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THESIS.
BY.

Andrew McL. T. Rattray..

On. Respiration.

De Respiratione

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Within the Chest, or Thorax (ax. acis: from Θορεω to leap. "from the Heart being contained" in it). The region which intervenes between the Head & Neck, & Abdomen) are found many important parts, such as the Heart, Lungs, Pleurae, Esophagus, Thymus gland, Thoracic duct, Arch of Aorta & a part of the vena cava, vena azygos, & of the Eighth pair of Nerves, with all of which we must be familiar to understand the function of respiration.

The Chest is conical in form having its base under & its apex above. It is a moveable framework, composed of a nearly fixed column, the dorsal Spine, on which the twenty four ribs move, and are articulated; & these from their curvature, and inclination, embrace the above conical space, and meet in front of the Chest and joined together by cartilages through the medium of the Sternum (except the last three ribs on each side (the floating ribs).

Like the abdomen, the Chest has been divided into regions. I. Right & Left. Humeral. II. Right & Left Sub-clavian, III. Right & Left. Mammary, IV. R. & L. axillary. V. R. & L. sub-axillary. VI. R. & L. scapulary. VII. R. & L. intrascapulary & finally a R. & L. subscapulary.

Now we purpose before entering on the above subject, to describe, shortly the development and structure of the organs by means of which the function of Respiration is carried on, because without a general knowledge

knowledge of the structure of the thoracic viscera; - form of the chest, &c. we cannot form a proper conception of the manner by which air is received into & given off from the body, far less can we understand the Chemical & Physical properties of the air, and the circulation of the vital fluid.

Lung (development of in Man)

"About the sixth week, simple elevations of the ~~outer~~ layer of the esophageal wall, represent the first appearance of the lung, the surface of these elevations are covered by "warty like projections," formed by corresponding enlargements of their cavity. these enlargements elongate, & develope similar "buddings" or enlargements from their sides. Hence we see that the organ by degrees becomes changed, & increased from above downwards, from the extension of the Bronchial ramifications at the apex from the one tube. & pari passu, also the parenchymatous structure of the Lung is increasing. & comes to fill up the interspaces between the bronchial ramifications."

From the fact that in this parenchymatous tissue the Pulmonary vessels are distributed, it, as it were is provided for, according to the distention of these vessels. as also their development.

Baër, looks upon the trachea as a prolongation some-what of the form of a tube from the Esophagus, Others believe it to be formed upon the Esophagus, & to become intimately connected with it & to open into its canal, two opinions as to the formation of trachea I. That its rings are formed of lateral halves which afterwards unite. II. That they arise by simple strips of cartilage. These rings seem to increase during development.

For a long time the Lungs are very small, and occupy a small space in the back part of the chest, but after birth they undergo most remarkable & rapid changes, as in position, size, form, consistence, texture, & colour &c. thus they expand & completely cover the pleural portions of the sac, & are also in close connexion with the thoracic parieties, which is covered with the pleural membrane, but are fully developed at the age of 30.

These phenomena, which are due to the introduction of air - an increased quantity of blood into the Lungs, (which before birth are heavy, granular, & compact) convert their tissue into a light, rosy-pink, spongy structure, & they occur at the anterior margin of the Lung at first, & pursue a back=ward course through the Lung structure.

Trachea. From Τραχεια from its roughness.

Its upper part termed the larynx, is composed of five cartilages, the highest of which overlaps the glottis or mouth of the larynx. and from its closing the passage to the lungs in the act of swallowing has been & is, called the "Epiglottis." The trachea is a cartilaginous & membranous canal, which lies (in front of the mesial line) or rather in the mesial line in front of the Esophagus.

The cartilages of the trachea are from 16 to 20 in number, & have the form of an imperfect circle, when viewed separate=ly, & on examination, each much resembles the letter C. Their depth from above downwards is from one.

line to two lines, and in thickness they measure half a line. Internally their surface is convex, from above downwards, but their external surface is flat. The trachea is furnished with muscular fibres, which, to suit themselves to its various movements, are arranged in a circular & longitudinal manner: hence when these fibres contract, the trachea both in its length, & diameter, becomes diminished: i.e. theirlength is shortened, and diameter is contracted. & by means of or "through" the relaxation of these fibres the opposite change takes place in the tracheal structure & from the contractility & dilatation of these Fibres, we are enabled to receive & expel the air in a greater or less quantity, & with more or less velocity, as is required in Singing & declamation.

Lungs.

In the natural condition the thorax is divided into two lateral cavities, or chambers, in which are contained respectively, the Right & Left Lungs. each of these compartments is lined throughout, by the pleurae (i.e. a distinct shut sac. therefore, a serous membrane, for all shut saces are membranes such as described. The lungs, occupy by far the greater part of the thoracic cavity, and are always in close contact with the internal surface of its walls. in life, because they are well adapted to its varying dimensions. We have formerly seen that each lung is of the form of a cone. Its base is characterised as being semicircular Horse-shoe-shaped. Concave, & broad in form & supported on the Diaphragmatic arch, and its apex, rises as high (or a little above) the upper margin of the first rib. & therefore into the

Horse Sho

the root of the neck, and in form resembles a blunted point. The right lung is different from its fellow of the opposite side, by possessing three lobes, the other only two. but a notch is found in the anterior border of the left lung, corresponding to the middle or third lobe of the R. Lung. for the reception of the apex of the heart ~~is received~~. again owing to the largness of the Liver, on the R. side, the Diaphragmatic Muscle is pushed up into the Chest, on this side, therefore the R. Lung is shorter, but wider than the left. and it from the encroachment of the Heart & pericardium, becomes narrowed in its breadth. Both lungs range in weight from thirty to forty-eight ounces. but the more prevalent weights are between thirty-six & forty-two ounces. and in comparison of weight the R. lung is heavier than the L. for example, if both lungs weigh forty-two ounces, then the proportion is as twenty-two to the R. & twenty to the L. lung. and they are heavier in the male, than in the female. Anteriorly the lungs are thin & form a sharp margin, which touches the sides of the anterior Mediastinum. posteriorly, they are rounded, & fit themselves into the cavity ~~to~~ on each side of the Spinal column, which is formed by the ribs. The inner aspect, is concave, to suit the convexity of the pericardium, and more posteriorly than anteriorly, we meet with the root of the lung. so called, from the bronchi & great vessels entering & passing out. of it.

The outer surface of the lung is convex to suit the concavity of the arches of the ribs & cartilages. it is therefore of greater extent ~~than the left lung~~ or depth behind than in front.

Lungs. (Structure of)

They are composed of an external or serous coat, a sub serous cellular layer, and the pulmonary substance, the sub serous coat, (which as the term means, lies be=neath the serous layer) is continuous with the areolar tissue in the interior of the lung, and has been described as the internal layer of the Pleurae.

Instead of being thin, in the lion, leopard. &c. this sub-serous layer, becomes a very strong membrane, & from the amount of its elasticity, is chiefly composed of elastic tissue. The lung is composed of numerous small lobules, which are attached to the ramifications of the air-tubes. These lobules, singly, are about the size of a pin's head, they are polyhedral, & fitted to each other, but not communicating with one another directly, because the Fibro-cellular tissue separates them. in fact the lung may be considered as consisting of this fibrous tissue, with the lobules hanging from it, just like grapes from their pedicle. An ultimate lobule (on the margin of a healthy lung) may be seen with a lens.

In emphysema the interlobular cellular tissue wh. sur=rounds these lobules, and connects them together, becomes inflated with air from the bursting of the cells. & hence air gets through & passes into the cells.

The larger lobes divide into lobules & the structure of an ultimate lobule, respresents in fact that of the organ as a whole, being composed of air cells. the pulmonary & bronchial blood vessels, lymphatics tissues, & areolar tissue, in health the air cannot pass directly from one cell to another, but must go foreward first to the general cavity, then back to the cells individually.

Root of the lung.

We have formerly seen that the root has entering into its composition. Bronchus. Nerves. Lymphatics & blood vessels &c. all of which are closely connected ~~together~~ by cellular-tissue. and surrounded by a fold of the pleurae, moreover we find that the connexions on both sides of the lungs are different; thus we find that the Sup. V. cava, and a part of the R. auricle lie in front of the root of the R. lung. and below we find the vena azygos, arching over it, to end in the Superior V. Cava. On the L. side, the root lies in front of the descending aorta, while its arch passes above the root, besides these, the Nervous Structures alone are seen to pursue the same course and direction, on both sides, thus behind the root of each lung the vagus is found passing down, & in front the Phrenic Nerve. & The pulmonary plexuses of nerves lie on the anterior & posterior aspect of the root beneath the pleurae. but are slightly different; in the posterior being larger than the anterior plexus.

Along the side of the Bronchial tubes we find the branches

The Pulmonary Artery, which takes its origin from the infundibulum of the right ventricle, then passes, upwards, & backwards, to reach the arch of (or rather the concavity of) the aortic arch, where it divides into its right and left branches, which are different on both sides, from the course of the primary vessel, the R. branch is larger & longer than the Left and passes into the R. root behind the ascending aorta, almost transversely, but the Left branch (from the Pulmonary artery being more to the left than right side) is shorter than right, & passes horizontally in front of the descending aorta & left bronchus, to its destination. Pulmonary Veins, whose office it is to convey the red blood back from the lung to the left side of the heart, are four in number, two of which are found on each side. those of the right side differ from those of the left by being, longer, by passing, below the R. pulmonary artery, behind the Sup. V. cava. to enter the left auricle, the left veins pass in front of the descending aorta. The branches of the pulmonary artery (ut demonstratum supra) follow the bronchial tubes, but subdivide more frequently, and are much smaller, in their course they dont anastomose, but at length end on the walls of the air cells in a fine capillary net-work, from which the radicals of the pulmonary veins spring, & which communicate with each other interlobular, & differ from the other veins of the body in their carrying arterial that is red blood, in being more capacious, & having no valves. From the fact that the veins convey the red blood. The Arteries, if all this function is carried on harmoniously must contain & course along the dark or venous blood., which is strikingly characteristic of these said vessels.

"Beneath the mucus-membrane of the terminal & lateral air cells, we meet with the capillary net work of the Pulmonary vessels, and around each cell, is found a circle of arteries, all of which freely communicate with neighbouring circles. The capillary net work, at the bottom of each cell, arises from these circular vessels, the diameter of which varies from $\frac{1}{1290}$th, $\frac{1}{846}$th inch. This capillary net work, is single in the Human lungs, but forms a double layer in the reptilian lungs, where it rises into the inter-cellular septa. (Rainey). The capillaries them-selves are such that, in injected specimens, the smallest measuring from $\frac{1}{2540}$th to $\frac{1}{5000}$ of an inch.) thus we see that the coats of the capillaries are very fine, to permit the free exhalation & absorption, of which the Pulmonary vessels are the seat."

"The Pulmonary vessels & air tube differ on both sides, from above downwards. On Right-side we have the Bronchus the highest, next the pulmonary artery, then the vein. And on left, the artery is highest, from the bronchus having to pass under its level. and thirdly the vein is "lowest. Opposite the second dorsal vertebrae the Trachea divides into two divisions - tubes or Bronchi one ~~two~~ for each lung, they are not similar, as the left one is from 2½ to 3 inches in length, whereas the right bronchus is only 1½ inches in length.

The bronchus before entering the lung substance divides into branches for the number of lobes in each lung, thus the right lung having an additional lobe, or third one is supplied with a bronchus. and the left lung has its normal two lobes, therefore it has two bronchi.

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Air tubes. or Branchia

The principal subdivisions of the bronchi go on dividing & subdividing, diverging through the lung substance in all directions & yet never anastomosing; they pursue a certain fixed manner of division, & that is a dichotomous one; but at times ~~a~~ three branches arise ~~together~~. and after a certain stage of dividing after this way, they i.e. each bronchial tube is diminished to a small calibre, & forms a lobular bronchial tube. & finally, still further, on entering a lobule (Pulmonary). divides it; and thereafter ends in air cells or small cellular recesses. or pulmonary cells. Within the lungs the air tubes are, ~~circular~~ their cartilages, are spread over all sides of their tubes, like plates of various dimensions, & irregular shapes, united as it were to each other. evidently for the express purpose of keeping open the air tubes, but from the circumstance that the ultimate branches are always occupied by air, there does not seem any necessity that these cartilages should be present in them, nor indeed are they.

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The mucous membrane, which is present in the whole respiratory passages, is continuous with that lining the air ~~cells~~ ... passages is of the ciliated columnar epithelial.

passages

Character.

The fibrous coat extends to the most minute tubes, & becomes thinner & thinner, when they are converted into areolar tissue. The Muscular fibres, are circular & lie inside the cartilaginous plates, but are found even beyond these in the smallest tubes, in the form of irregular annular fasciculi; they are of the class of nonvoluntary Fibres, and are pale & nonstriped.

Air cells. These are the ultimate divisions of the bronchial tubes, and are when healthy never empty of air., when a lung which is inflated ~~for~~ with air & dried, is examined, they are easily seen, they vary from $\frac{1}{200}$ to $\frac{1}{70}$ of an inch in diameter, and are larger at the margins than any where else.

If we trace one of the smaller bronchial tubes, when entering a distinct & separate lobule, we find that the small air tube divides & subdivides from four to nine times. if the lobule large, the divisions is greater & vice versae, & its branches which diverge at more & more ~~[illegible]~~ obtuse angles, after lessening at each subdivision, become & continue stationary, when they are about the size of from $\frac{1}{50}$ to $\frac{1}{30}$. of an inch in diameter, and by & by they, instead of being cylindrical ~~[illegible]~~ manifest the appearance of irregular passages through the lung. which are beset with recesses or dilatations, and finally end near the surface of the lobule in a group or similar recesses, which are in fact the air cells, & which on section, under the microscope) give the appearance of a honey comb ~~structure~~.

(cell.) — They appear like polyhedral alveolar cavities, are separated from one another by a thin, intervening septa, but ~~..~~ open into the air passages. and not into each other either laterally, nor by anastomosis.

Bronchial vessels.

They are usually two, coming from the aorta, or an intercostal artery, they supply the coats of the bronchia, & have veins corresponding to them. Their capillaries anastomose with those of the pulmonary artery where the terminal bronchia become lobular passages.

Nerves of the Lung.

They are from the eighth pair & great intercostal. or the branches of the anterior & posterior pulmonary plexuses, formed by the vagus & sympathetic.

The absorbents are of two orders (1) superficial & (2) deep seated. the former are more readily detected than ~~the~~ latter, from their constituting a plexus on the surface of the lung, & being joined by the interlobular lymphatics of the deep seated ones. These glands are called bronchial, because they intimately connected with the bronchi. and are muciparous. I now proceed to Respiration. whose process is not simply one of secretion, for it involves an interchange of gases, O & CO_2 therefore O enters into the blood, or & is carried through the system, and CO_2 is evolved.

(Function of)

It "essentially consists in the evolution of Carbonic-acid from the fluids of organised beings, and the absorption of oxygen, from the surrounding" mediums, usually in a nearly equal proportion. the amount of Oxygen in volume, absorbed is greater than that of Carbonic exhaled in the proportion of 100 of the former & 85 of the latter.

Plants in like manner, perform this function and it may be regarded as arising out of the same general requirements in both kingdoms, although it answers some special purposes in the latter, by means of which it is rendered more essential to their maintaining their vital activity, than it seems to be in the former. For we shall afterwards find that the impervious necessity for the continued introduction of Oxygen and the evolution of CO_2; (which requires a most active state of the respiratory functions, and causes a short suspension of it ~~to~~ prove fatal, in the highest animals,) is consequent upon the energetic exertion of their peculiar animal powers and upon the performance, of that combustive operation by which their high temperature is maintained, as in carnivora. Whilst on the other hand, while we pass to those birds as the Herbivora, which are of inert habits; and therefore in them the amount of metamorphosis of the tissues is by no means sufficient, and consequently a large part of the food consisting of substances, which cannot be applied to the nutrition of the tissues.

Enters directly into combination with the O of the air and thus to compensate for the deficiency.
In man and other animals which can sustain considerable varieties of climates, & can suit themselves to great diversity of habits, the amount of CO_2 formed by the combination of the elements of the food, with the O of the air, will differ extremely under different circumstances. The mixture of the azotized & non. compounds (gluten & starch) which exist in the wheaten flour seems to be just that which is most generally useful to man; hence we see the explanation of the fact that from very early ages, bread has been regarded as the "Staff of Life". There are however particular conditions of existence, under which life may be advantageously supported upon animal food alone. For instance the Guachos of South America, who lead a life just like the Carnivora, & pass the whole day in the saddle, seldom or ever taste any-thing except beef & nevertheless, even, of it they dont by any means consume very much, because of the height of the temperature of the surrounding atmosphere & therefore the body has no occasion to generate more heat than is supplied by the combustion of the hydro-carbonaceous portion of the waste of the tissues. Here then the demand for histogenetic material being at its maximum, & that of combustive materials at its minimum, the former supplies all that is needful for the latter. It (the CO_2) will serve as the complement of that which is formed in other ways; so that it will diminish with the increase, & increase with the diminution of muscular exertion.

It will also vary in an inverse ratio to the external temperature, increasing with its diminution (as more heat must then be produced) and diminishing with its increase; thus we see that the effect of external heat is exactly opposite in the warm blooded animals to that produced in the cold blooded. In all cases without exception, if the supply of food be not sufficient to build up the economy, then the store of fat is "drawn upon", which if long used or exhausted, death of the animal results from cold. The amount of Respiration (which is requisite for the full discharge of the organic functions of ani=mals) is in general small; and it is not surprising that the existence of this function should have been long overlooked in plants; in which its effects on the atmosphere are marked by a change of a total=ly different nature, which is subservient to the reception of nutritive materials into the system namely the decomposition of the CO_2 of the air, under the influence of the light - the fixation of the car=bon in the tissues (vegetable). - & the resulting evolution of its oxygen. The term Respiration has been applied to this last process; and this function in plants is commonly spoken of as diametrically opposed to that of animals, wh is true, if under the term Respiration be comprehended the sum total of the changes, which are produced by the growth of a Plant in the air; but it will be shown that.

whilst animals life, gives rise to but one set of change in the air (that the removal of a portion of its O. and a replacement of it by CO_2) vegetable life produces two sets of changes which (from the circumstance that their nature & sources are different) ought to be kept completely distinct & separate, in such a description as this, and it has obtained the term of respiration from its excess of one set of these changes, beyond that to which it is opposed.

Term restricted.

In which CO_2 is given off in the gaseous form from the system, and O is introduced into the same.

The sources of demand (for this phenomenon in the vital economy) are of a two fold character I. Arising from the disintegrating changes, which are carried on in the economy, without stop or hinderance. II. As the result of some of those chemical operations, which necessarily participate in the constructive functions.

The first seems to be the most general, the second are rather of a special character, and become most apparent at certain periods in vegetable life (as in Germination). in which the respiration goes on with unwonted activity.

Bodies which are organised, are therefore prone to continual disintegrations. Yea even whilst performing the normal actions of life, in fact a succession of organs, whose individual existence is short, but whose functional power is great, seems indispensible for the maintenance of the more permanent parts of the frame.

One of the chief products of decay is CO_2. Of which a large

large amount is set free, during the decomposition of nearly all the kinds of organised matter, the C. of the body, being united with the O supplied by the air, indeed we find ~~that~~ CO_2 (from the above facts) ~~that~~ is not only generated in, but also evolved from the body after death with great rapidity, as also in plants. Plants, so soon as they become unhealthy, disengage more of C. in the form of CO_2, than they fix of it from the CO_2 of the atmosphere, and the same change takes place, during the period that precedes the ex=uviation of the leaves, their tissue being no longer able to discharge its normal function, & its commenc=ing decay giving rise to a large increase in the quantity of CO_2 set free. In some of these cases it would seem that the C. of the decomposing tissue unites with the O. present in the fluids of the system, & that thus CO_2 is formed, whose removal contributes to the initiation or introduction of O. In other in=stances ~~the~~ O may be derived from the atmos=phere. Having thus briefly stated the first source of demands for respiration. viz: that arising out of the disintegrating changes, which are always carried on in the body during life, we proceed ~~to the~~ other. i.e:

II. That which is consequent on some of these chemical oper=ations which of necessity take part in the constructive functions. It springs from <u>chemical transfor=</u>mations, and is alike common to plants and animals. These transformations are going on in in their systems, as a part of their nutrient operations & they as yet, are but little understood; still from what is known, we may with comparative safety, conclude that in many of them the presence of O. is a sine qua non & that CO_2 is formed in their products, and by this we see that the conversion of starch into sugar, a change which takes place in the vicinity of many growing parts, involves the combination of C. with O. to a marked extent; & that generally, the production of the vast multitude of organic compounds produced by plants, from the gum, starch & sugar which are first produced by them at the expense of the inorganic elements) requires a series of chemical changes, in not a few of which O is inhaled & CO_2 is evolved.

Aeration.

This term implies the whole series of reactions, which take place between the living body, & the air in the immediate neighbourhood of it, or rather surrounding it. or that which is contained in the water in which it has its existence, like absorption, it would seem to be a change dependent upon agencies of a physical nature, and to take place in conformity with their laws, when the necessary conditions furnished by the structures of an organised being, and by the functional alterations, which the living state involves.

All gases of different densities, which are not disposed to unite chemically with one another, have a strong affinity to mutual admixture. Thus if you fill a vessel with Hydrogen gas, and Con. the latter which (from H. equiva=

lent only being one.) is 12 times heavier than H. instead of remaining at the bottom of the vessel, will shortly be found to become equally & uniformly mixed with the H. On this principle the state of the atmosphere is equal every-where, while the gases wh enter into its composition are of very different specific gravities. This interchange, therefore resembles the "endosmose and exosmose" of fluids & though the tendency of the two gases is the fundamental cause of their movement, the nature of the septum has so much influence over the phenomenon, as at times to reverse the results: If, as the medium of diffusion, we use the Plaster of Paris, the exchange will take place with simple relation to the relative densities of the gases, hence we find according to Professor Graham's "law of mutual diffusion of gases," that they vary inversely as the square root of their densities.

We have formerly seen that the living tissues are subject to incessant disintegration, and hence a way must be provided, on the one hand, for the carrying away the wastes of the body, and on the other for supplying new materials in their stead, this is in part supplied by the venous circulation, which takes up a large amount of the incipient products of decomposition, and carries them to the the various excretory organs, whose office it is to separate and remove from the body, those products of decay, the chief of which is CO_2.

because if allowed so to remain in it, one, or many of them) would, from the fact of their increasing nature, prove most injurious=ly to the system. And for the prevention of this other=wise unavoidable result, we have an apparatus (provided, and at the same time fitted to carry off this CO_2, i.e. the Pulmonary, to which the whole venous current of blood passes, before it is sent again through the system. And in all warm blooded animals, an organ is provided viz. the Heart the function of which is to propel the circulating fluid through the lungs; & hence any interference with or im=pediment to the natural action of this organ must as a matter of necessity affect the "Well being" of the said ani=mals. In the above organs the blood is exposed to the influ=ence of the air, by which the CO_2 is expelled, and O is taken in & this phenomenon takes place (by the "physical law of the mutual diffusion of gases") through the thin & delicate membranes which line the air-cells of the lungs. & moreover for the maintenance both of the Nervous & Mus=cular systems, & for their being kept in a suitable state of activity, the introduction of O. is a sine qua non.

Composition of the atmosphere.

The atmospheric air consists of a mixture of Nitrogen & oxygen, with a small amount of Carbonic gas & of Hydro=gen gases: thus 100 parts of atmospheric air, consist of 79 parts of nitrogen and 21 of oxygen; the CO_2 has been ascertained to vary between 0.0003. and 1.0. per cent: and of it there are present from 4 to 6 measures. in 10.000 of air & the proportion of Carbon=

carburetted hydrogen, may amount to about one per-cent. The expired air yields nearly the same quantity of Nitrogen, as the inspired; except that it contains less oxygen, and more CO_2 & Hydrogen. The air also contains minute quantities of the different volatile compounds which are evolved at the surface of the earth. The quantities of O. & CO_2, in the air have altered during respiration, so that the volume of the O. which has disappeared is greater than that of the CO_2 which has made its appearance.

Ammonia occurs in the atmosphere, and united separately with CO_2 and NO_5; forms respectively the Carbonate & Nitrate of Ammonia. It is contained in snow (melted) & for its detection you put the snow in a still, and of it a fourth part is distilled over. vide 22. (top).

Mechanism of respiration.

The apparatus for it consists of three parts I. Thorax — II. Muscles. III. Nerves I. The chest is capable of being dilated, foreward, backward, transversely, & vertically. In forced inspiration (in which, the dimensions of the chest are increased in all directions, as far as the physical disposition of this cavity will allow of) the heart recedes deeper into the said cavity & during expiration (whose mechanism, is produced by the elasticity of the cartilages and the ligaments of the ribs, which tend to resume their former shape, from the inspiratory muscles, becoming relaxed,) the Heart again comes foreward. vide top of 24

The chief enlargement of the chest, in deep inspiration over. The carbonate of Ammonia, from its volatility, accompanies the water, which rises first in vapour. To which after its condensation a small quantity of Hydrochloric acid is added, which unites with the NH_3. And you have thus formed (NH_3HCl), i.e. sal-ammoniac. and this liquid is then evaporated to dryness, and as a residue you have a ammoniacal salt, which when mixed with quicklime, its ammonia is given off.

The presence of oxygen in the atmosphere is proved by combustible bodies, becoming converted into oxides when made to burn in it. For instance Hydrogen becomes water, which is the oxide of that gas. Again we see that respiration is supported in animals, by the oxygen entering by their lungs, or other breathing organs, and effecting changes on the fluids & tissues, which are essential to the ~~an~~ support of life. Combustion in confined portions of air prove that Nitrogen exists in the atmosphere. and this Nitrogen, is fitted to dilute the oxygen to the point or strength most suitable for the wants of living beings. Animals made to breathe pure oxygen, fall into a febrile state, & which very soon proves fatal. Nitrogen, also serves an important. end in the economy of nature, by increasing the volume of the atmosphere.

and yet not conferring upon it active chemical properties.

Lime water exposed in an shallow vessel to the air, very soon becomes turbid, & this is due to the CO_2 uniting with the lime, and as a result carbonate of lime is obtained.

As regards the density of the air, it is now reckoned to be 1000, and it is the standard for the specific gravities of gases & vapours. It is 810 times lighter than water, and 11.000 times lighter than mercury, still its quantity is such that it exerts a very marked pressure on objects at the surface of the earth, and this pressure, at the sea-level is equal to fifteen pounds on each square inch, or to the weight of a column of Mercury, thirty six inches in height, or one of water, nearly thirty-four feet, but this pressure doubtless varies.

The air is not a chemical compound, but is a mechanical mixture, and of a very uniform constitution. In all parts of the habitable globe, in composition, air seems to be the same, and that found in the greatest elevations or lowest valley - is - characterised by no appreciable difference at all. Vide lower half of page. 21 For Mechanism of Respiration and continued at page. 24 (top).

Is made not by the Diaphragm, but by the ribs (Dr. Hutchinson). In forced expiration, the sacro-lumbales, latissimi dorsi, with their accessory muscles, as high as the highest costal insertion, also the serrati postici, inferiores, and the triangularis sterni, in all probability assist in the approximation & depression of the ribs. and this takes place from an undue or abnormal contraction of the expiratory muscles. and hence the diaphragm is more than usually depressed – and a greater diminution of the thoracic capacity. is the result.

II. Three varieties of ordinary respiration, by Messrs. Beau & Maissiat. I. Abdominal. II. Costo-inferior. i.e. from 7th rib, downwards. III. Costo-superior. The first variety is seen in infants of both sexes up to the end of the third year. as is mainly effected by the diaphragm after the above time the II. or Costo-superior in girls & inferior in boys. prevail, and their differences becomes more evident as life advances, ergo. almost all men breathe by the ~~i~~ inferior, and women by the superior part of the Chest. III. Costo-superior, in which the upper part of the chest is carried up. by the superior ribs & Sternum. this type is characteristic of females, specially those in a state of gestation. and which mode of breathing, may have for its object the sufficient extent for respiration. in the event of the lower part of the chest, being pressed ~~upon by~~ the pregnant Uterus.!!

Inspiration (muscles of).

Are external intercostals (which (according to Hamberger's) experiments) must elevate & open out the ribs. while the internal intercostals, which are expiratory, depress and.

and approximate them, and therefore as the fibres of the one set are contracted, those of the other must be lengthened; and in addition to the External Intercostals, we have the levatores costarum, and part of the triangularis sterni; all of which combine to elevate the ribs.

Expiration (muscles of)

They are the proper costal parts of the Inter-costales muscles, with the infra-costales and a part of the triangularis sterni, to which may be added many accessory muscles, and all the muscles which elevate the Scapula, may act through it on the ribs, and the upper ribs rise by the action of the scaleni, whilst those which erect the spine, fix more efficiently the origin of the above, and also of other thoracic muscles. During forced expiration it has been noticed that the longissimus dorsi, Sacro-lumbales &c. cooperate.

"The power of the expiratory muscles is nearly one third stronger than that of the inspiratory, and when the force of expiration is less than that of inspiration then disease is present. The power of the inspiratory muscles is greatest in a man of 5 ft. 9 inches, and a healthy man of 5 ft. 7 inches should raise by inspiration a column of three inches of mercury."

The frequency of Respiration varies "thus"

Quetelet's Table. Inspiration.

Quetelet's Table.	Observations on three hundred persons.		
	Average.	Maximum.	Minimum.
At birth.	44.	70.	23.
At 5th Year.	26.	32.	0.
From 15th 20th	20.	24.	16.
" 20 - 25.	18.7.	24.	14.
" 25 - 30.	16.	21.	15.
" 30 - 50.	18.1.	23.	11.

Mr. Hutchinson gives the following table of the number of respirations per minute in adults of the male sex when sitting, numbering 1714. and all in a state of health.

Number of respirations per minute. (1)	Number of cases. (2)	Number of respirations per minute. (3)	Number of cases. (4)
6.	1.	26.	8.
9	1.	27.	2.
10.	2.	28.	30.
11.	1.	29.	2.
12.	19.	30.	6.
13.	10.	31.	1.
14.	21.	32.	6.
15.	12.	33.	0.
16.	216.	34.	1.
17.	95.	35.	0.
18.	181.	36.	1.
19.	70.	37.	0.
20.	510.	38.	0.
21.	120.	39.	1.

(1)	(2)	(3)	(4)
22.	136.	41.	7.
23.	41.	0.	
24.	220.	Total.	1714.
25.	16.	"	"

"From this table it would appear that the greater number of male adults, breathe, between 16 & 24 times per minute, and of these a greater number make 20. respirations in the minute. but they have been known to be as low as 7. and as high as one hundred."
I have been informed by a Surgeon, that in a case of Delirium Tremens. he gave Morphia, in solution, to such an extent, as that the respirations, were reduced to the almost incredible, number of four. per minute, and, nevertheless the Patient, rallied, and did well afterwards. The ratio of the respiratory movements is to the pulsations of the heart as one is to four. and as the day passes by the pulse diminishes, but such is not the case in respiration. for there are 18. respirations in the Evening for 17 in the Morning., and the position of the body is the chief cause of the variation.
The quantity of air inspired in forced inspiration, and again expelled varies to a considerable extent, in different persons of the same age. Sir. "H. Davy. at a temperature of from 58°. to 62°. Fahr. when containing his lungs after a forced expiration) 41. cubic inches. After a full voluntary, inspiration there passed out of the lungs

from 189 to 191. cub. in. After a natural inspiration from 78 to 79. And after a natural expiration from 67 to 68. He came to the conclusion that his lungs in a state of voluntary or forced inspiration, contained about 254. cub. inches."

We see from the following table of Mr. Hutchinson, that the amount of air expelled by the strongest expiration after the deepest inspiration, for every inch of height between 5 & 6 feet as determined by his Spirometer.

Height.			From Observation.	Regular progression.
ft. in.		ft. in.	Cubic inches.	cub. in.
5. 0.	to	5. 1.	174.	174.
5. 1.	"	5. 2.	177.	182.
5. 2.	"	5. 3.	189.	190.
5. 3.	"	5. 4.	193.	198.
5. 4.	"	5. 5.	201.	206.
5. 5.	"	5. 6.	214.	214.
5. 6.	"	5. 7.	229.	222.
5. 7.	"	5. 8.	228.	230.
5. 8.	"	5. 9.	237.	238.
5. 9.	"	5. 10.	246.	246.
5. 10.	"	5. 11.	247.	254.
5. 11.	"	6. 0.	259.	262.

Age and weight, in addition to Height regulate the quantity of air that passes to & from the lungs. in forced & voluntary respiration.

Frequency of respiratory movements.

When the number of respirations is less than usual, then the percentage of CO_2 in the expired air is increased, while its absolute volume is diminished. and vice versae. Vierordt attempts to point out the diminution of the percentage of the CO_2 gas in the air expired, when the respirations are more frequent, which probably has a certain relation to their frequency or length per minute, supposing their bulk the same.

Nerves of respiration.

We inspire & expire even without our consciousness. therefore these movements are excito-motory.

The Medulla Oblongata ~~&~~ chiefly its upper part is the principal centre, into which may be traced the incident Nerves which convey the stimulus on which the movements depend — and from which pass out the chief excident Nerves, which carry these movements into effect. and thus the Medulla oblongata, as a nervous centre. receives the impression of the — "Necessity of breathing." and reflects it to the motor-nerves of inspiration.

Indeed the whole of the Encephalon may be removed from above & the Spinal cord (as high up as the origin of the phrenic Nerve) from below. and yet the most essential movements of respiration are not suspended. The principal nerve concerned in the movements of respiration is the Vagus

vagus, which on division on both sides, the number of respiratory movements is lessened to a marked degree - even to about one half. Its power as an "Excitor" is very great since on section of it the number of inspirations is diminished, and irritation of its trunk in the neck is followed by an act of inspiration, ~~and~~ It would seem likely that this power originates in impressions made on its peripheral extremities, and the said impression is in all likelihood due to I. Presence of venous blood in the lung capillaries. or II. To the presence of CO_2 in the in air-cells. (Dr. M. Hall.)."

We have said that the vagus is the principal nerve, wh. excites respiratory movements; but not the only one, for if it were, then on cutting it, on both sides, death would follow, from cessation of respiration, the effect produced by such an operation is a diminution of the frequency of these movements; hence we infer that others than, or besides this nerve are concerned in this most important function of Respiration. And first we may enquire into the effect produced by the nerves of the general surface on respiration.

"It is well known that the splashing of cold water on the face will produce inspiration, almost in an instant, as also the first plunge into cold water, and besides these a slap of the Hand upon the Nates of a newly-born Infant will produce the first inspiration."

~~and~~ The Fifth nerve appears to be the principal agent in inducing the first respiratory movement.

"Dr. Reid, removed both the cerebrum & cerebellum and at the same time the vagi were divided, & there followed further diminution of the respiratory movements, but not ~~of~~ suspension. and their continuance "though very small. seemed to depend on blood which circulated in the Med. oblongata. of a very imperfectly aerated character. It is most probable that the Sympathetic Nerve, which has special connexion with the vagi. is one of the centripetal nerves concerned in Respiration.

In young animals. division of the vagi. trunks. or even their recurrent branches. is very soon followed by death. and this seems due to the pliant nature of the laryngeal cartilages, and thus permitting the atmospheric pressure in inspiration to close the glottis, death in this case is by suffocation. In cases of old animals, the glottis (from the rigidity. of the arytenoid cartilages) is prevented from closure as in the above case. and indeed the animal can breathe (only having a small opening at the posterior part) though the muscles are in a state of paralysis.

The most common morbid changes that occur in cases of slow death after division of both pneumogastric Nerves. are I. Congestion of the blood vessels & II. An effusion of frothy serum in to the air cells & bronchial tubes. These changes may be ascribed to the hindrance of the passage of the blood through the lungs.

Lungs, in consequence of the supply of atmospheric air being lessened, and thus an excess of Carbonic gas in the air cells.

Formerly Physiologists adopted the opinion that the Serum, by interfering with the normal changes in the lungs, caused the congestion (i.e. a preternatural accumulation of blood in the vessels proper) of the pulmonary vessels, & thus laboured Respiration, and doubtless to a certain extent they were right, because in those instances in which serum is present, these said changes do present themselves. "But Dr. J. Reid from his carefully noted results of experiments concludes thus I. That congestion of the Lungs or rather of the blood vessels of the Lungs; is the first departure from their healthy action & condition. And II. That the serous effusion is a subsequent effect."

Nerves of the Larynx.

Its motor is the inferior laryngeal, or recurrent, and the superior laryngeal is the sensory or excitor nerve whose office it is to convey to the Medulla Oblongata, the impressions, by means of which the muscular movements are excited, but a few motor fibres are mixed with this Nerve (Incident) which supply the crico-thyroid muscle. Hence we conclude that these Laryngeal Nerves (by which the aperture of the Glottis is governed, and also by which an irritation of the larynx is made to close) to prevent any foreign body entering the trachea. Constitute the circle of incident & excident nerves—

The Superior Laryngeal nerve excites the Respiratory muscles. & thus a blast of air is expelled. and CO_2 causes spasmodic closure of the glottis. Certain phenomena which are induced either. by mental emotions or by a stimulus taking its rise in the organs of Respiration. themselves. may here be alluded to and I. "Sighing. it is just. an inspiratory movement., longer than usual. & therefore one in which more air enters the — lungs or is inhaled."

II Yawning. "It is an inspiration of a still deeper nature, followed by a contraction of the muscles, of the jaw (which contraction partakes of the, spasmodic character.) and also elevation of the ribs, in which the Scapulae share, this is well, seen in Palsy, then the Patient can't raise the, shoulder by an effort of the will, but does so. in the act of yawning."

III. "Sobbing. (Which is not unfrequently followed. by closing of the glottis) is the result of Diaphragmatic Contractions, and these are convulsive in their character."

IV. Hiccups. Its movements are convulsive, and at once in the middle of these movements the glottis closes. the orifice, and the —

the rush, or column, of air in motion against the glottis.
V. Causes this peculiar sound. Whereas in Laughing.
the glottis is fully open, the breath is pass=ed out after a "jerking" manner & the muscles of expiration are in a convulsive movement.
VI. Crying. It is nearly the same as the last, as far as the movements of Respiration are concerned, though, induced by a contrary emotion.
As sighing may be produced by depression of the mind, so yawning by seeing another yawn, again, crying may & does arise from pain and laugh=ing from "tickling" &c. in the one case, we have emotion=al expressions, in the other simple results of Sensation.
VII. Coughing & Sneezing. are produced by foreign sub=stances either in the trachea, or bronchial tubes, which keep up a state of irritation, by a cough we mean, a long inspiration, which inflates the lungs, and a forcing open of the glottis, by a powerful expiratory movement by which the said fore=in body is not alone expelled, for rather a sudden gust of air rushes up the tube or wind-pipe pushing before it the body.
In Sneezing. (From the coming together of the sides of the velum palati, over the posterior part of the tongue,) the blast of air is passed almost totally through the nose. & carries before it any substance, which can be removed —

Of course in this phenomenon the connexion which naturally exists between the larynx, and the mouth is partly, or almost wholly shut off.

Changes of the air in Respiration.

One of the most important is the increase of the temperature of the air inspired and therefore, an increase of its bulk, which is altered, by an increase of the watery vapour of the air. and be=sides is altered in its bulk & elasticity, therefore the expired air contains more caloric, more watery=vapour, & is more elastic & of less. specific gravity than the inspired air.

The air we breathe is not unfrequently saturated with moisture, and the lower the temperature of the inspired air, the less it approaches, to the point of saturation with moisture, and the greater its volume, the greater will be the loss of watery vapour by the lungs.

"Valentine calculates that if a person breathe atmospheric air saturated with moisture at a temperature of 60° of Farh. and if the expired air, be at the same temperature of 99.5. Farh. and at the same time moistened, about two-thirds of the watery vapour in the ex=pired air, will be furnished by the fluids of the body".

How much oxygen absorbed by the Lungs.

Man annually inspires 7 cwt. of oxygen gas. one third of which unites with carbon to form carbonic acid gas. which is evolved by the lungs.

The quantity of O. gas which disappears from the inspired air by absorption at the lungs is not uniform in the same person for any length of time.

About 400 to 500. cubic feet of atmospheric air pass daily through the lungs of an adult, in a case of moderate exercise. and ~~2~~ also 23. cub. ft. of O. gas are absorbed, during the same period. The same the air breathed twice (cannot be ~~without~~ injurious effects.) air breathed 9 or 10 times contains 9.5 p. cent of CO_2.

Diminished respiration reduces the amount of CO_2 evolved from the blood in a given time, as may be seen in the state of the blood & circulation.

As it is a matter of vital importance to know how much pure air should be furnished to those whose life is that of a sedentary kind, or who are confined. attention has been bestowed on this point, & the result is ~~that~~ 800. cub. ft have been fixed upon as the minimum. for each person except. where unusual provisions are in operation for its constant removal by ventilation. and we are aware of the fact "that good ventilation" is a sine qua non for health. In the new Kings College Hospital each patient has from 1850 to. 2500 cubic feet.

It is not sufficient for health that a room contain the quantity of air necessary for the support of its inhabitants during a fixed time, because after they have remained in it for a part of that time, the CO_2 which is contained in the atmosphere of the room, will suffice to interfere materially with the due aeration of the blood, and as a result of accummulation of CO_2 in the blood we meet with oppression of the brain and other morbid diseases.

If the blood come to the lungs charged with CO_2 and be exposed to the influence of the air in their cells, an "endosmose & exosmose" of gases take place, in which the CO_2 is evolved and O is inhaled, and this oxygen is greater than the CO_2 in the proportion of 1174 to 1000. The excess of Oxygen which is one sixth, is absorbed into the system, supposed to combine with Hydrogen, furnished by the food, & by the disintegration of the tissues, to produce water and part of this water is exhaled from the lungs in the form of vapour, whilst another part is employed for the oxidation of Sulphur & Phosphorus, which are taken in with the food and which are excreted in the form of Sulphuric and Phosphoric acids, after forming part of the solid tissues.

The absolute amount of CO_2 given off in the hour may be stated to be about 160 grains by a full grown adult, under ordinary circumstances. or 8 ounces troy in the 24 hours. i.e. 3840 grains
The amount of watery vapour varies also (according to certain conditions, as temperature - diet, exercise &c.) from 6 to 27 ounces.
Cold increases the amount of CO_2 exhaled by warm blooded animals, and heat has the opposite effect. As is seen from the following examples.

"At Temperature about 32 Fahr.		Tempt. 59-68.	Tempt. 86-106
I. A canary exhaled	0.325.	....0.250.	....0.129.
II. A turtle dove. "	0.974.	....0.684	....0.336.
III. Two mice "	0.531.	....0.498.	....0.268.
IV. A guinea pig "	3.006.	....2.080.	....1.453."

From this table it is seen that the quantity of CO_2 gas exhaled by mammals, between 86° & 106°. Fahr. is less than half that set free near the freezing, whilst that exhaled between 59° and 68° is a little more than two-thirds of the same amount.
The period of the day has an effect on the quantity of CO_2 gas expired. Thus it is greatest at 10. A.M. and 2. P.M. and is least at or about 8. 30. and continues nearly uniform till 3. 30. A.M. -
In 100 parts of expired air by volume (as an average of many experiments -)

		Carbonic acid.
"Coathupe.	found . . .	4.02.
{Brunner & Valentine}	"	4.38.
Vierordt.	"	4.33.
Thomson	"	4.16.

"Fasting lessens the CO_2 gas in the expired air.
Exercise (moderate). such as walking, at first appears to increase the CO_2 evolved, but when exhaustion is induced, then the CO_2 gas is diminished, thus we see that exercise will increase to a marked extent the evolution of this gas from the lungs. Vierordt has shown that in moderate exercise, there is an average in=crease per minute of 19 cub. inches in the air ex=pired, and of 1 cub. inch in the carbonic acid ex=pired.
Alcohol. lessens the amount of CO_2 in the expired air. especially when taken on an empty stomach, and moreover its tendency is (when habitually taken) to induce a fermentible condition of the blood. from obstructing, the free elimination of effete matters from it. by means of the lungs. Dr. Prout states that a strong infusion of tea has the same effect as $C_4H_6O_2$.

In Sleeping. the evolution of CO_2 is lessened, probably from the tranquil state of the respiration.
Conditions of the mind. Ecstacy, Melancholia.

And anxiety diminish the carbonic acid in the expired air.

ce. <u>Age. Sex.</u> MM. Andral and Gavarret, from their observations, came to the conclusion I. That the quantity of CO_2 gas evolved varies according to age. sex &c.
II. That at all periods of life from 8 up to old age." the CO_2 evolved differs in both sexes, and the male exhales more than the female. Thus the male child between the ages of 8 & 15. exhales 77 grains of CO_2 gas. and the female of the
62 gr. same ages. grs. 62 The differences are most marked between the ages of 16 and 40. (3). In the male the CO_2 gas increases from 8 to 30. but at puberty it amounts to 157 grains. between 40 and 60. it averages only 155 grains — and continues thus to decrease up till old age. In a man, noted for health, aged 102. the carbon exhaled in the form of CO_2 gas. only amounted to 91 grains.
IV." In the female the evolution of CO_2 gas increases from infancy till puberty, when no marked increase, as in the male, takes place, but rather it becomes stationary, and as long as the function of menstruation is normally performed, and regular." the exhalation of carbon (in average) is but 98 grains in the hour, but when the menses cease, it is not a little remarkable — to

to notice that the carbonic acid evolved undergoes a decided augmentation, but after a while it begins to decrease, and to continue (as in males) as she grows in years.

V. A female in a pregnant state, exhales the same amount of CO_2 gas as she does at the time of the cessation of the Menses.

"The following table of Andral & Gavarret show the result of experiments on males of various ages.

	Carbon exhaled per Horam		Do. exhaled p. Horam
Age 8	77 grains	Age 37	164.78 grs.
" 12	113 "	" 48	161.7 "
" 14	126.2 "	" 59	154.0
" 20	166.3	" 68	147.8
" 26	169.4	" 76	92.4

Effects of Seasons.

Birds, when placed exactly under the same circumstances and with the surrounding air, of same oxygen, consume more oxygen in winter than in summer.

Ingesta and the varying conditions of the atmosphere, also have an effect on the evolution of CO_2 gas from the body.

Now we take up the subject of

Respiration in animals. Rather than entering largely into, & describing at great length, this phenomenon in animals, interesting, though the subject is, and on which a great deal might be written, I, from having said so much, on respiration in general, in the preceeding pages. think it more desirable to take up, one or two classes in each Sub-Kingdom. and shortly enquire into, & describe the structure &c. of the organs or parts more immediately concerned in the function of Respiration. And first then we begin with the Echinodermata. So called from the spines or tubercles with which their external surface is commonly covered, they are in short hard-skinned. Of which the Star-fish, Sea-Urchins &c. are examples. In these special organs exist, and on the tegumentary membrane (its upper surface ~~as~~ of the Asterias) are found small transparent tubes, & these fleshy, - which are seen to advance & recede ~~through~~ openings in the integument. On the interior of these tubes, cilia are found, by whose vibrations, currents of water are are propelled, ~~in~~ through the visceral cavity into which they open, and the serous membrane which lines this cavity, (from so much of its surface, being in contact with the surrounding medium) appears to be the principal seat of of respiration

II. Tunicata. These are animals which breathe by Branchiae. which occupy the interior of a cavity which is traversed by currents of water. They are soft. aquatic, acephalous animals. and their organs of respiration are ciliated, just as is seen in the higher classes of Mollusca, for the production of the current of respiration. The mouth opens at the bottom of the abdominal cavity, and is destitute of tentacula, or other organs of sense. But the entrance into the respiratory cavity, is supplied for most. with numerous delicate tentacula, and this opening is surrounded by the longitudinal Nervous filament, which filament terminates in a small ganglion. These animals are all marine, many of them are organically connected in groups. others are solitary, most of them are fixed, but some are free. As to the Gasteropoda. From Gaster the belly & πους. ποδος. the foot. i.e. belly footed & so named, because they have a muscular foot situated on the ventral surface as seen in the snail & Welk; their body is inarticulate, and provided with a distinct head - eyes & tentacles. at times they are found naked, but in the great majority of cases they are covered with a univalve - unilocular - external shell, wh. is of a of a solid consistency. In them the process of Respiration is carried on as in the Tunicata, by Branchiae, whose form is arranged after the manner of fans. combs. or tufts. which are disposed over various parts of their surface, or under an open Mantle, but we find that some of the Gasteropoda breathe air directly from the atmosphere, and therefore are denominated "Pulmonata", of which the Snail is an example, it has no respiratory organs, but when a net-work of blood vessels. are formed in a cavity, then the animal breathes pure air.

A word about the Crustacea. They are articulated animals, with feet articulated examples. Crab. Lobster. &c. they breathe the air, through the Medi=

mec =um of the water; but in those which live for some time on the land, their Branchiae are kept moist by the membrane, lining, the cavities being dis=posed in folds to serve as reservoirs for water, and even at times it presents a spongy texture for the same end.

III. Insecta. Are different to the above in not breathing by means of Branchiae, but by Tracheae. which are just air tubes, dividing and subdividing, and at the same time lessening in size & diameter. and finally entering the substance of all the organs. of the bodys.

bi These animals consist of Head. Thorax. and abdom abdomen, and in addition, six legs, which are carried by the Thorax. The head is provided with a ~~—~~ labrium, labrum, mandibles, maxillae, eyes. and a pair of antennae, and besides with palpi. The Thorax thus carries the legs, and two pairs of wings, which are its locomotive. organs. It is Composed of three distinct rings. a. Anterior. R.. i.e. Proto-Thorax. b. Middle or. Meso. T. c. Meta. T. The abdomen is destitute of these appendages. but it is itself attached to the Thorax. and contains the organs of digestion — generation — and of the circulation.

The forms of insects are often very strange, their lives very irregular, sometimes in water, at other times in the air; many of them begin in worms, and end their lives as flies and moths.; and according to these varieties of their form, or life, or generation their air tubes are various.

There we see that they pass through a series of meta=morphosis., & throw off their exuvial coat, five or six times during their development. This class is the most numerous in the animal kingdom, comprehend=ing about one hundred thousand species.

The greater part of their life is spent in ~~the~~ Larva state, during which period they are most voracious In them the <u>air tubes</u>. which are surrounded every=where by the blood; diffused through the body.

body, branch over, and penetrate into all parts of their body. the stomach, bowels. other viscera, yea the legs & wings, and even the very scales of insects have branches of the air tubes dividing over their surfaces like the delicate vessels of leaves and flowers. In fact the magnitude of these air tubes, is surprising; and their branches are so small, delicate, and universal over the body, that it looks almost as if the air tube had exchanged functions with the heart and arteries.

The large quantity of air contained in the bodies of insects impart the necessary lightness and elasticity to them, and the highly oxygenated condition of their circulating fluids imparts energy to the muscular system, & precision and activity to their movements; and to this same cause we must attribute the high temperature which they so often acquire.

At times their ~~[illegible]~~ air tubes have nearly the form of a lung i.e. they begin like two bags like ~~those~~ of the Alga Marina (i.e. Sea-weed) but for most these air tubes are direct, mere tracheas of a very peculiar constitution; they have rings similar to those of ~~—~~ animals, a delicate membrane covers these rings and thus they are formed into a tube: which tube continues always tense, rigid, hard. they ~~—~~ begin by many open mouths ~~[illegible]~~

mouths opening along the sides of the insects and they terminate by myriads of vessels. Which (in their forms & progress over the various parts of the body) resemble blood vessels more than it is easy to conceive. These tubes always contain air. owing to the rigidity & by their refraction through the transparent parts of the body of the insect the tubes then give it in the microscope a great degree of brilliancy; as seen in the air tubes of the Pediculus (Louse). which make the brilliant lines & points which are contrasted like silvery colour, with the dark and opaque parts,

The stigmata, or spiracles, are furnished with muscles to open & close them, and also with valves processes, and hairs, variously modified in the different families, in order to their protection against the entrance of any substance, which would (did it enter) greatly interfere with their normal function.

These stigmata, or breathing points; correspond with the folds or rings, of the insect while it continues a Worm and with the scales or divisions of its body when it metamorphosed into a Fly. Thus while it is a Worm, (since it must breathe less easily) it has more of these stigmata, than when it has become a Fly, when they are freely exposed to the air.

In the Rhinoceros Beetle the Worm has more

more of these breathing points; because it crawls on the ground amidst mud or dust; but in the Fly, they are less numerous, from the fact that its air holes are always more freely exposed, and when the Beetle is actually flying, the points which were closed by the cases of the wings, are fully opened, and then the insect breathes more freely, and in all probability its body is lightened, and as a consequence it flies the easier. Its puncta, or points, (when it is full-grown) are less in number, but the lungs are enlarged, and both change their form & become more capacious, and the air tubes are mere tracheas or straight lines, with direct branches in the Worm, but in the Beetle they are formed into air bags, from being dilated from point to point.

When the Stigmata are closed up of one of these insects, the result is, that it becomes paralised, and if only one or two points ~~are~~ left free or open, the animal still lives, but as may be anticipated in a very languid state, ~~and~~ only for two days, does it thus continue, during which time its Heart is non pulsat=ing, and it dies right out on the closure of these two points, which are highest.

We now come to speak of the analogy.

Analogy between the Spiral vessels of Plants and the Tracheae of Insects.

The tracheae or air-tubes of Insects which ramify by minute subdivisions through the whole of their bodies, are formed after the type of Spiral vessels of Plants, and of an external membrane, distended by Spiral Fibre and, which is coiled up with the most beautiful regularity; The air tubes of Plants differ from the Tracheae of Insects, in being closed (but their gaseous contents find their way by permeation through the membrane which composes their walls) Whilst the Tracheal system of Insects, exhibit the most beautiful and minute ramifications, which are formed by the subdivision of its chief trunks, which directly communicate with the atmosphere, but still, though their special office is not yet fully doubt known, little remains, but that they in some way or other aid in aerating the internal fluids.

In a great many of the simpler & more highly organised, cavities are found, whose special use is for the inclusion of air and which would seem rather to give buoyancy to the structure, than to take any active part in the Phenomenon of Respiration, and on analysis, the air thus contained, is found, rarely to be of the same.

same composition as that of the atmosphere.

We now come to the interesting class. i.e. IV. Aves. In these the circulating system is the same as in Man, they are endowed with the power to fly, as well as the Insects, and though they both have wings, yet these differ, thus those of the latter, are in a Homological character different to, those of the former, in, as, much as, the wings of the Insect merly consist of an expansion of a tube variously branched, which is just a continuation of the tracheal system, and is composed of a flexible membrane. Whereas in birds the former anterior limbs are converted into Wings, for which reason its Head & Neck, are adapted for feeding, and Respirations.

The Lungs of birds, are very small, dense, & bloody, not unlike the Human Lungs. and are located high up in the Chest, braced down to the back, and in part are niched in among the ribs. From being braced down by a membrane, which is very strong, yet thin, they can not move. this membrane is the Peritoneum, which lines both the Thorax and Abdomen, and forms large cells, which fill the whole cavity up from the neck down to the anus. and from the Breastbone to the back, and which as the Chest moves, they move. and their order of arrangement is very regular. In short we find that the essential parts of

of respiration to be these. First there exists no Diaphragm, and therefore the Thoracic and
cavities. Abdominal are one, so to speak. a true muscul=ar Diaphragm, would be of no use in birds, as it would not be of any service in respiration. and also. from the Lungs. being so immoveable and, high up in the back, no Diaphgram, nor any power of vacuum could unfold them, and again from the Lungs being perforated at every point they can't be expanded by. air. The large cells formerly aluded to, have been Confounded with the Lungs. but these cells are just for the purpose of rendering the ani=mal light, that it may fly, and in propelling the air through the Lungs. In birds the Thorax does the whole; it is raised, and thus
by. the cells are expanded, and, this means two functions are performed; for the air which comes into the cells, passing through the Lungs,
I: oxydates the blood, and the cells at the same time
II become full, so as to make the body lighter.
again the Thorax is depressed. and the air. which passes a second time through the Lungs. may again oxydate the blood, for it is not altogether spoiled.

It is worthy of notice that even the very bones of birds become hollow, & their cavities communicate with the Lungs, and those whose bones are thus permeated with air, on passing a ligature round the Trachea, and making an opening in one of the large bones, as the "Femur" or "Humerus" still respiration will be carried on.

With reference to Serpents, it is a very interesting fact, that the Lung is single, & that of one side being developed to a great length, the other side remains in a rudimentary state, or is generally undeveloped. The aquatic Serpents, from the large quantity of air contained in their bodies, are rendered buoyant!

Amphibia. (a). Reptilia. they are furnished with feet & flat naked ears, without auricles. examples. Frogs. Lizards. In the Frogs at one part of their lives present Gills and at another, Lungs, hence they must undergo a metamorphosis, and the first change is that the "male deposits the egg in the water, which by & by, breaks open (or rather is broken open by the animal) & then the animal takes its leave of its former abode, behind its head a branched projection, of vascular tufted Gills is found, by means of which it carries on its respiration, during a period of its embryonic development, but which as the Lungs become developed, are in proportion absorbed.

The Lungs of the Frog are like a fir-cone in shape, with the stalk of the cone on each side & fixed to

to the side of the heart. These Lungs are, delicate, silvery, totally transparent, and divided with=
=in into innumerable cells honey-comb-like.
& these are so extremely delicate, ~~that~~ though the out-side membrane is as transparent as a soap-bubble, the division can hardly be seen, except the Lungs be dried, inflated & then cut into.

Frogs The mechanism of respiration in them is as follows. Their broad jaws are always shutt. and fit into each other by grooves; their mouth is quite closed. and forms a sort of bellows. the air=
holes of which are the nostrils, and the muscles of the jaws. which arise from the Hyoid=
bone, draw in the drought by their alternate contraction & ~~dilatation~~ - (rather relaxation) and the nostrils, from their oblique position over the hole in the skull, the least move=
ment of them, enables them to perform ~~the~~ the function of a valve. First, the nostril gives a "twirl", then the air enters, and straight=
way the bag under the jaws is dilated, by which the mouth becomes greatly enlarged, & filled with air, but on a second motion of this bag, the mouth is emptied of the air, & the Lungs are filled with it, but on the slightest motion of the sides of the animal, this

this air is again expelled. (the abdominal Muscles are here called into action.). In them the Muscles of the Jaws are those of Respiration and not those of the belly.—— Inspiration in them is the swallowing of the air by their broad expanded jaws. with their coverings driven into the Lungs. and Expiration is the driving out of it by the Abdominal Muscles.

~~Their skin is destitute of scales or other covering~~

Lastly. on this part of our subject we allude to.

Pisces.

In them respiration is carried on by breathing water or air. or both, and first the mouth is distended with water, the muscels of which are thrown into a state of contraction, whereupon the water is squirted out through the apparatus on each side of the Pharynx. into ~~the~~ Gillscavity, & then the bony=arches are elevated and separated from each other by a muscular arrangements, set apart specially for this end, so that the Gill-fringes may hang freely, & thus permit a free flow of water between them, in this way the water is expelled by means of muscular pressure. and its return to the Pharynx is prevented, through the valves which guard these orifices. The Heart of the fish consists of two chambers. an "Auricle". and. "Ventricle".

the veins bring back the venous blood to the ventricle.

The Heart is exclusively venous, and is therefore to be from this circumstance, distinguished from all the Other classes of the Vertebrata.
The Gills, which are in general four in number on each side of the head, convert the venous into arterial blood, by the action of the Oxygen. The arteries also possess the power of propelling the blood, and the heart acts by intervention of the Gills on each side, - but, in addition to Gills most fishes possess a hollow organ, to wit "the "swimming bladder" or air sac" which is the true homologue of the lung, and therefore performs an accessory part in the function of Respiration. On its contracting the fish sinks, and on expanding it again rises up to or near the surface the of water, it is situated in the cavity of the abdomen, and is also found along the vertebral column, and in general, communicates with the Pharynx, and Stomach, by a membraneous canal. It would appear that it is more complete in those fishes which come to the surface of the water most frequently and, which at the same time, are remarkable for their powerful & prolonged muscular movements, and that it is least developed, or even wanting in those species which live at the bottom, & burrow in the sand, or mud, as the "rays" &c..!

Respiration in Plants.

"The atmosphere being the source, whence carbon is supplied to the living plant, its introduction has been confounded with the opposite change, hence we see ~~that~~ plants give out oxygen, and take in Carbonic acid, but vice versae with animals." The phenomenon of the introduction of Carbon is effected by the power which the green surface of Plants posess of decomposing under the Stimulus of light the CO_2 found in the air, or in the liquids supplied to them; and of retaining or fixing the C. whilst the O. is evolved. The essential nutrition of plants consist specially of the elements of water, along with certain saline matters or impregnations as C. & N. The water is derived from the fluid, principally, which percolates the soil, and is absorbed by the roots, and partly from the moisture of the air which is imbibed by the leaves.

Priestly in 1771, pointed out ~~that~~ plants were able to grow in air vitiated with the breathing of animals, and that they very speedily restored such air to its pristine purity. Percival confirmed these observations, and showed ~~that~~ air containing so much CO_2 as to prove fatal to animals was rendered fit for respiration to be performed, after plants had grown in it.

f fit

"Ingenhouz. performed experiments of a like kind, with immersed leaves, and found, ~~that~~ they purified the air, in a very short time, in sun-shine."

Although the fixation of C. by the decomposition of CO_2, is the most essentially dependent of all the processes of Vegetable economy, upon the influence of Light, yet it is not the only one, especially among the higher plants: in which that agent becomes an important condition. The exhalation of superfluous matter by the Stomata of the leaves, is also very much affected by it. and through its influence upon these two important operations, Light affects more or less directly, almost every process in the Vegetable Kingdom. By depriving a "growing" plant of Light, and, that privation, if continued, the result is that the green surface, Chlorophyll, or colouring Matter, becomes blanched or "Etiolated". the solid parts loose their weight, and a "dropsical distention" of the tissues, endues, from the non-exhalation of Water which is continually being absorbed. In these circumstances no .O. is evolved, but CO_2 is on the contrary generated.

<u>Confervae</u>.

These plants are found on the banks of the

the Traversine. and are aquatic, & seem to have a very important function. to perform, "To-Wit" the maintenance of the purity of the water. by rendering it suitable for the support of animal life, by absorbing foul matters, which are found in Pools, and which pollute them, and at the same time yield a supply of. O. to the water.

The whole mass of vegetation on the surface of the Globe is thus principally dependent on the small amount of CO_2 in the atmosphere, which is not above 4.79. parts in the 10,000. and it is found that plants will flourish in an atmosphere containing 6 or 8. P.C. of CO_2. In Summer the proportion of CO_2 is said to be greater than in Winter as. 7.13 to 4.79 in the 10,000. The quantity of CO_2 in the air, before inhaled, is about 1-2500th; and, in that, exhaled it is about. 1.25th or it has increased 100 times in quantity.

Mr. Haseldine Pepys. after careful & oft. repeated experiments, gives as his firm conviction, that leaves, which are in a healthy state of vegetation assist in the purification of the air by the disengagement of. O. and the absorption of CO_2. Light is also, of importance (as we have seen) to the proper discharge of this function"

"Cloez" & "Gratiolet." are of the same opinion, and consequently, affirm that. O. is very quickly dis=

engaged in the solar rays. almost imperceptible in diffused light, and not at all in darkness. and that in this case no CO_2 is given off by plants. From all this it seems, ~~reasonable enough~~ ~~that~~ CO_2 during the night is absorbed, by the leaves, but that during the day, its absorption is far less.
Now from the above remarks, we, infer ~~that~~ the great function of leaves seems to be that of deoxidation. and they are therefore instrumental in maintaining a pure state of the atmosphere.
"Cloez & Gratiolet". affirm ~~that~~ the decomposition of CO_2, by aquatic plants exposed to light in a temperature raised by degrees from 39.2° Fahr., does not commence until the temperature is 59° Fahr., and is at its maximum at 86° Fahr. The decomposition of the same gas, by plants exposed to light in a temperature which is less than 86° Fahr. continues when the temperature is as low as 57.2°, 55.4°, 53.6°, 51.8°, but ceases when it is down to, or, as low as 50. Fahr.
Nitrogen enters largely into the composition of plants, but all of it, which they seem to require is, derived probably from the decomposition of the ammonia. which is absorbed in the soil (and not directly

from the atmosphere.) but still it is a "Questio vexata", whether the free Nitrogen of the air, has any thing to do with vegetable Respira= tion; because from experiments, it appears that azote is more commonly exhaled than ab= sorbed.

Causes of the change of colour of the blood.

How this change is effected, (as the blood passes through the Pulmonic, and Systemic capillary vessels). is still a matter by no means yet sufficiently shown, however it seems that the colouring matter of the blood is enclosed in the enveloping membrane of the red corpuscles, and that though in union with Iron, yet it does not obtain its colour from ~~the~~ it. Nitrate of Potash, Carbonate of Lime, and other bodies, as well as oxygen, can impart to the venous blood the arterial hue, but at the same time, no evolution of carbonic acid takes place,

And now subsequent researches have pointed out — that the change into "arterial," from "venous" blood, is due to the actions of the salts, dissolved in the blood, upon the Hoematosine, after the removal of the free CO_2 of the venous blood, by means of the attractive power of the .O. of the air.

We go further and say that the change in the blood from "venous" into "arterial", is not the result of a "Chemical", but a Physical action.

and though there is some strong evidence for the opinion that this Physical change consists in an alteration of the form of the red corpuscles. Never-the-less it is still a matter not beyond the reach Dubitationis.

"Difference between arterial and venous blood."

Before the circulating fluid has been exposed to the air, & also before it has passed through
it the Lungs it is termed "Arterial". The blood returns along the veins of the abdomen, and is conveyed to the Right auricle, by the Superior "vena Cava", and differs from that which enters the Superior. V. cava. in as much as it contains some water and certain substances which are taken in the food & absorbed by the Mesenteric and Gastric glands.

hue. The Arterial blood is of a Scarlet red hue but venous blood is of a dark Modena hue, and this colour varies in the different Vertebratae, in as much as it is greater in Mammalia and birds, than in Fishes and Reptiles, and it may be again a matter of some difficulty (If a mechanical impediment exist, to the free passage of air through the Lungs.) to distinguish between venous and Arterial blood. for the blood flowing in the arterial vessels has more of the Characteristic venous, & therefore dark colour, than the bright

hd of Arterial blood. But we do draw a distinct line between them by I. The Arterial blood contains more Fibrin than Venous. II. A less number of blood corpuscles ~~in~~ in Venous than ~~an~~ arterial blood.
III. (Dr. Davy). Arterial blood ~~Sp.~~ Sp. gr. is 1050 and that of venous is 1053.

In Conclusion very shortly ~~we~~ enquire into "the" "Theory" of "Respiration".

"Respiration is partly a Chemical and partly a Physical process; Chemical as far as regards the results; Physical, with reference to the means by which these results are produced."

Oxygen is absorbed and Carbonic acid is evolved, a result solely from, or by, a physical process; while the formation of Co_2 is essentially a chemical process, and in whose production many complicated Chemical decompositions take place. now we ~~~~ see that the great object of Respiration are First. "The introduction of oxygen gas, by which the products resulting from the disintegration of the tissue are changed into compounds, easily got rid of from the body by the common organs of secretion; & Second. The removal of the most important and most destructive of these, Co_2 at the Pulmonary surface. (Dr. I. Reid. Cyclopaedia of Anatomy & Physiology &c).

It is, now we may say, settled, that the blood passes as well as the air, to and from the Lungs, and this is.

is performed as a combined result of the vital properties of the Muscular & Nervous tissues but the changes they there undergo, do not appear to be influenced by vitality.

When venous and arterial blood are brought out in contact of the body, the same phenomena, evidently occur as in the Lungs in life: i.e. The atmospheric air looses its oxygen (or part). and in its place acquires CO_2. when the blood presents the characteristic arterial colour.

The distribution of the blood in innumerable small vessels on the surface of the air cells, filled with atmospheric air. affords much more advantageous means than can be obtained by experiments out of the body, for rendering more easy the mutual actions of the atmospheric air and the blood from the known velocity with which gases pass through the living and dead membranes (animal). the most delicate membrane which separates or intervenes between the blood contained in the capillaries of the Lungs, and the atmospheric air in the cells. (air) will readily allow of the "endosmose" of a portion of the atmospheric air. and the "exosmose" of a portion of the gases, held in solution in the blood.

It has been supposed, CO_2 was formed to an.

appreciable extent in the Lungs. but this has fallen to the ground —— and the opinion which is now almost universally held "is that the "CO_2, which is evolved by the Lungs. is, present in a state of solution in the venous blood, before it arrives at the Lungs, and an interchange takes place, between the air in the cells of the Lungs and the blood in the Pulmonary capillaries, which latter receives the oxygen and yields up part of the CO_2 (Free) held by it in the state of Solution".

From the solubility of this gas, it at once permeates the thin moist membrane, which exists between the circulating fluid & the atmospheric air in the cells of the Lungs.

In the present state of our knowledge, it is almost impossible to form an adequate, and correct, estimate of the circumstances, which, regulate, this interchange of gases i.e. between the oxygen of the air, and the CO_2 of the blood, but it is obvious that this interchange will be affected in a most important way by the relative proportions of the gases in the air, & contained in the air cells of the Lungs, and in the blood and, also, by the amount of atmospheric air and blood which pass through the organs of Respiration.

When the atmospheric air in the Lungs is rapidly renewed by an increased frequency of respiration then the diffusion of Oxygen in the upper ~~in the~~ ~~upper~~ parts of the air tubes, and of CO_2 in the lower. will proceed more rapidly, and the air in the deeper parts will ~~contain~~ a less per=centage of CO_2. and a greater of O. than when the respirations are naturally performed.

This diminution of CO_2 and augmentation of O. in the lower parts of the Lungs will accelerate the interchange between the O. of the air and the CO_2 of the blood. it being understood that the blood holds its normal amount of free salts in solution. and a greater amount of CO_2 than usual will be separated from the blood in the Lungs and therefrom given off.

As to the Nitrogen. It is such that it cant per=meate the said moist membrane, from its being far less soluble than O. or CO_2 gas. in the blood. and on this account it is held in solution to a very small extent in the blood, and it is evolved from the blood in the function of respiration. and this evolution may be increased or suspended. indeed it may be neither of these, but may be

aêe absorbed. The exact condition in which the O. absorbed at the Lungs. exists in the blood after all the light thrown upon the subject. is not free from difficulties, and regarding it not a few opinions have been given —

and accordingly from the majority of these, the conclusion arrived at "is" that the O. unites in whole, or part, with the red corpuscles. and more particularily to the Iron. present in them. but other views resolve themselves into this "viz"; That the O. is united to some of the other constituent parts of the arterial blood, and from these it again, is separated, in passing in through the Systemic Capillaries, and combines with the Carbon to form Carbonic acid gas.

In fine: it is, almost, if not universally held, that the CO_2 which exists in a free state in the blood, is formed by the combination of the O. absorbed, with the Carbon present in this fluid. and chiefly, if not "in toto." in the course of its circulation, through the Systemic capillaries." But even this Opinion is not based on any very persuasive evidence. Striking & natural enough though it may appear to be—

FINIS.