On
The Function of Respiration
And
Its relation to Life.

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In treating of this subject I find it necessary to refer to

1st The mechanism of respiration

2nd The chemical changes which take place during respiration.

3rd The mode in which life, or organization in action, is interfered with by the undue performance of this function.

1st The mechanism of respiration, or the mode in which atmospheric air is brought in relation with the blood in the lungs. This is effected by the lungs themselves, and by the muscular, osseous, and cartilagenous structures external to those organs.

The lungs are composed of a number of lobules, each is suspended by the ultimate division of a bronchus, and are bound together by connective tissue, which becomes more delicate the smaller the lobules are, and is continuous with the lining membrane of that organ. As each lobule represents the lung, both in structure and function

it is necessary only to describe one, which consists of a number of air cells which open into a minute division of the bronchus and a dense capillary plexus upon the walls of each cell. The tube entering the lobule is about $\frac{1}{100}$ of an inch in diameter, and does not possess the structures which characterize a bronchus of larger size, consisting merely of a tough elastic membrane, with traces of fibrous membrane, which has been supposed to be muscular, but is not. The air cells may open into these tubes singly, forming simple recesses, frequently a series of these cells opening into apparently a second tube, and this communicating with the primary one. The structure of the cells is similar to that of the tube just described and the whole is lined by tessilated epithelium. The cells of adjacent lobules do not communicate, as a general rule the cells of the large lobule do not either, and they have no tendency to collapse, in consequence of the elastic tissue they contain. The arteries supplying the lobule, take the same course as the

branches, the main branch passing along the infundibulum of the lobule, and dividing into as many branches as there are air cells, The arteries do not anastomose till they reach the air cells, when they form a dense capillary plexus the meshes of which are less than the breadth of the capillary vessels which is about $\frac{1}{300}$ of an inch in diameter. The lobule is supplied with blood, as soon as it becomes oxygenated the other parts of the lung being supplied by the bronchial artery. There is no nervous supply for the lobule as it requires none, in consequence of the elastic tissue it contains, serving the purposes, which muscular and other tissues, which would require nervous influence

The pneumogastric and branches from the sympathetic both contribute to supply the other parts of the lung. The mucous and muscular textures, are probably supplied by both sympathetic and cerebro-spinal nerves. According to Remak there are small ganglionic enlargements upon some of the branches of the sympathetic

in the lung. but Professor Goodsir believes there to be no ganglionic structure in the lung, the nervous centre of that organ not being situated in itself, but in the Medulla oblongata, this latter I think has been satisfactorily proved, both by the experiments and observations, of Sir Charles Bell, by both of which methods of research it was found that disorganization of the nervous structures above and below a part of the medulla-oblongata, corresponding to the origin of the pneumogastric, did not cause the respiratory actions to cease, but destruction of that part at once terminated all respiratory actions. In the medulla oblongata a communication takes place between the vagus, and the portio-dura of the seventh pair, and the sensory division of the fifth, therefore the movements of the nostrils and lungs are synchronous. The chest is a cavity which is at all times completely filled by its containing viscera air and blood passing in during inspiration and the same passing out during expiration

in exact proportion as the area of the chest is increased or diminished, and the air having free access to the air cells, and the bronchial tubes, the atmospheric pressure is equal on the exterior and interior of the chest, therefore the force required to expand the chest in inspiration is not greater, than that which would be required to raise the weight of the thoracic and abdominal walls, and to overcome their elasticity. The means by which this is effected in ordinary inspiration, is by the contraction and descent of the diaph= =ragm, the intercostal muscles also assist the actions of which have been clearly demon= =strated by Hamburger, who employs a model analagous in many respects to the thoracic parietes, it consists of two parallel bars which slope downwards, and being articulated at one extremity, to a fixed vertical column, and at the other to a piece of wood, and allowing of free movement, then by intervening a contractile force, as by a piece of elastic the movements are determined by the obliquity of these forces, therefore from the difference

in the direction of the external and internal intercostals, their action must be antagonistic but from the experiments of Dr. Gibson, it appears that this does not hold good throughout, for when Dr. Gibson had exposed these muscles in a living animal he found, that instead of the external intercostals, being muscles only of inspiration, and the internal entirely that of expiration, on the contrary that that part of the external intercostals which intervenes between the angles and necks of the ribs, act as expiratory muscles, and the internal intercostals between the cartilages act as inspiratory muscles. These differences may be explained by the superadded forces which exist in the thorax and not in the model, and the nature of the joint, and also by the fixed point or fulcrum, being in some cases at the sternum and not at the spinal column. In addition to these muscles the scalani, cervicalis ascendens and serratus posticus superior, act in ordinary inspiration, and the muscles of the abdominal wall, and the levator ani in expiration. Certain of these muscles act by

dilating certain portions of the chest, the independance of this action being shown, in morbid conditions of the lungs, when their dilatation cannot be effected, and a corresponding absence in the action of certain muscles. The elasticity of the lungs, and walls of the chest, is probably sufficient to accomplish an ordinary expiration. The existance of a vacuum in the chest, at the close of an expiration, necessitating an inspiration, is incorrect, but the atmospheric pressure on the interior of the lungs, at the close of inspiration, is probably a little greater than that on the exterior, and vice versa. The ribs rotate round the axis of their necks and during inspiration are both raised and everted, by the action of the external intercostals, and the capacity of the chest is increased in every direction, but especially in the vertical, and particularly so in child-hood, in which the abdominal mode of respiration is most characteristic. The antero-posterior diameter is also increased more in women than in men, in consequence of the greater mobility of the first rib, this mode of

respiration is subservient to the state of the abdomen during pregnancy. The various nerves which determine these movements, are chiefly the pneumogastric and phrenic, the former being the principle incident, and the latter the chief excident nerve, Sir Charles Bell also adds the spinal accessory, and external thoracic. There is little room for doubting, that the pneumogastric is the only incident nerve in respiration, for experiment shows that when both pneumogastrics are cut, respiration does not generally cease, and from the fact that when irritation is applied to almost any centripetal nerve, it causes an increase in the respiratory movements, we may conclude that respiration will not cease, so long as any centripetal nerves, are in communication through the medulla oblongata, with centrifugal nerves which supply muscles of respiration, thus for the application of cold water to the chest causes an inspiration, the incident nerves there being the sensory branches of the intercostal. and the same holds good, with other stimuli, to other nerves which have similar

connections. The medulla oblongata being the centre, to which so many nerves converge, the range in which this reflex action, may be induced, is very extensive. The pulmonary branches of the pneumogastric then, are not necessary to the maintainance of respiration, at least this function is not immediatly arrested on division of the pneumogastric, and the fatality of such injuries as recorded by Sir Charles Bell, in which the medulla oblongata was involved, chiefly at the origin of the pneumogastric, seems to depend, not upon the paralysis of that nerve, but upon the destruction of that part of the medulla oblongata, in which the impressions of the necessity of breathing are received. The presence of motor fibres in the pulmonary branches of the pneumogastric, has not been demonstrated, but their existence is rendered probable, by certain experiments, in which the lung was galvanized, when contraction of the minute bronchial tubes took place, and consequently a more or less forcible expulsion of the contained air, and it is probable also,

that it is through the motor fibres of this nerve, that the attack of spasmodic asthma is determined. The medulla oblongata therefore seems to be the centre of both the excident, and incident nerves of respiration, for if the communication of the phrenic nerve with this centre be cut of, even maintaining its connection with the spinal ~~column~~ cord entire, the movements of the diaphragm are interfered with. The various processes of respiration are carried on by the medulla oblongata independently of the brain, and therefore of volition, and at the same time they may be controlled voluntarily. The reflex action necessary for respiration, seems to be peculiarly maintained in circumstances in which reflex acts of a less important character are destroyed, as in complete anesthesia, in which respiration continues perfect, but the reflex acts of winking of the eye-lids, and swallowing are entirely lost.

2nd The Chemical changes which take place during respiration. These changes

necessarily take place in the air, and Blood.

The aerial capacity of the lungs, varies greatly, with the height, age, and sex, of the individual, these differences have been carefully ascertained by Dr. E. Smith, and recorded in the Philosophical Transactions of the Royal Society of London for 1859. the accuracy of his experiments, depending greatly upon the perfection of the instrument he used, superceding greatly those used by former experimentors as Prout, Coathupe &c. by which it was impossible to measure the inspired air, or to continue the obser=-vation for any length of time. both these objections, which were of great moment were overcome by Dr. Smiths machine, which shows that the aerial capacity of the lungs in a man of six feet in height, is on an average 280 cubic inches, but during ordinary respiration the lungs only contain about half that quantity or. 140 cubic inches, of which about 30 are changed in each respiration, so that at the end of an ordinary expiration the lungs only contain 110 cubic inches of

air. With regard to age, and increase in the respiratory range, takes place up to the 35th year, when it seems to arrive at its maximum, and then gradually decreases. Females do not have so great a capacity as men, and weight does not increase, but rather tends to diminish the aerial capacity of the lungs. I shall insert a table containing the reports of various experiments performed by Dr. Smith upon himself and two other gentlemen, which is illustrative of the foregoing statements, The table states the age height, and quantity of air inspired per minute, during the working day, also the quantity of Carbonic acid collected in the same time, and during the same experiment

	age.	height.	air inspired per minute.	Co exhaled in same time
Dr. Smith	38	6 feet	575 cubic in.	8·75 gr.
Wm. Noul	48	5-9½	483·1 " "	8·6 "
Dr. Marie	26	5-7½	464·5 " "	7·93 "

A relation also exists between the amount of Carbonic acid exhaled, and the quantity of air inhaled, being on an average one grain of Carbonic acid to every 56·3 cubic inches of air.

inspired. This proportion varies with circumstances such as fasting exercise &c., in which the amount of carbonic acid inhaled in proportion to air inspired, is much greater, Dr. Smith also sought to discover a relation between the pulsations, and respirations, but could find none. The air thus inhaled, is composed of, when purified from carbonic acid, and aqueous vapour, in 100. volumes, 21 volumes or more correctly 20.9 vol: of ~~Carbonic acid~~ oxygen and 79 vol: of Nitrogen. The proportion of carbonic acid in atmospheric air is about one volume in 2000 of air, which may be detected by passing air over caustic potash, which absorbs the carbonic acid. The oxygen may then be removed by passing the air thus purified, over red hot copper filings, the increased weight of the filings giving the amount of oxygen, in the quantity of air examined, the original weight of which is already known, and then by deducting the weight of the two former ingredients, the quantity of Nitrogen is ascertained, the composition of air is thus

rendered a simple matter to discover.
Ordinary atmospheric air also contains, a
variable quantity of gaseous vapour, which
depends upon the temperature. The minute quan=
=tity of other gases, which are occasionally met
with, are so trifling as not to deserve any
attention here. The air thus inspired is mater=
=ially altered in its composition when expired.
The temperature is greatly increased, approaching
that of blood. The aqueous vapour is also
greatly increased, which varies according to
the temperature and moisture of the surrounding
atmosphere, being diminished when the atmos=
=phere is moist, whence this moisture comes
must evidently be the mucous surfaces through
which the air passes, and also, in consequence
of ~~water~~ the formation of water in the air cells
of the lungs, by the union of the oxygen of
the air with the hydrogen of the food, the
relative proportion from these two sources, it
is impossible to ascertain, the air however when
exhaled generally speaking is nearly saturated
with water, the amount of which is exhaled
in the twenty four hours in a temperate

climate is from 12 to 24 ounces. The carbonic acid is also increased, which may be shown by the decrease in volume of the expired air when it is mixed with a strong solution of potash, as in the former experiment, it is now found to contain from 3·5 to 5 vol of carbonic acid in 100. the volume therefore is increased by more than 100 times. Various circumstances influence the exhalation of carbonic acid, which have been carefully determined by the experiments of Dr. Smith already referred to The frequency of the respirations decrease the amount of carbonic acid exhaled in each respiration, but considerably increases the amount in a given time. Thus Dr. Smith found that whilst walking at the rate of two miles per hour, and carrying the spirometer, he expired 18·1 grains of carbonic acid per minute, but whilst walking three miles per hour, he expired 25·83 grains. A relation also exists between the carbonic acid exhaled, and the air inhaled. which is as I stated before to be 1 grain of carbonic acid, to every 56·3 cubic inches.

of air inspired. During digestion also the exhalation of carbonic acid, is increased, and various articles of food have the same effect as Tea, Alcohol, &c.. During the influence of chloroform also the quantity of carbonic acid exhaled is increased, so also with regard to atmospheric, temperature, this ingredient is modified in its quantity, the colder the air the greater the amount of carbonic acid exhaled, and vice versa, this is explained by the fact that a cool atmosphere is necessarily a dense one, and therefore contains a greater quantity of oxygen, than a similar volume of air at a higher temperature, this increase of oxygen forming the excess of carbonic acid, Males generally exhale a greater quantity of carbonic acid than females a rapid increase generally being observed at the time of puberty in the male, not so in the female, as long as the catamenia are regular, but at their natural cessation a remarkable increase takes takes place during pregnancy the same also occurs. As age advances the amount is also greatly decreased

The amount of oxygen is also greatly lessened in the expired air, in comparison to that which is inspired. containing only about 11.5 volumes in 100. The nitrogen is constantly exhaled in small quantities, part of which in the form of ammonia, but after prolonged fasting its seems to be absorbed.

The changes which take place in the blood are. 1st Its colour, which is changed from the dark venous, to the bright red colour of arterial. This is due to the absorption of oxygen and the removal of carbonic acid, which takes place to a considerable amount, as ascertained by Magnus, who found that venous blood contained about 35 per cent of carbonic acid and 5 per cent of oxygen, and that arterial contained, 10 per cent of its volume of oxygen and 20 of carbonic acid. The change has been ascertained to take place in the blood corpus-cles, which are composed of two substances Globuline, and Haematine, the former sub-stance is very analagous to albumen. and forms the solid part of the corpuscles. Haem-atine on the other hand, consists of Carbon

Hydrogen, Nitrogen, Oxygen, and Iron. in various proportions, the carbon being in excess The oxygen according to Liebig is attracted by the iron, and exists in the form of the carbonate of the protoxide, in venous, and of hydrated peroxide in arterial. The facts which Liebig advances to prove that part of the oxygen in the blood, is in chemical union, and not merely absorbed by that fluid are, that the law which regulates the absorption of gases by fluids, is that the absorptive power increases with the atmospheric pressure upon the liquid, in a definite ratio, and that the absorption of oxygen by the blood does not follow this rule is proved by ex= =periment. and secondly the absorptive power of a liquid depends upon the presence of some substance in the blood with which it unites, as is proved by agitating first water, and then blood with air, it is found that the former absorbs a much less quantity of oxygen than the latter. The opinion that the change in colour of the venous blood depends upon the absorption of oxygen, which

is united to the iron of the haematine, is opposed to the opinion of Scherer, and Mulder, the former authority deprived the blood of its iron, by adding sulphuric acid to it, after which the colour still remained. the latter considering the iron to exist, as a simple ingredient. Iron therefore would not seem essential to the colour of the blood though it is an essential constituent of normal haematine. Mr. Wharton Jones, has also shown that in the blood of some of the invertebrata in which no colour can be distinguished, there exists iron, probably in as great a quantity, as in red corpuscles. The inter-change of the gases which takes place, through the delicate membrane of the air cells, is regulated by the law, that the diffusible power of a gas is inversely as the square root of its density. The diffusion of gases which takes place in the lungs however is not true diffusion, but of a spurious kind and depends upon the temporary liquifaction of the carbonic acid. According to this law therefore a definite relation must exist

between the oxygen absorbed, and the carbonic acid given off, and the amount of the former absorbed would be greater than that of the latter exhaled, and such is the case; The carbonic acid which thus passes from the lungs is not formed in these organs, as was formerly thought, but in the textures throughout the body, if the former opinion were correct, the lungs would be warmer than any other part of the body, which is not the case, Other changes than that of colour take place in the blood during respiration, as an rise in temperature, which is generally to the extent of a 1° or 2°, and also as has been described, it contains less carbonic acid and more oxygen, and also less nitrogen, and appears to contain more fibrine, The form of the blood corpuscles is also changed, the round ones becoming bi-concave.

3rd. The mode in which life or organization in action, is interfered with by the undue performance of this function.

Death from this cause may originate in either of two ways. 1st. By mechanical

obstruction to the entrance of air into the lungs 2.nd from the suspension of the nervous influence, which is necessary to conduct the movements of respiration, and therefore by inducing apnea, life is termin= =ated in precisly the same way as from the former cause. The pathological appearances presented after death in both cases, are also the same. The first change which takes place in an animal, after the arest of the respiration, is that the pulmonary circulation is retarded, and in a short time completely stopped. The retardation of the pulmonary circulation being undoubtedly caused by the nonelimination of the carbonic acid, of the venous blood, which may be proved by passing a stream of carbonic acid over the web of a frogs foot, when it will be seen that the blood corpuscles, apparently adhere to each other, and the current of blood is partly stopped, but the entire stoppage cannot thus be accounted for, as the ex= =periment of Mr. Erichsen shows that when the right bronchus of a dog is tied, and,

artificial respiration maintained in the left, that dark venous blood passed through the right lung, but not so readily as in the left, when the arterial blood was circulating, but the current was not completely checked. The stoppage therefore must be caused by the engorgement of the right ventricle, with venous blood, which passing in quicker than it is circulating in the lungs, this overdis=-tention causing its weakness, and inability to contract, this is similar to a morbid con=-dition of the uterus, in which it is over-distend=-ed with liquor amnii, and is unable to contract likewise. This distention of the right side of the heart necessarily causes venous congestion, and if the cause of apnea be sudden=-ly applied, it will cause coma, in consequence of the unequal pressure upon the brain, for if the arteries are unusually full, the veins must be correspondingly empty, in order to adapt themselves to the cerebral cavity, which is similar to an inverted pneumatic trough, containing a certain quantity of matter at all times. The insensibility thus produced

and particularly that of the medulla oblongata, acts by suspending the function of respiration, and at last the heart ceases to beat, in a time varying in different animals, but estim= =ated in the human subject to be within five minutes, as few are resuscitated, who have been immersed for that time. The post mortem appearances, in an animal, which just has died in this way, are, that the right side of the heart, and lungs, and venous system generally are gorged with blood, and the left side of the heart nearly empty, but containing a little dark blood. The same appearances are observed after apnea originating in the brain, as by poisons, the effect of which is the suspension of the respiratory movements then the heart, if then artificial respiration can be conducted, on the principles laid down by Dr. Marshall Hall, and continued till the poison has had time to be eliminated, the life of the animal would be preserved.