system.

Mr. Brodie was the first and chief experimenter upon this subject. Whence the nervous energy was suspended in what way never, either by destroying the influence of the brain
directly as by decapitation or by the influence of irritation upon it, although respiration was kept up, and the usual changes effected upon the blood rendered arterial from venous and conversely, while the temperature continued to decrease, and in a greater ratio than in those cases where after the same measures the animals were left to themselves. Therefore, he concluded that respiration has no share in the production of animal heat.

Choppe's experiments agree with Brodie's. The nearer the brain he made a section of the spinal marrow, the more quickly the animal cooled. Limbs that are paralytic or from which the nervous energy has been cut off, even with a perfect circulation are considerably less warm and have a more variable temperature than the other sound parts of the body.
Mr. Earle has related some interesting cases of this kind.

On the other hand, Legallus placed animals on their backs and in other constrained positions, emburshing Respiration, in all which a diminution of animal heat was the consequence. According to Dr. Williams, also, Respiration artificially kept up retards the cooling process and sometimes absolutely increases the heat of the body.

That Respiration is one of the principal causes of animal heat may be fairly conceived to persuade us among which are

1. The common division of animals into warm and cold-blooded, in the former of which the whole of the blood is subjected to the action of the air at every round of the
Circulation, and the change from venous to arterial is most conspicuous in the latter part of it only and this change is less obvious. Wherever there is the greatest provision for the aeration of the blood, there the highest temperature is observed. Birds which have a most extensive and elaborate respiratory apparatus the air not only filling the lungs which are large, but also penetrating into the cavities of the bones possess a great vitality and a temperature of 107°-108° F. Next to them in temperature are the mammals, but as we descend the scale and as the structure of the lungs becomes less complicated we find the animal heat decreasing in a similar ratio as in fish, amphibian & where heat is not much above that of the medium in which they reside.
2. The phenomena of hibernation likewise support this theory. In animals which hibernate, the temperature decreases as the respiration is gradually suspended. According to Pinnelée, their temperature is in a ratio corresponding with the oxygen absorbed.

3. The general coldness and lividity of asthmatics increasing during the paroxysm. Dr. Ree has observed the temperature of the body in one of these to descend from 99° to 82° F.

4. The lividity and low heat of coruleans or those in whom the fetal structure of the heart persists, preventing the proper oxygenation of the blood at each circulation. It is also worthy of notice that Mr. Edwall observed young animals in which the
ductus arteriosus remained previus to have a temperature relatively lower.

Yet it is probable that other functions as secretion, digestion, and the influence of the nervous system are auxiliary to respiration in the production of animal heat.
The following were the principal works consulted in the composition of this dissertation:

Alvares' Physiologia
Boott's
Addison
Turner's Chemistry
Stevens on the Blood
Edwards de l'influence des aéros phyique du th'ion de la nature des forces médicales

Edin. Medical and Surgical Journal
Jamaicensis Journal
Philosophical Transactions
Medico-chirurgical Transactions
Reiseberichte über den Bau der Lunge
Zeitschrift für Physiologie
Ellis on Respiration
This candidate required a receipt for his thesis, which he must produce before receiving it back.