PART II.

DISSERTATIONS ON HEALTH.

DISSERTATION IV.

NATURAL CAUSES CONTINUED.

MALARIA, AND MARSH MIASMATA.

THE natural state of the two great elements, air and water, is motion. Motion is as essential to the purity of both, as circulation is to the blood and exercise to the human body. In this state air and water are kept from impregnation with foreign matters, both having a power of self-preservation which they do not possess in an equal degree when in a quiescent or stagnant condition. Where water does not gurgle from a fountain, foam in a cascade, or run in a stream, certain saline particles are added to it in order to preserve it from change; but even this would scarcely be sufficient were it not for the perpetual motion and frequent storms which are seen on the face of the troubled ocean. Thus the very means which the great Author of our being employs for the purity of the water of the ocean, have also the effect of preserving the air from corruption. When air and water are in a quiescent state, a third great element, caloric, exerts its powers with greater effect: the water, being partly evaporated, rises into the atmosphere during the day, but in the evening, as the sun has declined in power, this vapour falls again upon the earth in the form of dew, as the air, when condensed by cold, has no longer the power of retaining the same quantity of water. When this vapour descends it does not always fall immediately upon the earth, but is often suspended, in the evenings especially, in the form of fog. The cause of this is, that the earth, retaining a considerable portion of that heat imparted to it during the day, continues to evaporate water for some time after the sun's rays are withdrawn.

The vapours thus exhaled by the earth's heat are no longer capable of rising high into the atmosphere for the reasons already stated, but the ascending vapours meeting the descending, both are for a time suspended near the earth's surface. Something of the same kind happens in the mornings during certain states of atmosphere, till the force of the sun's rays again dissipates the vapours near the earth's surface, and, rarifying the air, thus enables it to retain more moisture.

Fog, then, is merely a visible aggregate of minute drops of water suspended in the atmosphere. The same aggregate which in this situation obtains the name of fog or mist, is called cloud in the higher regions of the atmosphere, but it is concluded, from numerous observations, that the particles of which a cloud consists are always more or less electrified. This is the common effect produced by heat or caloric on water, and we have explained the reason why all exhalations from the earth's surface become generally more dangerous to health in the evenings and mornings.

If the air, during this change, be in a quiescent state, it will very soon become saturated with moisture; but if it be in motion, the same thing does not happen, because the air, before it becomes saturated, is carried away, and is constantly succeeded by that which is dryer. It is in this way that wind acts in drying moist bodies so much better than stagnant air. The same thing explains why calm weather in certain situations proves injurious to health.

Water during evaporation carries off a proportion of caloric from whatever body it is raised, but this abstraction of caloric, like the process we have just explained, is dependant on the atmosphere, for if it be at the time in a state of rest, much less water will be evaporated, and, of course, less heat be abstracted.

The influence of evaporation in cooling bodies, or, which is the same thing, abstracting caloric from them, has been long known. Wine is cooled by suspending the bottles containing it in bags, and throwing water over them from time to time. The houses in India are kept comparatively cool by evaporation artificially produced. Some fluids may be frozen by the evaporation of other fluids, and death itself may be induced by similar means.

But, besides this influence on the temperature of bodies, evaporation acts an important part in other points of view. Vapour is the cause of clouds, rain, and dew, all of which purify the atmosphere even mechanically, but by promoting vegetation they impregnate the atmosphere in various ways; in particular, odoriferous, volatile, and aromatic substances are separated from herbs and plants, and a due supply of oxygen, or vital air is afforded. Heat, then, is the cause of cold; difference of temperature in places produces perflation in the air; and motion of the air will be followed by motion in the water also. Thus the two great elements, air and water, are kept in a healthy condition, partly by the agency of a third—caloric.

Hitherto we have confined our observations to the ordinary operation of the elements on each other. Other effects of the combined operation of air, water, and caloric, must now come into view. These three agents act a principal part in supporting and maintaining animal and vegetable life: but as life is the cause of death, and the end of both animals and plants is made to depend upon their beginning, so the very same agents operate in inducing disease, death, and decay, in all organised matter. This decay, or decomposition of dead organised matter, is known by the general term *putrefaction*, in promoting which, air, moisture, and caloric, are the principal agents. But death and decay of organised matter make

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way for new and vigorous life, nay, are the direct means of a succeeding growth, maturity and death. For the putrefying vegetable becomes the food and nourishment of the living, and this in its turn yields subsistence to the animal kingdom. In short, in the whole circle of the natural world we never witness a single instance of destruction or annihilation.

It is plain, however, that this important process of decay, or putrefaction, must be kept within certain bounds. For, if all animals and vegetables were to live the same length of time, or die at the same age, or if the process of after-decay, or putrefaction, had been regulated exactly by the same laws in all of them, instead of it yeilding nourishment, and giving vigour to living animals and plants, putrefaction must have been the cause of instant death to all living organised matter. Such a degree of corruption would have been inconsistent with life of any kind. Fortunately, however, this danger has been wisely guarded against by Nature.

As the air acts upon the water, the water upon the air, and caloric upon both, by certain fixed and unalterable laws only, so the process of decay in dead organised matter is regulated and restrained within bounds, beyond which it cannot pass.

Perhaps no subject which man is capable of conceiving is more worthy of his admiration and his praise.

It is generally admitted that no substances are capable of putrefaction but such as have been elaborated by the principles of animal and vegetable life. All the agents employed by Nature in the process are perhaps not yet known, but heat, moisture, air, and rest or stagnation, are all essential for this purpose. Certain modifications or degrees of these, according with the different inherent properties of the different animal and vegetable substances opposed to their operation, will undoubtedly decompose dead organised matter, of whatever kind. The mode in which these different agents operate now fall to be explained. All bodies in nature, whether living or dead, are subject to the action of two opposite forces, the natural attraction of their particles on the one hand, and the repulsive power of caloric on the other. So that bodies exist in the solid, liquid, or gaseous state as one or other of these forces prevail. Certain counteracting causes, therefore, operate in retarding putrefaction. Where the attraction subsisting between the particles or component parts of any body is very powerful, of course the repulsive power of caloric will have less effect, and the substances will go slower into putrefaction. On the other hand, when air or water, or their elementary principles happen to possess a stronger attraction for some of the elementary principles of the dead organised matter, than the elements composing them have amongst themselves, the repulsive power of caloric may not be so necessary to promote their separation, in other words, the decomposition. In this way the agency of heat, air, and moisture, in promoting putrefaction, is partly explained.

The effect of rest or stagnation in this process is easily understood, for bodies of different natures not only require to be in close contact for some time before they can act effectually on each other, so as to produce a chemical change, but they must remain sometimes in the due proportions required, otherwise no change in their component parts can take place. When the two agents, air and water, are in motion, the temperature, to say nothing of the arrangement of particles in the dead organised matter, must necessarily undergo perpetual change. Another effect of stagnant water or air falls to be noticed.

The products of putrefaction, in other words the elementary parts of dead organized matter, are not let loose when separated from each other, as some people imagine, to corrupt the air and water.

Under ordinary circumstances these products, whether in a gaseous or other state, soon enter into new combinations, which are hurtful to neither air nor water; both being protected from such change by laws of their own. Those products of putrefaction which cannot find new combinations on the spot where they are separated, are carried by the wind and water to other places more favourable for new formations. In this way the whole may soon be taken up. Where the air and water are in a state of rest however, it may so happen that a greater quantity of the elements of dead organized matter may be disengaged by the process of putrefaction in a place than what can find a new alliance in that particular spot; and these products, not having the advantage of either air or water in a state of motion to convey them to other situations more favourable for this purpose, may thus corrupt both the stagnant air and water in that particular locality to such a degree, as to prove hurtful to animal and even vegetable life.

Heat acts in promoting putrefaction as it does in other instances, by lessening the force of attraction subsisting between the elementary particles of dead organized matter subjected to its operation; but in some cases this repulsive power of caloric will not be sufficient; for unless other substances be present to exert their attraction for the elementary or component parts of the dead mass at the same time, decomposition will not begin. On this principle we can readily understand why putrefaction may sometimes be retarded, even where air and water are in a stagnant state. In this last instance too, we are furnished with an explanation why, in some instances, both air and water may remain at rest for a length of time without becoming contaminated or proving injurious to animal life. In tropical climates, where vegetation is more luxuriant, and of course its decomposition attended with greater hazard of the accumulation of putrid particles in air and water, Nature employs stronger means of dispersion. In these regions the dews are like showers of rain; the rain like torrents; the rivers like seas; and the storms, tornadoes or hurricanes.

Thus far we have regarded water chiefly as a vehicle or transporter of dead organized matter. Its influence in promoting putrefaction falls now to be considered.

Animals and plants, when deprived of the living principle, may be preserved from decomposition in an high or low temperature of air. Flesh and fish are preserved by northern nations during Winter, by packing them in snow, without the aid of other means. This seems to be effected in consequence of the freezing of the humidity they contain, thereby preventing its decomposition and the consequent re-action of its principles on the component parts of those matters.

On the other hand, the rapid extraction of humidity from inert animal and vegetable substances by means of heat will have the same effect, of which many familiar instances might be given; and in this way the bodies of men and animals that have perished in crossing the deserts of Africa have been discovered in their natural appearance after a lapse of many years. From these observations, it would appear that the moisture contained in the remains of organized matters is the chief cause of their decomposition; this is further illustrated by the fact, that the decay of such matters immediately commences, if after having been frozen they are again thawed and exposed to a temperature but a few degrees above 32°, or when the necessary portion of water is added to such as have been dried by means of an high degree of heat. Matters preserved by drying may be transported to any other climate without undergoing any decomposition, providing they be carefully preserved from the action of the air, or insects. This may easily be effected by means of varnish.* Bodies preserved in a low tempe-

* In 1812, a young surgeon carried to sea the lower extremity of a man which had been prepared in this way in London, the leg being inclosed in a box which was put under his bed-place in his cabin. No smell was perceptible so long as the ship remained in England. On her proceeding to Lisbon, however, the doctor's secret treasure could no longer be concealed, and a ludicrous exposé took place; but permission having been obtained to have it up in the main top, the doctor had still hopes of saving it. When it became dark, not a sailor could be found who had courage to ascend the rigging, though grog in liberal quantities was offered. The leg had, therefore, to be thrown overboard.

rature can only be kept in an atmosphere below the freezing point. The quantity of moisture present is likewise a matter of great consequence in the process of putrefaction; for, in many instances, too much retards it. Animal bodies decay slower in a wet than in a dry grave; and, when a dead body is immersed in water, it is converted into a substance something between wax and fat, hence called adipocire.

Although water, therefore, in a certain portion is necessary to promote putrefaction both in animal and vegetable matters, its superabundance is found to be equally powerful in preventing and restraining this process, as when it is contained in a diminished quantity. Sir John Pringle and Dr. Macbride ascertained, by experiment, that small quantities of sea salt promote the putrefactive process; this circumstance, perhaps, admits of explanation, from the great affinity for water that subsists in the impurities with which culinary salt is always mixed, the necessary quantity of this fluid being imbibed from the atmosphere. All matters that have a strong affinity for water, as acids, alkalies, sugar, and ardent spirits, hinder putrefaction, probably by being dissolved in the humidity contained in the dead organized matter, and preventing its decomposition, although they may form new combinations with some of the other inherent principles of dead matter at the same time.

It has not been determined what precise changes the atmosphere undergoes in putrefaction; but the powerful influence it exerts in the process cannot be doubted.

The temperature must be considerably above the freezing point (32 degrees,) but vegetables seem to require a higher temperature than animal remains; and in either case, as before said, it is necessary it should not be so great as to cause the rapid evaporation of their humidity.

Such is a concise view of the general principles by which putrefaction is regulated. What has been said is at least sufficient to demonstrate that this important process is not left to chance, but is restrained within due bounds by the very agents which Nature employs in other circumstances to promote it. Heat promotes putrefaction, but heat also arrests its progress. Moisture promotes it, but moisture will also retard its progress. Air is necessary, but air in a state of motion is the most powerful instrument used in the prevention of the bad effects which would otherwise result from it.

The injury that would arise from the superabundance of putrid particles in the atmosphere, is prevented by other means.

Some plants come to maturity at one season, some at another, although the greatest number begins to decline in Autumn. The Winter succeeds, and hinders putrefaction from going beyond its proper limits. When it is Autumn, or the season of the greatest decay in one country, it is Winter in another. In this way dead matters undergo decomposition only in some parts of the globe at the same time, and even in the same places at different times.

The mode in which dead matters decay is not less variable.

The leaves of trees decay in a different manner from the bark, stem, or roots; the rotting of all these matters is different from that of wheat-straw. "Were the leaves when they fall," Dwight* properly remarks, "to go through the same process of fermentation and putrefaction as other vegetables, the atmosphere would be rendered so unwholesome, that it would be impossible for man either to inhabit or to clear a forested country. But the juices are exhaled before the leaves fall; they lie lightly on the ground, so as to permit a free circulation of air. So far from being offensive in their decay, they have even a peculiar fragrance, which poets have sometimes noticed among the melancholy charms of Autumn."

"The mould into which they are converted appears to be best of all manures, being united to more kinds, and producing higher degrees of vegetation than any other.

* Dwight's Travels in New England.

"This last observation accords with the experiments of Berthollet, who has shewn that, whenever the soil becomes charged with such matter, the oxygen of the atmosphere combines with it and converts it into carbonic acid gas.

"The consequence is, that the same carbon is absorbed by other vegetables, which it clothes with new foliage; these in their turn decay, and thus dissolution and renovation go on to the end of time."

During the decomposition of many vegetable substances, new products are formed, which possess properties inimical to putrefaction; salt, sugar, vinous and spirituous liquids, and acids, furnish examples of this kind; they are all powerful antiseptics, and are employed to preserve other substances from decomposition. What is still more surprising is, that the very same matters produce sugar at one stage of fermentation, wine at another, and vinegar or acetous acid at a third, according as the process is regulated with regard to heat, rest, and time.

Peat-moss is another instance of the same kind. This substance, which is only found in cold or temperate regions, is allowed on all hands to be derived from vegetable matter.

The reason why it is never found in warmer latitudes is, that the higher temperature of tropical countries promotes speedy decay, and thus prevents the necessary accumulation. It has been observed that one of the great defects of this substance as a soil is, that it is either too wet or too dry. The same property in some measure may account for its not being subject to putrefaction; but, besides this, it is known to possess peculiar antiseptic qualities which not only preserve trees and some other vegetable, but animal substances from decomposition.

Mr. Aiton, in his Treatise on Moss Earth, gives many instances of large trees having been dug out of mosses many feet deep. Some of these were afterwards used by the farmers in Scotland for roofing and flooring their houses—no small proof of their preservation, although they must have been buried for many centuries under this singular substance,