

grown as large as the glass globe that contained it. Several species of the carp kind, and especially the gold-fish, have a similar power; and even the pike, the most gluttonous, perhaps, of the whole class, will both live and thrive upon water alone in a marble basin.

The bee, and various other insects, derive their nutriment from the nectar and effluvia of flowers. So also does the trochilus genus, or humming-bird, which appears to be the connecting link between the two classes; buzzing like the bee itself with a joyous hum around the blossom on which it lights; and in one of its species, *t. minimus*, not exceeding it in size, and only weighing from 20 to 45 grains.

Air alone appears sufficient for the support of animals of other kinds. Snails and chameleons have been known repeatedly to live upon nothing else for years.\* Garman asserts that it is a sufficient food for spiders; and that though they will devour other food, as fishes will that may be maintained alone on water, they do not stand in need of any other. Latreille confirms this assertion to a considerable extent, by informing us that he stuck a spider to a piece of cork, and precluded it from communication with any thing else for four successive months, at the end of which time it appeared to be as lively as ever.† And Mr. Baker tells us, in the Philosophical Transactions, that he had a beetle that lived in a glass confinement for three years without food, and then fled away by accident.

The larvae of ants, as well as of several other insects of prey, are not only supported by air, but actually increase in bulk, and undergo their metamorphosis without any other nourishment. It is probable, also, that air is at times the only food of the scolopendra *phosphorea*, or luminous centipede, which has been seen illuminating the atmosphere, and sometimes falling into a ship, a thousand miles from land.

Amphibious animals have a peculiar tenacity to life under every circumstance of privation; and not only frogs and toads, but tortoises, lizards, and serpents are well known to have existed for months, and even years, without other food than water—in some instances, without other food than air.

Mr. Bruce kept two cerastes, or horned snakes, in a glass jar for two years, without giving them any thing. He did not observe that they slept in the winter-season; and they cast their skins, as usual, on the last day of April.‡

Lizards, and especially the newt species, have been found imbedded in a chalk-rock, apparently dead and fossilized, but have reassumed living action on exposure to the atmosphere.§ On their detection in this state the mouth is usually closed with a glutinous substance, and closed so tenaciously, that they often die of suffocation in the very effort to extricate themselves from this material.||

In respect to toads the same fact has been ascertained, for nearly two years, by way of experiment;¶ and has been verified, by accident, for a much longer term of time. The late Edward Walker, Esq., of Guestingthorpe, Essex, informed me, not long since, that he had found a toad perfectly alive in the midst of a full-grown elm, after it was cut down by his order, exactly occupying the cavity which it appeared gradually to have scooped out as it grew in size, and which had not the smallest external communication by any aperture that could be traced. And very explicit, and apparently very cautious, accounts have been repeatedly published in different journals, of their having been found alive, imbedded in the very middle of trunks of trees and blocks of marble, so large and massy, that, if the accounts be true, they must have been in such situations for at least a century.\*\* There is a very particular case of this kind given by M. Seigue, in the Memoirs of the Royal Academy of Paris.††

\* Encyclop. Brit. art. Physiol. p. 679.

† Voyages, Appendix, p. 296, 8vo. edit.

‡ Journal of Science, No. xii. p. 375.

§ See Davy's Introd. to his Translation of Spallanzani's Traacts, p. xliii. 1803.

\*\* See various instances, Encyclop. Brit. art. Physiol. p. 651.

†† Mem. 1731, H. 24. Dr. Edwards, of Paris, has sufficiently ascertained of late, that blocks of mortar

† Monthly Rev. Appx. Iv. 494.

§ Wilkinson, Tilloch's Phil. Mag. Dec. 1816.

These observations lead us to another anomaly of a more extraordinary nature still; and that is, the power which man himself possesses of existing without food, under certain circumstances, for a very long period of time. This is often found to take place in cases of madness, especially that of the melancholy kind, in which the patient resolutely refuses either to eat or drink for many weeks together, with little apparent loss either of bulk or strength.

There is a singular history of Cicely de Ridgeway, preserved among the Records in the Tower of London, which states, that in the reign of Edward III., having been condemned for the murder of her husband, she remained for forty days without either food or drink. This was ascribed to a miracle, and the king condescended in consequence to grant a pardon.

The Cambridgeshire farmer's wife, who, about twenty years ago, was buried under a snow-storm, continued ten or twelve days without tasting any thing but a little of the snow which covered her. But in various other cases we have proofs of abstinence from food having been carried much farther, and without serious evil. In the Edinburgh Medical Essays for 1720, Dr. Eccles makes mention of a beautiful young lady, "about sixteen years of age," who, in consequence of the sudden death of an indulgent father, was thrown into a state of tetanus, or rigidity of all the muscles of the body, and especially those of deglutition, so violent as to render her incapable of swallowing for two long and distinct periods of time; in the first instance for thirty-four, and in the second, which occurred shortly afterward, for fifty-four days; during "all which time, her first and second fastings, she declared," says Dr. Eccles, "she had no sense of hunger or thirst; and when they were over, she had not lost much of her flesh."

In our own day we have had nearly as striking an instance of this extraordinary fact, in the case of Ann Moore, of Tutbury, in Staffordshire, who, in consequence of a great and increasing difficulty in swallowing, at first limited herself to a very small daily portion of bread alone, and on March 17th, 1807, relinquished even this, allowing herself only occasionally a little tea or water, and in the ensuing September pretended to abstain altogether from liquids as well as solids. From the account of Mr. Granger,\* a medical practitioner of reputation, who saw her about two years afterward, she appears to have suffered very considerably, either from her abstinence or from that general morbid habit which induced her to use abstinence. He says, indeed, that her mental faculties were entire, her voice moderately strong, and that she could join in conversation without undergoing any apparent fatigue: but he says, also, that her pulse was feeble and slow; that she was altogether confined to her bed; that her limbs were extremely emaciated; that convulsions attacked her on so slight an excitement as surprise, and that she had then very lately lost the use of her lower limbs.

It afterward appeared, that in this account of herself she was guilty of some degree of imposition, in order to attract visitors, and obtain pecuniary grants. Dr. Henderson, another medical practitioner, of deserved repute in the neighbourhood, had suspected this, and published his suspicions:‡ and an

and heaps of sand are porous enough to admit so much air as is requisite to support the life of lizards, toads, and other amphibians of the batrachian family: but that they all perish if surrounded by mercury, or even water, so as to intercept the air by their being encompassed by an exhausted receiver. In boxes of mortar or sand, however, they live much longer than in boxes plunged under water. The probable cause is, that the air of the atmosphere pervades the pores of the sand or margin pretty freely; but that it is not extricated from the circumfluent water so as to pervade the pores of the box buried in it. This, however, is not the explanation offered by Dr. Edwards. He found also that frogs will live a longer or shorter period of time under water, according to the temperature of the water, and the previous temperature of the surrounding atmosphere. They die speedily if the water be lower than 32° Fahr. or higher than 108°: that the longest duration of life is at 32°, at which point life will continue for several hours; that its duration diminishes with the elevation of the scale above this point, and that it is extinguished in a few minutes at 108°.

The most favourable point in the temperature of the atmosphere is also 32°. If the season have maintained this point for some days antecedently to the frog's being plunged under water, itself of 32°, the animal will live from 24 to 60 hours. De l'Influence des Agens Physiques sur la Vie; also, Memoires sur l'Asphyxie, &c. 1817. Paris, 8vo. 1824.

\* Edinburgh Med. and Surg. Journal, No. xix. July, 1809, p. 319.

‡ An Examination of the Imposition of Ann Moore, called the Fasting Woman of Tutbury, &c. By Alexander Henderson, M.D. 8vo. 1813.

intelligent committee was at length arranged, and assented to by the woman herself, for the purpose of watching her by day and by night. Cut off hereby altogether from fluids, which she had of late pretended to relinquish, as well as from solids, she was hardly able to reach the tenth day, and still less to confess, as she then did, that she had occasionally been supplied by her daughter with water and tea. "On the whole," the committee conclude, in their account of her, "though this woman is a base impostor with respect to her pretence of total abstinence from all food whatever, liquid or solid, yet she can perhaps endure the privation of solid food longer than any other person. It is thought by those best acquainted with her, that she existed on a mere trifle, and that from hence came the temptation to say that she did not take any thing. If, therefore, any of her friends could have conveyed a bottle of water to her, unseen by the watch, and she could occasionally have drunk out of it, little doubt is entertained that she would have gone through the month's trial with credit. The daughter says that her mother's principal food is tea, and there is reason to believe this to be true."\* But this opinion leaves the case almost as extraordinary as before the detection of the fraud; for if true, and it is greatly borne out by the fact to which it appeals, this woman was capable of subsisting on what is ordinarily regarded as no nutriment whatever, and required nothing more for her support than an occasional draught of pure water.

Hildanus, Haller, and other physiologists have collected various instances of a similar kind: many of them of a much longer duration of abstinence; some of them, indeed, extending to not less than sixteen years; but in general too loosely written and attested to be entitled to full reliance. Yet the Philosophical Transactions in their different volumes contain numerous cases of the same kind, apparently drawn up with the most scrupulous caution, and supported by the best kind of concurrent evidence. In one of the earlier volumes† we meet with an account of four men who were compelled to subsist upon water alone for twenty-four days, in consequence of their having been buried in a deep excavation by the fall of a superincumbent stratum of earth under which they were working, and it being this length of time before they were extricated. The water which they drank of was from a spring at hand; and they drank of it freely, but tasted nothing else.

A still more extraordinary account is recorded in the same journal for the year 1742, and consists of the history of a young man, who, at the age of sixteen or seventeen, from having drunk very freely of cold water when in a violent perspiration, was thrown into an inflammatory fever, from which he escaped with difficulty, and with such a dislike to foods of all kinds, that for eighteen years, at the time this account was drawn up, he had never tasted any thing but water. The fact was well known throughout the neighbourhood; but an imposition having been suspected by several persons who saw him, he had been shut up at times in close confinement for twenty days at a trial, with the most scrupulous care that he should communicate with nothing but water. He uniformly enjoyed good health, and appears to have had ejections, but seldom.

A multitude of hypotheses have been offered to account for these wonderful anomalies, but none of them do it satisfactorily; and I should be unworthy of the confidence you repose in me, if I did not ingenuously confess my utter ignorance upon the subject. Water in most cases appears to have been absolutely necessary, yet not in all; for Hildanus, who, though somewhat imaginative, appears to have been an honest and an able man in the main, assures us, that Eva Flegen, who had fasted for sixteen years when he saw her in 1612, had abstained entirely from liquids as well as solids: and in the case of impacted toads, especially those found in blocks of closely crystallized marble, the moisture they receive must often be very insignificant.

\* A Full Exposure of Ann Moore, the pretended Fasting Woman of Tutbury, Svo. 1813. The newspapers have informed us that this poor woman died at Macclesfield about the beginning of October, 1825, at the advanced age of seventy-six.  
† Phil. Trans. 1684.

Perhaps one of the most singular cases, and at the same time one of the best authenticated on record, is that of Janet M'Leod, published in the Philosophical Transactions by Dr. Mackenzie.\* She was at this time thirty-three years of age, unmarried, and from the age of fifteen had had various paroxysms of epilepsy, which had considerably shaken her frame, rendered the elevator muscles of the eyelids paralytic, so that she could only see by lifting the lids up, and produced so rigid a locked jaw that her mouth could rarely be forced open by any contrivance. She had lost very nearly her power of speech and deglutition, and with this, all desire either to eat or drink. Her lower limbs were retracted towards her body she was entirely confined to her bed, slept much, and had seldom any other egestions than periodical discharges of blood, apparently from the lungs, which was chiefly thrown out by the nostrils. During a very few intervals of relaxation she prevailed upon with great difficulty to put a few crumbs of bread, comminuted in the hand, into her mouth, together with a little water sucked from her own hand, and in one or two instances a little gruel; but even at these attempts almost the whole was rejected. On two occasions also, after a total abstinence of many months, she made signs of wishing to drink some water, which was immediately procured for her. On the first occasion the whole seemed to be returned from her mouth; but she was greatly refreshed by having it rubbed upon her throat. On the second occasion, she drank off a pint at once, but could not be either prevailed upon or forced to drink any more, notwithstanding that her father had now fixed a wedge between her teeth, two of which were hereby broken out. With these exceptions, however, she seems to have passed upwards of four years without either liquids or solids of any kind, or even an appearance of swallowing. She lay for the most part like a log of wood, with a pulse scarcely perceptible from feebleness, but distinct and regular; her countenance was clear and pretty fresh; her features neither disfigured nor sunk; her bosom round and prominent, and her limbs not emaciated. Dr. Mackenzie watched her with occasional visits, for eight or nine years, at the close of which period she seems to have been a little improved. His narrative is very precisely as well as minutely detailed, and previously to its being sent to the Royal Society, was read over before the patient's parents, who were known to be persons of great honesty, as also before the elder of the parish, who appears to have been an excellent man; and, when sent, was accompanied by a certificate as to the general truth of the facts, signed by the minister of the parish, the sheriff-depute, and six other individuals of the neighbourhood, of high character, and most of them justices of the peace.

Yet even with the freest use of water, what can we make of such cases upon any chain of chemical facts at present discovered? What can we make of it, even in conjunction with the use of air? The weight and solid contents of the animal body are derived chiefly from that principle which modern chemists denominate carbon; yet neither water nor air, when in a state of purity, contains a particle of carbon. Again, the substance of the animal frame is distinguished from that of the vegetable by its being saturated with nitrogen, of which plants possesses comparatively but very little; yet though the basis of atmospherical air consists of nitrogen, water has no more of this principle than it has of carbon; nor is it hitherto by any means established, that even the nitrogen of the animal system is in any instance derived from the air, or introduced by the process of respiration: for the experiments upon this subject, so far as they go, are in a state of opposition, and keep the question on a balance—*factis contraria facta*.

Shall we, then, suppose with others, that the circle of perpetual mutation, which is imposed upon every other species of visible matter, is in these cases suspended, and that the different organs of the system are, so long as the anomaly continues, rendered incorruptible? But this is to suppose the intervention of a miracle, and without an adequate cause. Let us, then, rather con-

\* Vol. lxvii. year 1777.

less our ignorance than attempt to be wise upon the basis of conceit. All that we do know is, that bodies of every kind are reducible to a few elementary principles, which appear to be unchangeable, and are certainly invisible; and that from different combinations and modifications of these proceeds every concrete and visible form: hence, air itself, and water; hence mineral, vegetable, and animal substances. Air, therefore, and water, or either separately, may contain the rudimental materials of all the rest. We behold metallic stones, and of large magnitude, fall from the air, and we suppose them to be formed there: we behold plants suspended in the atmosphere, and still, year after year, thriving and blooming, and diffusing odours: we behold insects apparently sustained from the same source; and worms, fishes, and occasionally man himself, supported from the one or the other, or from both. These are facts, and as facts alone we must receive them, for we have at present no means of reasoning upon them. There are innumerable mysteries in matter as well as in mind; and we are not yet acquainted with the nature of those elementary principles from which every compound proceeds, and to which every thing is reducible. We are equally ignorant of their shapes, their weight, or their measure.

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### LECTURE XIII.

#### ON THE CIRCULATION OF THE BLOOD, RESPIRATION, AND ANIMALIZATION.

The progress of science is slow, and often imperceptible; and though in a few instances it has been quickened by an accidental discovery or an accidental idea, that has given a new turn, or a new elasticity to the chain of our reasoning, still have we been compelled in every instance to follow up the chain, link after link, and series after series, and have never leaped forward through an intermediate space without endangering our security, or being obliged to retrace our career by a painful and laborious reinvestigation.

It required a period of three thousand six hundred years to render the doctrine of a vacuum probable, and of five thousand six hundred to establish it upon a solid foundation. For its probability we are indebted to Epicurus, for its certainty to Sir Isaac Newton. The present theory of the solar system was commenced by Pythagoras and his disciples five centuries before Christ, and only completed by Copernicus fifteen centuries after Christ. Archimedes was the first who invented the celebrated problem for squaring the parabola, which was upwards of two hundred years before the Christian era; yet an exact problem for squaring the circle is a desideratum in the present day. The simple knowledge of the magnet was familiar to the Romans, Greeks, and some of the oriental nations while in their infancy; it has been employed by the mariner for nearly six centuries in Europe, and for a much longer period by the Chinese, in their own seas; yet at this moment we are acquainted with only a very few of its laws, and have never been able to appropriate it to any other purpose than that of the compass.

The circulation of the blood in the animal system is our subject of study for the present lecture, and it is a subject which has laboured under the same difficulties, and has required as long a period of time as almost any of the preceding sciences, for its complete illustration and establishment. Hippocrates guessed at it; Aristotle believed it; Servetus, who was burnt as a heretic in 1553, taught it; and Harvey, a century afterward, demonstrated it.

I shall not here enter into the various steps by which this wonderful discovery was at length effected; the difficulty can be only fairly appreciated by those who are acquainted with the infinitely minute tubes into which the distributive arteries branch out, and from which the collective veins arise; but every one is interested in the important fact itself, for it has done more

towards establishing the healing art upon a rational basis, and subjecting the different diseases of mankind to a successful mode of practice, than any other discovery that has emblazoned the annals of medicine.

In our last lecture we traced the action of the digestive organs: we beheld the food first comminuted by means of jaws, teeth, or peculiar muscles or membranes; next converted into a pulpy mass, and afterward into a milky liquid; and in this state drunk up by the mouths of innumerable minute vessels, that progressively unite into one common trunk, and convey it to the heart as the chief organ of the system, for the use and benefit of the whole.

But the new-formed fluid, even at the time it has reached the heart, has by no means undergone a sufficient elaboration to become genuine blood, or to support the living action of the different organs. It has yet to be operated upon by the air, and must for this purpose be sent to the lungs, and again returned to the heart, before it is fitted to be thrown into the general circulation.

This is the rule that takes place in all the more perfect animals, as mammals, birds, and most of the amphibials;\* and hence these classes are said to have a double circulation. And as the heart itself consists of four cavities, a pair belonging to each of the two circulations, and each pair is divided from the other by a strong membrane, they are also said to have not only a double circulation, but a double heart—a pulmonary and a corporeal heart.

The blood is first received into the heart on the pulmonary side, and is conveyed to the lungs by an artery which is hence called the pulmonary artery, that soon divides into two branches, one for each of the lungs; in which organs they still farther divide into innumerable ramifications, and form a beautiful network of vessels upon the air vesicles of which the substance of the lungs consists; and by this means every particle of blood is exposed in its turn to the full influence of the vital gases of the atmosphere, and becomes thoroughly assimilated to the nature of the animal system it is to support. The invisibly minute arteries now terminate in equally minute veins, which progressively unite till they centre in four common trunks, which carry back the blood, now thoroughly ventilated and of a florid hue, to the left side or corporeal department of the heart.

From this quarter the corporeal circulation commences: the stimulus of the blood itself excites the heart to that alternate contraction which constitutes pulsation, and which is continued through the whole course of the arteries; and by this very contraction the blood is impelled to the remotest part of the body, the arterial vessels continuing to divide and to subdivide, and to branch out in every possible direction, till the eye can no longer follow them, even when aided by the best glasses.

The arterial blood having thus visited every portion of every organ, and supplied it with the food of life, is now returned, faint, exhausted, and of a purple hue, by the veins, as in the pulmonary circulation; it receives, a short space before it reaches the heart, its regular recruit of new matter from the digestive organs, and then empties itself into the right side or pulmonary department of the heart, whence it is again sent to the lungs, as before, for a new supply of vital power.

The circulation of the blood, therefore, depends upon two distinct sets of vessels, arteries and veins; the former of which carry it forward to every part of the system, and the latter of which return it to its central source. Both sets of vessels are generally considered as consisting of three distinct layers or tunics: an external, which in the arteries is peculiarly elastic; a middle, which is muscular in both, but whose existence is doubted by some physiologists; and an internal, which may be regarded as the common covering or cuticle. The projectile power exercised over the arteries is unquestionably the contraction to which the muscular tunic of the heart is excited by

\* Cuvier seems to ascribe a double heart to the class of amphibia, without any limitation. See Lawrence's additional note E, chap. xii. of his translation of Blumenbach's System of Comparative Anatomy. Blumenbach himself has remarked, that many of the frogs, lizards, and serpents have a simple heart, consisting of a single auricle and ventricle, like that of fishes.—Sect. 163.