

AN
INAUGURAL DISSERTATION
ON

Respiration

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Respiration

The word Respiration, is derived from the Latin words Re and spiro; and signifies to breathe, to take breath. But the respiratory function, is not fully expressed by the term Breathing, nor yet by the aeration of the blood; for the most important office of respiration, is the oxidation of the vast tissues of the body. This important function is performed by the Lungs and Respiratory muscles; the structure and organization of which are peculiarly and wonderfully adapted to its performance. The Lungs are two in number, situated in the cavity of the Thorax, and protected from external injury by the bony and cartilaginous walls of that cavity.

The Lungs themselves are exceedingly spongy and elastic in their texture and are made up by the ramification of the Bronchial tubes, divided into minute cells which do not anastomose or communicate with each other. They are lined by a mucous membrane, and terminate in very minute cells which are said by some to possess muscular contractibility. The capillaries of the blood vessels of the Lungs are spread out over the cells in a very dense net work; and all that intervenes between the air in the cells and the blood in the capillaries is this lining membrane.

The movements by which Respiration is

performed, are that of inspiration and expiration: or that by which it is expelled. In order fully to understand this function, it is necessary to remember that we are surrounded by an ocean of atmospheric air which exerts a pressure of about fifteen pounds on every square inch at the surface of the earth;

Now inspiration consists simply in enlarging the dimensions of the cavity of the thorax, by which a partial vacuum is produced, and the air by its own weight passes into the lungs to fill the vacuum.

The Diaphragm, a broad muscle separating the cavities of the thorax and abdomen, is the great muscle of inspiration. When relaxed, this muscle is highly arched and encroaches on the cavity of the thorax, but when it contracts it descends almost to a plane, and this forms the vacuum above spoken of, and which is immediately filled with fresh air. But the contraction of the diaphragm only increases the diameter vertically; where as, the cavity of the chest is also increased anteriorly posteriorly as well as laterally; and these two last diameters are increased by the action of the intercostal muscles.

The air is expelled from the lungs by the contraction of the abdominal muscles, which force

the viscera of the abdomen upwards against the diaphragm, which being relaxed again, resumes its arched form, and also by the elasticity of the walls of the thorax, which resides in the cartilages of the ribs.

Besides this the lungs themselves as before remarked possess a certain amount of elasticity which aids in expiration. There are some peculiarities in respiration dependent on age sex, etc. which it may not be amiss to mention. Children for instance, breathe almost entirely with the diaphragm and abdominal muscles, while adult females, breathe more with the upper part of the chest; and this seems to be a wise provision of nature, adapted to certain conditions of ~~male~~ female life: males breathe rather more with the lower part of the chest and with the abdominal muscles.

The number of inspirations and the quantity of air taken in during each inspiration, differ in different individuals.

The average number of inspirations during a minute, may be set down at from fourteen to eighteen.

The quantity of air which is changed in the lungs in each act of ordinary, tranquil breathing, varies from twenty to twentyfive cubic inches.

The complimented air is that which is forced

into the lungs by an extraordinary effort at breathing.

After ordinary expiration a certain quantity of air remains in the lungs, which may be expelled by a more forcible and deeper expiration, which is called reserve air; and after the most forcible expiration it has been found that a small quantity still remains, and this has been termed residual air. This residual air has been so variously estimated that it is almost impossible to say what it does amount to. The vital capacity differs in different individuals; and it has been found that it bears a considerable proportion to the height of the individuals.

Mr. Hutchison's experiments show that in a man five feet seven inches high, it amounts to 225 cubic inches.

Tall men have a greater capacity and vice versa.

The greater vital capacity of some men depends on the mobility of the walls of the chest: persons who have a great vital capacity, can endure labor and hardships of all kinds better than men of less capacity; a striking illustration of which was lately given by the Professor of Physiology in the medical department of the University of Louisville in a partridge hunt with one of his students; it is but justice however to remark that the student had a sore on his foot which disabled him some-

We come now to consider the changes of the air in respiration. The atmosphere we breathe, is generally uniform in its composition. It appears to consist of oxygen, nitrogen carbonic acid and some watery vapour, and chemist differ as to whether they exist in a state of chemical combination or merely as a mechanical mixture: but according to Professor Yarell who is regarded as good authority they exist in a state of mechanical mixture only.

For every hundred volumes of air, there is about seventy nine of nitrogen and twenty one of oxygen and every ten thousands parts of air contains about four to five of carbonic acid; the quantity of watery vapour varies greatly according to temperature, locality, etc; but some moisture is always present. Now the changes produced in the air by Respiration are the following; first its temperature is elevated, its carbonic acid is increased, its oxygen is diminished and the watery vapor is increased and is said to contain some animal matter. When the air is received into the lungs its temperature soon rises very near to the temperature of the blood in consequence of which it becomes lighter and is continually rising, to be replaced by fresh air. But the most obvious and important change

produced in the air by respiration, is an increase in the amount of carbonic acid, and diminution of the oxygen; for as I shall hereafter have occasion to show, it is mainly on this that animal heat depends. The change which thus takes place, can be explained on purely physical principles. The blood which comes to the lungs being charged with carbonic acid, is exposed to the atmosphere which contains nitrogen and oxygen; and a change takes place by what is called endosmose and exosmose, by which the carbonic acid is exhaled and the oxygen and some of the nitrogen pass into the blood.

The amount of nitrogen received and given out appears to be about the same that there is the use of the nitrogen in the air. It seems only to serve as a diluent; it dilutes the oxygen and renders it less stimulating.

Nitrogen of all other gaseous substances, performs this office best; for it is known merely by its negative properties. The carbonic acid in respired air is said to be always increased, but various circumstances influence the quantity. It however may be stated that under ordinary circumstances about eight ounces are exhaled from the lungs every twenty four hours. Age, sex, respiratory movements, external temperature, and the purity of the atmosphere, all exert an influence over the quantity

of carbonic acid expired. In children, the amount is smaller and it goes on increasing up to about the thirtieth year of age at then remains stationary until about forty five, and then it diminishes till the close of life. Thus in Androl's experiments, he found that children eight years old, exhaled about seventy seven grains per hour; men of twenty six exhaled about one hundred and sixty nine grains, and old men of seventy five only exhaled about ninety two grains per hour.

Sex also have a modifying influence until about the eighteenth year it does not differ in males and females; but beyond that age it is greater in males. It gradually increases in females to puberty and then remains stationary during the menstruating period. It is increased during pregnancy for obvious reasons, which were mentioned both by Professor Miller and Gandell in their lectures; to wit, that during pregnancy the female has not only her own system to be oxygenated but also that of the fetus in utero, and consequently a greater demand for oxygen exists.

The development of the body has its influence also. Robust individuals exhaled more carbonic acid than feeble ones, *ceteris paribus*. Thus it has been found that even an old man of ninety who still preserved

an uncommon amount of muscular power, exhaled at the rate of one hundred and thirty five grains per hour a quantity equal to that exhaled by a young man of eighteen years of age. The quantity also varies according to the state of health, and altho few accurate researches have been made on this subject, yet sufficient is known to establish the fact that a difference really exist. I shall here not enter into the subject fully but content myself by merely refering you to the various works on the subject such as Carpenter, Kirk Paget etc: from which I have collected most of the statistics contained in this humble Thesis. Muscular exertion of every kind considerably increases the amount of carbonic acid exhaled.

It is diminished during sleep and also by fasting and increased by eating and diminished by alcoholic drinks; which last is a remarkable fact and as yet so far as I know not fully explained. The period of the day has some influence on the amount of carbonic acid exhaled. Thus it steadily increases in the fore noon and diminishes in the after noon.

I merely state these facts briefly from the circumstance that they have some bearing on that which I have to say hereafter on the subject of

animal heat. We come next to consider those changes which are produced in the blood by respiration, and the most obvious but not the most important is the change of color it sustains. Venous blood, which is of a dark color while circulating in the veins, on arriving at the capillaries of the lungs where it is exposed to the action of the atmosphere, assumes a bright scarlet red and becomes arterial blood. That this change is effected by chemical and physical means, seems to be certain because the same change is produced by exposing the blood to the air out of the body. This experiment and many others relating to this subject, were exhibited to the Medical class last winter in Louisville by Professor Gardell.

The most essential and important change produced in the blood by respiration, is that which we come now to consider; viz the change in the gaseous contents of the blood. It was formerly supposed that the union of the carbon and oxygen was effected in the lungs themselves; and one of the main objections to the chemical theory viz respiration rested on this ground; for if the union of carbon and oxygen was the cause of animal heat, and if this union took place in the lungs, why was it that the temperature of the lungs was not greater than the rest of the body?

But it is now generally conceded, that the red corpuscles of the blood, carry the oxygen from the lungs to the whole system, and where ever vital action goes on the oxygen unites with the carbon of the body, and forms carbonic acid, which is returned to the lungs by these same red corpuscles and is given off. It has been found by experiment, that the quantity of oxygen absorbed by the lungs, is not in proportion to the quantity of carbonic acid given off: in other words more oxygen is consumed than is necessary to oxidize the carbon of the body. What becomes of the surplus oxygen?

The most recent and satisfactory answer to this question is, that a part of it unites with the hydrogen of the food and promotes disintegration of the tissues, and forms water; a part of which is given off from the lungs as vapor, whilst an other part is applied to the oxidation of the sulphur and phosphorus which having been taken in with the food are now changed into sulphuric and phosphoric acid, and excreted chiefly through the kidneys.

The subject of animal heat tho' not necessarily included in the subject of respiration, is at least very closely and intimately connected with it, in as much as one is considered the main cause of the production of the other. Animals and particularly man, are endowed with the power of maintaining a temperature independent of

the surrounding medium. How is this heat produced? It has long been a subject of the deepest mystery. It was formerly attributed to some unknown agent under the vague and unmeaning term of the vital force. It must be gratifying to every friend of science that this vague theory has passed away and that modern scientific experiments have furnished us a theory so much more rational and satisfactory. A theory which explains many of the phenomena of life which were once hidden in obscurity.

Animal heat depends mainly on the union of oxygen and carbon in the blood. The oxygen is taken in through the lungs and carried to every part of the system; at there unites with the carbon of the blood and repairs the waste tissues carbonic acid is formed, and returned to the lungs where it is excreted.

It is a true combustion. Combustion in as full a sense of the word as that of wood or coal. The great beauty of this chemical theory of animal heat, is found in the fact, that nearly all, if not quite all of the phenomena of respiration and animal heat, are easily and satisfactorily explained according to its principles. This theory is strongly sustained by the fact, that through the whole animal Kingdom, a certain relation exist between the amount of oxygen consumed and that of carbonic

acid given out, and the amount of animal heat developed.

We find the temperature lower in those animals which breathe least, and highest in those whose respiration is most perfect. In the cold blooded animals, for instance, we find that they give out but little carbonic acid, and as a matter of course consume but little oxygen. In birds again which have a higher temperature even than the mammalia, we find that they require a larger amount of oxygen and necessarily evolve a very large amount comparatively of carbonic acid. Exercise elevates the temperature of the animal, because it consumes more oxygen and liberates more carbonic acid. During laborious exercise, the waste tissues are consumed by the oxygen which we breathe, and is evolved in the form of carbonic acid; and this fact suggests to us the great importance of exercise in the open air. I might state at length all the experiments which go to sustain this theory, and answer the objections offered against it; but will close by referring those wishing further information on this subject to the various works on Physiology.