EDUCATION.

The Lungs, their Structure and Functions.

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Mr. Finlaison estimates the fresh air inspired in one minute of time at 616 cubic inches, or, "as nearly as may be, eighteen pints." In one hour, it amounts "to 1066⅔ pints, or 2 hogsheads, 20 gallons, and 10⅔ pints!" In one day, it amounts "*to 57 hogsheads, 1 gallon, and 7¼ pints!*"

"To this quantity of air are presented for aëration in one minute of time 144 ounces of blood, being 259½ cubic inches, or nearly an imperial gallon In one hour, 540 pounds avoirdupois, or 1 hogshead, and 1¼ pints; and in twenty-four hours, 12,960 pounds, or 10,782½ pints, or 24 hogsheads and 4 gallons. Or, in other words, "there flow to the human lungs every minute nearly 18 pints of air, and nearly 8 pints of blood;" and "*in twenty-four hours, upwards of 57 hogsheads of air" are inhaled to oxygenate "24 hogsheads of blood!*"

Before entering the lungs, the atmospheric air consists, as we have seen, of twenty-one parts of oxygen and seventy-nine of nitrogen, with a very small trace of carbonic acid. When it is expelled, however, it is found to be greatly altered. The bulk of the air expired continues to be nearly equal to that inspired, but, on analysing its composition, we now find that rather more than eight out of the twenty-one parts, or nearly two fifths of the oxygen, have disappeared; that their place has been supplied by an equal volume of carbonic acid. The nitrogen is the only constituent which remains almost unaltered. Along with this expired air, a large quantity of watery vapour and some animal matter are also thrown out. If the same air is breathed again and again, the quantity of oxygen diminishes still further, and that of carbonic acid increases at every successive respiration, till at last, from deficiency of oxygen, the air becomes altogether incapable of sustaining life.

Precisely the same changes occur in the case of fishes, and of animals breathing by spiracula opening on the surface of the body. The air contained in the water passing through the gills of fishes, loses its oxygen and acquires carbonic acid. The same alteration takes place in the air expelled from the air-vesicles of the worm or the leach. In every class of animals, from the highest to the lowest, the presence of oxygen in the fluid which they breathe is thus essential to the continuance of life. Hence is derived the name of *vital air*, by which oxygen is distinguished from carbonic acid or *fixed air*, which has the property of causing almost immediate death when inhaled into the lungs.

It may be thought that if oxygen be really the life-sustaining part of the atmospheric air, life should go on better by increasing the proportion of it in the air we breathe, and that invalids might therefore be restored to health by causing them to inhale a highly oxygenated air. To a certain extent the inference is just; and accordingly we find that an animal placed in a vessel full of pure oxygen breathes with greater energy and lives longer than in the same bulk of common air, in the proportion of fourteen minutes to six minutes. But as the function of respiration and all the processes connected with it were originally instituted by the Creator with relation to an atmosphere containing only one-fifth part of oxygen, the excitement in the animal economy caused by breathing it, in its pure state, is far too great to admit of its being continued for any length of time without inducing disease and the ultimate extinction of life. Similar results follow, although more slowly, even when the proportion of oxygen in common air is only partially increased.

The only kind of air, then, which is calculated to sustain animal life in permanent health and vigour, is that containing the precise ingredients in the precise proportions ascertained to exist in the atmosphere. If the relative quantity of any ingredient be increased or diminished, the proper constitution of the blood will be immediately changed, and the general health endangered. If, for instance, the air contain more carbonic acid than the minute trace of it which exists in pure air, it will be to that extent unfit for the purposes of respiration, and act deleteriously upon the blood and general system. This effect is exemplified in the feebleness, headach, and other symptoms produced by breathing air vitiated by the carbonic acid poured out from several hundred pairs of lungs in a crowded room or church. When the quantity of carbonic acid in the air amounts to ten per cent., it acts as a poison, and renders the air incapable of supporting life. Hence the fatal accidents so common in breweries and other places, from the workmen rashly entering fermenting vats filled with fixed air. Hence also the immediate insensibility of dogs and other animals thrown into the stratum of fixed air, which occupies the lower part of the celebrated Grotto del Cane, near Naples.

If, on the other hand, the quantity of oxygen in the air we breathe be artificially increased, a feeling of active energy is felt at first, which soon passes into morbid excitement; and the more narrowly we observe what is passing around us, we shall become only the more satisfied that the proportion of the ingredients in the air, as determined by the Creator, is the only one conducive to our permanent comfort and welfare, and is consequently that which we should, in all circumstances, and at all times, endeavour to secure as an indispensable condition of really healthy respiration.

The restoration of the vital properties of the venous blood, is not the only change which is effected during its passage through the lungs. The *development of animal heat* is another and very important result of its oxygenation, and one scarcely less essential to the continuance of life. If the human body did not possess within itself the power of generating heat, so as to maintain nearly an equality of temperature in all climates, it could not long exist. In winter, and especially in the northern regions, the blood would speedily be converted into a solid mass, and life be extinguished, if no provision existed for replacing the caloric withdrawn from the system by the cold air surrounding it. In most parts of the globe, the heat of the atmosphere is, even in summer, inferior to that of the human body, and consequently a loss o caloric is always going on which must be made up in some way, otherwise, disease and death would speedily ensue.

During the ordinary combustion of carbon or pure charcoal in the open air, the carbon combines with the oxygen of the atmosphere, and forms carbonic acid. During this process, heat is evolved with a rapidity proportioned to the intensity of the combustion. The very same changes occur during respiration, and the relation between the production of animal heat and the condition of the respiratory functions in all classes of animals is so direct and remarkable as to be admitted by every one, however divergent the theories may be by which the explanation of the phenomena is attempted. In general, other conditions being alike, the quantity of heat generated is in proportion to the size and vigour of the lungs; and, when these are impaired, its production is diminished. Hence many persons with imperfectly developed lungs, and a predisposition to consumption, complain habitually of coldness of the surface and feet; and many who were previously in good health, become more and more sensible to cold, in proportion as the approach of disease weakens the functions of the lungs. I have noticed this increased sensibility to cold, as a precursor of chronic pulmonary disease, both in myself and in others, before any other very obvious symptom had appeared, and think I have seen its farther progress arrested by the timely use of proper means, where much greater difficulty would have been experienced, had the warning not been attended to.

The generation of heat in the living system being so immediately connected with the lungs, we find the temperature highest in those animals which possess them in the greatest perfection, namely birds. In many species, the internal heat exceeds that of man by twenty or thirty degrees; while that of man exceeds, to as great an extent, the heat of such of the inferior animals as are remarkable for imperfect organs of respiration, till we arrive at last at the cold-blooded animals in which the respiratory functions are very feebly performed. Animal heat, then, is really the produce of a physiological combustion, and bears a direct relation to the intensity with which the carbon and oxygen are brought into combination.

There is still another point of analogy between the processes of combustion and respiration, to which, from its important practical consequences, I am anxious to direct the particular attention of the reader. On burning a given quantity of carbon or pure charcoal in a given quantity of air, *they invariably combine in the same proportions and form precisely the same amount of carbonic acid.* For the combustion of 12.7 grains of carbon, for example, 100 cubic inches of oxygen are required, and the result is always 100 inches of carbonic acid. If the portion of air in which the charcoal is burned contain only 75 cubic inches of oxygen, combustion will cease, and 3·2 grains of the carbon will remain unconsumed. If, again, the oxygen exceed 100 cubic inches, the whole of the carbon will be consumed, and the excess of oxygen remain behind. The relative quantities, in short, are