ANIMAL AND VEGETABLE PHYSIOLOGY.

PART II.

THE VITAL FUNCTIONS.

CHAPTER I.

OBJECTS OF NUTRITION.

THE mechanical structure and properties of the organized fabric, which have occupied our attention in the preceding volume, are necessary for the maintenance of life, and the exercise of the vital powers. But however artificially that fabric may have been constructed, and however admirable the skill and the foresight that have been displayed in ensuring the safety of its elaborate mechanism, and in preserving the harmony of its complicated movements, it yet of necessity contains within itself the elements of its own dissolution. The animal machine, in common with

every other mechanical contrivance, is subject to wear and deteriorate by constant use. Not only in the greater movements of the limbs, but also in the more delicate actions of the internal organs, we may trace the operation of many causes inevitably leading to their ultimate destruction. Continued friction must necessarily occasion a loss of substance in the harder parts of the frame, and evaporation is constantly tending to exhaust the fluids. The repeated actions of the muscles induce certain changes in these organs, both in their mechanical properties and chemical composition, which impair their powers of contraction, and which, if suffered to continue, would, in no long time, render them incapable of exercising their proper functions; and the same observation applies also to the nerves, and to all the other systems of organs. Provision must accordingly be made for remedying these constant causes of decay by the supply of those peculiar materials, which the organs require for recruiting their declining energies.

It is obvious that the developement of the organs, and general growth of the body, must imply the continual addition of new particles from foreign sources. Organic increase consists not in the mere expansion of a texture previously condensed, and the filling up of its interstices by inorganic matter; but the new materials that are added must, for this purpose, be incorporated with those which previously existed, and become

identified with the living substance. Thus we often find structures forming in the bodies of animals of a nature totally different from that of the part from which they arise.

In addition to these demands, a store of materials is also wanted for the reparation of occasional injuries, to which, in the course of its long career, the body is unavoidably exposed. Like a ship fitted out for a long voyage, and fortified against the various dangers of tempests, of icebergs, and of shoals, the animal system, when launched into existence, should be provided with a store of such materials as may be wanted for the repair of accidental losses, and should also contain within itself the latent source of those energies, which may be called into action when demanded by the exigencies of the occasion.

Any one of the circumstances above enumerated would of itself be sufficient to establish the necessity of supplies of nourishment for the maintenance of life. But there are other considerations, equally important in a physiological point of view, and derived from the essential nature of organization, which also produce a continual demand for these supplies; and these I shall now endeavour briefly to explain.

Constant and progressive change appears to be one of the leading characteristics of life; and the materials which are to be endowed with vitality must therefore be selected and arranged with a view to their continual modification, cor-

responding to these ever varying changes of condition. The artificer, whose aim is to construct a machine for permanent use, and to secure it as much as possible from the deterioration arising from friction or other cases of injury, would, of course, make choice for that purpose of the most hard and durable materials, such as the metals, or the denser stones. In constructing a watch, for instance, he would form the wheels of brass, the spring and the barrel-chain of steel; and for the pivot, where the motion is to be incessant, he would employ the hardest of all materials,—the diamond. Such a machine, once finished, being exempt from almost every natural cause of decay, might remain for an indefinite period in the same state. Far different are the objects which must be had in view in the formation of organized structures. In order that these may be qualified for exercising the functions of life, they must be capable of continual alterations, displacements, and adjustments, varying perpetually, both in kind and in degree, according to the progressive stages of their internal developement, and to the different circumstances which may arise in their external condition. The materials which nature has employed in their construction, are, therefore, neither the elementary bodies, nor even their simpler and more permanent combinations; but such of their compounds as are of a more plastic nature, and which allow of a variable

proportion of ingredients, and of great diversity in the modes of their combination. So great is the complexity of these arrangements, that although chemistry is fully competent to the analysis of organized substances into their ultimate elements, no human art is adequate to effect their reunion in the same state as that in which they had existed in those substances; for it was by the refined operations of vitality, the only power that could produce this adjustment, that they have been brought into that condition.

We may take as an example one of the simplest of organic products, namely *Sugar;* a substance which has been analysed with the greatest accuracy by modern chemists: yet to reproduce this sugar, by the artificial combination of its simple elements, is a problem that has hitherto baffled all the efforts of philosophy. Chemistry, notwithstanding the proud rank it justly holds among the physical sciences, and the noble discoveries with which it has enriched the arts; notwithstanding it has unveiled to us many of the secret operations of nature, and placed in our hands some of her most powerful instruments for acting upon matter; and notwithstanding it is armed with full powers to destroy, cannot, in any one organic product, rejoin that which has been once dissevered. Through the medium of chemistry we are enabled, perhaps, to form some estimate of the value of what we find executed by other

agencies; but the imitation of the model, even in the smallest part, is far beyond our power. No means which the laboratory can supply, no process, which the most inventive chemist can devise, have ever yet approached those delicate and refined operations which nature silently conducts in the organized texture of living plants and animals.

The elements of organic substances are not very numerous; the principal of them being oxygen, carbon, hydrogen, nitrogen, sulphur, and phosphorus, together with a few of the alkaline, earthy, and metallic bases. These substances are variously united, so as to form certain specific compounds, which, although they are susceptible, in different instances, of endless modifications, yet possess such a general character of uniformity, as to allow of their being arranged in certain classes; the most characteristic substance in each class constituting what is called a *proximate organic principle*. Thus in the vegetable kingdom we have *Lignin*, *Tannin*, *Mucilage*, *Oil*, *Sugar*, *Fecula*, &c. The animal kingdom, in like manner, furnishes *Gelatin*, *Albumen*, *Fibrin*, *Mucus*, *Entomoline*, *Elearin*, *Stearin*, and many others.

The chemical constitution of these organic products, formed, as they are, of but few primary elements, is strikingly contrasted with that of the bodies belonging to the mineral

kingdom. The catalogue of elementary, or simple bodies, existing in nature, is, indeed, more extensive than the list of those which enter into the composition of animal or vegetable substances. But in the mineral world they occur in simpler combinations, resolvable, for the most part, into a few definite ingredients, which rarely comprise more than two or three elements. In organized products, on the other hand, although the total number of existing elements may be smaller, yet the mode of combination in each separate compound is infinitely more complex, and presents incalculable diversity. Simple binary compounds are rarely ever met with; but, in place of these, we find three, four, five, or even a greater number of constituent elements existing in very complicated states of union.

This peculiar mode of combination gives rise to a remarkable condition, which attaches to the chemical properties of organic compounds. The attractive forces, by which their several ingredients are held together, being very numerous, require to be much more nicely balanced, in order to retain them in combination. Slight causes are sufficient to disturb, or even overset, this equipoise of affinities, and often produce rapid changes of form, or even complete decomposition. The principles, thus retained in a kind of forced union, have a constant tendency

to react upon one another, and to produce, from slight variations of circumstances, a totally new order of combinations. Thus a degree of heat, which would occasion no change in most mineral substances, will at once effect the complete disunion of the elements of an animal or vegetable body. Organic substances are, in like manner, unable to resist the slower, but equally destructive agency of water and atmospheric air; and they are also liable to various spontaneous changes, such as those constituting fermentation and putrefaction, which occur when their vitality is extinct, and when they are consequently abandoned to the uncontrolled operation of their natural chemical affinities. This tendency to decomposition may, indeed, be regarded as inherent in all organized substances, and as requiring for its counteraction, in the living system, that perpetual renovation of materials which is supplied by the powers of nutrition.

It would appear that during the continuance of life, the progress of decay is arrested at its very commencement; and that the particles, which first undergo changes unfitting them for the exercise of their functions, and which, if suffered to remain, would accelerate the destruction of the adjoining parts, are immediately removed, and their place supplied by particles that have been modified for that purpose, and which, when they afterwards lose these salutary pro-

perties, are in their turn discarded and replaced by others. Hence the continued interchange and renewal of particles which take place in the more active organs of the system, especially in the higher classes of animals. In the fabric of those animals which possess an extensive system of circulating and absorbing vessels, the changes that are effected are so considerable and so rapid, that even in the densest textures, such as the bones, scarcely any portion of the substance which originally composed them is permanently retained in their structure. To so great an extent is this renovation of materials carried on in the human system, that doubts may very reasonably be entertained as to the identity of any portion of the body after the lapse of a certain time. The period assigned by the ancients for this entire change of the substance of the body was seven or eight years: but modern inquiries, which show us the rapid reparation that takes place in injured parts, and the quick renewal of the bones themselves, tend to prove that even a shorter time than this is adequate to the complete renovation of every portion of the living fabric.*

Imperfect as is our knowledge of organic chemistry, we see enough to convince us that a

* See the article "AGE" in the Cyclopædia of Practical Medicine, where I have enlarged upon this subject.

series of the most refined and artificial operations is required in order to bring about the complicated and elaborate arrangements of elements which constitute both animal and vegetable products. Thus in the very outset of this, as of every other inquiry in Physiology, we meet with evidences of profound intention and consummate art, infinitely surpassing not only the power and resources, but even the imagination of man.

Much as the elaborate and harmonious mechanism of an animal body is fitted to excite our admiration, there can be no doubt that a more extended knowledge of that series of subtle processes, consisting of chemical combinations and decompositions which are continually going on in the organic laboratory of living beings, would reveal still greater wonders, and would fill us with a more fervent admiration of the infinite art and prescience which are even now manifested to us in every department both of the vegetable and animal economy.

The processes by which all these important purposes are fulfilled comprise a distinct class of functions, the final object of which may be termed *Nutrition*, that is, the reparation of the waste of the substance of the organs, their maintenance in the state fitting them for the exercise of their respective offices, and the application of properly prepared materials to their developement and growth.