SECTION III.

REVIEW OF THE PREVIOUS RESEARCHES—THE FORMATIVE PROCESS OF CELLS—THE CELL THEORY.

The two foregoing sections of this work have been devoted to a detailed investigation of the formation of the different tissues from cells, to the mode in which these cells are developed, and to a comparison of the different cells with one another. We must now lay aside detail, take a more extended view of these researches, and grasp the subject in its more intimate relations. The principal object of our investigation was to prove the accordance of the elementary parts of animals with the cells of plants. But the expression "plant-like life" (pflanzen-ähnliches Leben) is so ambiguous that it is received as almost synonymous with growth without vessels; and it was, therefore, explained at page 6 that in order to prove this accordance, the elementary particles of animals and plants must be shown to be products of the same formative powers, because the phenomena attending their development are similar; that all elementary particles of animals and plants are formed upon a common principle. Having traced the formation of the separate tissues, we can more readily comprehend the object to be attained by this comparison of the different elementary particles with one another, a subject on which we must dwell a little, not only because it is the fundamental idea of these researches, but because all physiological deductions depend upon a correct apprehension of this principle.

When organic nature, animals and plants, is regarded as a Whole, in contradistinction to the inorganic kingdom, we do not find that all organisms and all their separate organs are compact masses, but that they are composed of innumerable small particles of a definite form. These elementary particles, however, are subject to the most extraordinary diversity of figure, especially in animals; in plants they are, for the most part or exclusively, cells. This variety in the elementary parts seemed to hold some relation to their more diversified physiological function in animals, so that it might be established as a principle, that every diversity in the physiological signification of an organ requires a difference in its elementary particles; and, on the contrary, the similarity of two elementary particles seemed to justify the conclusion that they were physiologically similar. It was natural that among the very different forms presented by the elementary particles, there should be some more or less alike, and that they might be divided, according to their similarity of figure, into fibres, which compose the great mass of the bodies of animals, into cells, tubes, globules, &c. The division was, of course, only one of natural history, not expressive of any physiological idea, and just as a primitive muscular fibre, for example, might seem to differ from one of areolar tissue, or all fibres from cells, so would there be in like manner a difference, however gradually marked between the different kinds of cells. It seemed as if the organism arranged the molecules in the definite forms exhibited by its different elementary particles, in the way required by its physiological function. It might be expected that there would be a definite mode of development for each separate kind of elementary structure, and that it would be similar in those structures which were physiologically identical, and such a mode of development was, indeed, already more or less perfectly known with regard to muscular fibres, blood-corpuscles, the ovum (see the Supplement), and epithelium-cells. The only process common to all of them, however, seemed to be the expansion of their elementary particles after they had once assumed their proper form. The manner in which their different elementary particles were first formed appeared to vary very much. In muscular fibres they were globules, which were placed together in rows, and coalesced to form a fibre, whose growth proceeded in the direction of its length. In the blood-corpuscles it was a globule, around which a vesicle was formed, and continued to grow; in the case of the ovum, it was a globule, around which a vesicle was developed and continued to grow, and around his again a second vesicle was formed.

The formative process of the cells of plants was clearly explained by the researches of Schleiden, and appeared to be the same in all vegetable cells. So that when plants were regarded as something special, as quite distinct from the animal kingdom, one universal principle of development was observed in all the elementary particles of the vegetable organism, and physiological deductions might be drawn from it with regard to the independent vitality of the individual cells of plants, &c. But when the elementary particles of animals and plants were considered from a common point, the vegetable cells seemed to be merely a separate species, co-ordinate with the different species of animal cells, just as the entire class of cells was co-ordinate with the fibres, &c., and the uniform principle of development in vegetable cells might be explained by the slight physiological difference of their elementary particles.

The object, then, of the present investigation was to show, that the mode in which the molecules composing the elementary particles of organisms are combined does not vary according to the physiological signification of those particles, but that they are everywhere arranged according to the same laws; so that whether a muscular fibre, a nerve-tube, an ovum, or a blood-corpuscle is to be formed, a corpuscle of a certain form, subject only to some modifications, a cell-nucleus, is universally generated in the first instance; around this corpuscle a cell is developed, and it is the changes which one or more of these cells undergo that determine the subsequent forms of the elementary particles; in short, that there is one common principle of development for all the elementary particles of organisms.

In order to establish this point it was necessary to trace the progress of development in two given elementary parts, physiologically dissimilar, and to compare them with one another. If these not only completely agreed in growth, but in their mode of generation also, the principle was established that elementary parts, quite distinct in a physiological sense, may be developed according to the same laws. This was the theme of the first section of this work. The course of development of the cells of cartilage and of the cells of the chorda dorsalis was compared with that of vegetable cells. Were the cells of plants developed merely as infinitely minute vesicles which progressively expand, were the circumstances of their development less characteristic than those pointed out by Schleiden, a comparison, in the sense here required, would scarcely have been possible. We endeavoured to prove in the first section that the complicated process of development in the cells of plants recurs in those of cartilage and of the chorda dorsalis. We remarked the similarity in the formation of the cell-nucleus, and of its nucleolus in all its modifications, with the nucleus of vegetable cells, the pre-existence of the cell-nucleus and the development of the cell around it, the similar situation of the nucleus in relation to the cell, the growth of the cells, and the thickening of their wall during growth, the formation of cells within cells, and the transformation of the cell-contents just as in the cells of plants. Here, then, was a complete accordance in every known stage in the progress of development of two elementary parts which are quite distinct, in a physiological sense, and it was established that the principle of development in two such parts may be the same, and so far as could be ascertained in the cases here compared, it is really the same.

But regarding the subject from this point of view we are compelled to prove the universality of this principle of development, and such was the object of the second section. For so long as we admit that there are elementary parts which originate according to entirely different laws, and between which and the cells which have just been compared as to the principle of their development there is no connexion, we must presume that there may still be some unknown difference in the laws of the formation of the parts just compared, even though they agree in many points. But, on the contrary, the greater the number of physiologically different elementary parts, which, so far as can be known, originate in a similar manner, and the greater the difference of these parts in form and physiological signification, while they agree in the perceptible phenomena of their mode of formation, the more safely may we assume that all elementary parts have one and the same fundamental principle of development. It was, in fact, shown that the elementary parts of most tissues, when traced backwards from their state of complete development to their primary condition are only developments of cells, which so far as our observations, still incomplete, extend, seemed to be formed in a similar manner to the cells compared in the first section. As might be expected, according to this principle the cells, in their earliest stage, were almost always furnished with the characteristic nuclei, in some the pre-existence of this nucleus, and the formation of the cell around it was proved, and it was then that the cells began to undergo the various modifications, from which the diverse forms of the elementary parts of animals resulted. Thus the apparent difference in the mode of development of muscular fibres and blood-corpuscles, the former originating by the arrangement of globules in rows, the latter by the formation of a vesicle around a globule, was reconciled in the fact that muscular fibres are not elementary parts co-ordinate with blood-corpuscles, but that the globules composing muscular fibres at first correspond to the blood-corpuscles, and are like them, vesicles or cells, containing the characteristic cell-nucleus, which, like the nucleus of the blood-corpuscles, is probably formed before the cell. The elementary parts of all tissues are formed of cells in an analogous, though very diversified manner, so that it may be asserted, *that there is one universal principle of development for the elementary parts of organisms, however different, and that this principle is the formation of cells.* This is the chief result of the foregoing observations.

The same process of development and transformation of cells within a structureless substance is repeated in the formation of all the organs of an organism, as well as in the formation of new organisms; and the fundamental phenomenon attending the exertion of productive power in organic nature is accordingly as follows: *a structureless substance is present in the first instance, which lies either around or in the interior of cells already existing; and cells are formed in it in accordance with certain laws, which cells become developed in various ways into the elementary parts of organisms.*

The development of the proposition, that there exists one general principle for the formation of all organic productions, and that this principle is the formation of cells, as well as the conclusions which may be drawn from this proposition, may be comprised under the term *cell-theory,* using it in its more extended signification, whilst in a more limited sense, by theory of the cells we understand whatever may be inferred from this proposition with respect to the powers from which these phenomena result.

But though this principle, regarded as the direct result of these more or less complete observations, may be stated to be generally correct, it must not be concealed that there are some exceptions, or at least differences, which as yet remain unexplained. Such, for instance, is the splitting into fibres of the walls of the cells in the interior of the chorda dorsalis of osseous fishes, which was alluded to at page 14. Several observers have also drawn attention to the fibrous structure of the firm substance of some cartilages. In the costal cartilages of old persons for example, these fibres are very distinct. They do not, however, seem to be uniformly diffused throughout the cartilage, but to be scattered merely here and there. I have not observed them at all in new-born children. It appears as if the previously structureless cytoblastema in this instance became split into fibres; I have not, however, investigated the point accurately. Our observations also fail to supply us with any explanation of the formation of the medullary canaliculi in bones, and an analogy between their mode of origin and that of capillary vessels, was merely suggested hypothetically. The formation of bony lamellæ around these canaliculi, is also an instance of the cytoblastema assuming a distinct form. But we will return presently to an explanation of this phenomenon that is not altogether improbable. In many glands, as for instance, the kidneys of a young mammalian fœtus, the stratum of cells surrounding the cavity of the duct, is enclosed by an exceedingly delicate membrane, which appears to be an elementary structure, and not to be composed of areolar tissue. The origin of this membrane is not at all clear, although we may imagine various ways of reconciling it with the formative process of cells. (These gland-cylinders seem at first to have no free cavity, but to be quite filled with cells. In the kidneys