CLASSICS OF SCIENCE:

Cells in Animal Tissue

Biology

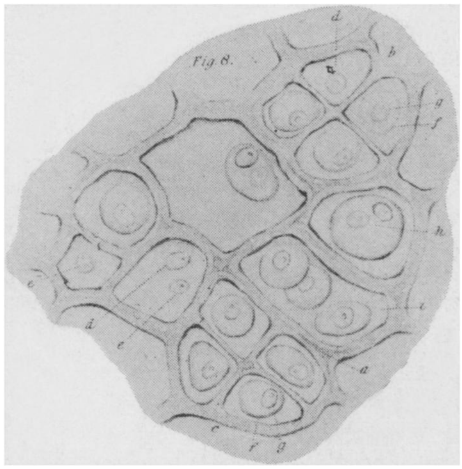
By following the directions in the first paragraph you can see the same cells that Schwann saw. They started him on a search for cell structure in every kind of animal tissue. You will note in this extract that Schwann actually saw cells in the act of division, but, since he worked entirely with dead matter, he did not realize the significance of his cells with two nuclei. He thought cells form by precipitation, like crystals.

MICROSCOPICAL RESEARCHES into the Accordance in the Structure and Growth of Animals and Plants, (1839). *Translated from the German of Dr. Theodor Schwann by Henry Smith* (*The Sydenham Society*), *London,* 1847.

Cells in Chorda Dorsalis

The Chorda Dorsalis in the larvæ of frogs and fishes lies in, or in some instances, under the bodies of the vertebræ, and is continued behind the coccyx, through the whole length of the tail. It is inclosed by a firm sheath, and forms a spindle-like, consistent, gelatiniform, transparent cord, which is thickest at the commencement of the tail, and thence gradually diminishes in each direction, both towards the skull and the point of the tail. It cannot well be separated entire in recently killed animals, but is best obtained from them in the form of delicate transverse sections. If the animal be placed in water for twenty-four hours or longer after death, and the tail then severed from the body at their point of junction, the chorda dorsalis may be entirely pressed out, by gently scraping along its course from the point of the tail, or from the head, towards the wound. As this does not succeed if the animal be allowed to lie out of water for the same period after death, the easier separableness appears to depend upon a penetration of the water between the chorda dorsalis and its sheath; the firmer connexion of it in the fresh condition, however, only upon a more close contact, or wedging in of the chorda dorsalis, and not upon a vascular connection, for I do not suppose that it contains any vessels. Microscopically examined, it exhibits, as J. Müller has discovered in fishes, a cellular structure in its interior, surrounded externally by a proportionately thin cortical substance (rinde), which is beset with scattered granules.

Young cells, which float free, form within the cells of the chorda dorsalis, as in plants. They are, however, in the larvæ of the frog so transparent, that very favorable light and good instruments are required to see them. The number of cells, also, in which new ones are formed in the larvæ is not great, at least in such as are to be had in the latter part of autumn. In the above mentioned species of Cyprinus, and also in other fishes, they are, however, easy to be seen, and in greater number. Vesicles of very various sizes may be perceived in the cavities of many of these cells, and also in those of the larvæ of the frog, though they are more difficult of observation in the latter; a single one of these vesicles sometimes fills the greater part of the cavity; and occasionally several lie in one cell. They are commonly quite round; but not unfrequently two are in contact, and flattened against each other. That they lie free in the cell follows from the fact that they may be isolated without rupture. If, for instance, a small portion of the chorda dorsalis be torn into minute pieces, and a thin plate of glass with water be placed upon them, by moving this lightly backwards and forwards a few times, some such isolated vesicles may often be brought into the field of vision. They may then be made to roll about, and thus demonstrate their globular form. I have taken great pains to discover a nucleus in their walls, but without success. The young cells of the chorda dorsalis, also, in the larvæ so often mentioned, have often the appearance, so long as they are not isolated, of possessing a nucleus; but one may readily be deceived here, since such a nucleus may belong to a cell lying above or below them. Caution must also be used, not to confound a globular epithelial cell, which may have slipped into the chorda dorsalis in making the transverse section, with the true cells of that structure. I have not as yet been able, with certainty, to observe any nucleus, at least not of the characteristic form, in isolated young cells of the chorda dorsalis. In rare instances, a very small corpuscle lay in the inner surface of the young cell. It must remain a question whether the nucleus is really wanting, or whether it is only not visible in consequence of its translucency, or whether these corpuscles are developed into the nucleus. The chorda dorsalis accords with the vegetable cells, at least in this respect, that young cells are formed within the old ones. . . .



CELLS IN ANIMAL TISSUE, as drawn by Schwann

To sum up the researches upon the chorda dorsalis in a few words; it may be said to consist of polyhedral cells, which have, in or on the internal surface of their walls, a structure, according in its form and position with the nucleus of the cells of plants, namely, an oval flat disc containing one, two, or more rarely three nucleoli. The cells usually lie in close contact with each other; but sometimes at points where three or more cells meet together, a sort of intercellular substance, or an intercellular passage is seen. Young cells, which are at first round, and float free, are formed within parent cells. Nuclei of the characteristic form, are not distinctly observed in these young cells, but sometimes a small globule lies upon their inner surface. . . .

Cells in Cartilage

The accordance of the structure of cartilage with the tissue of plants is of more importance in reference to animal organization. We have here to do not only with a more widely extended animal tissue, but also with one which, at least, in its subsequent stages of development, contains vessels, and therefore bears more decidedly the character of an animal tissue. The simplest form of cartilage is exhibited in the cartilages of the branchial rays of fishes. If, for example, a branchial ray of Cyprinus erythropthalmus be loosened from the branchial arch, and the mucous membrane be removed by gentle scraping, the cartilage remaining presents the appearance of a little (*Turn to next page*)

Cells in Animal Tissue—*Continued*

rod, which diminishes from the point of its insertion on the branchial arch towards its free end, its sides being somewhat compressed, and exhibiting on their margins some blunt prominences. The structure of this cartilage is very simple. At the point it perfectly resembles, in its whole appearance, the parenchymotous cellular tissue of plants. Little polyhedral cell-cavities with rounded corners are seen lying closely together. The cell-cavities are separated from each other by extremely thin partition walls. The cell-contents are transparent, and a small pale round nucleus may be seen in some cells when in the recent state, in others only after the action of water upon them. The structure of the lateral prominences of the cartilage is similar to that at the point, only that the cells are somewhat extended in length. Advancing from that point towards the middle, or still better, from the point towards the root of the branchial ray, the partition walls of the cell-cavities are observed to become gradually thicker; and the cavities are here somewhat smaller. On the thickened cell-walls it may now also be seen that the intermediate substance of the cell-cavities is not a simple structure, but one composed of the walls peculiar to the contiguous cells; that is to say, each cell is surrounded with a thick ring, its peculiar wall, the external outline of which is more or less distinct. In the preparation from which the delineation is taken, it was in some parts quite as distinct as the internal. Between two cells these external outlines blend into one line, but separate again when the contact of the cell-walls ceases; there is thus often left between the cell-walls a three or four-cornered intermediate space filled with a kind of intercellular substance. No other structure, no deposition of strata or distinction between primary cell-membrane and secondary deposit can be observed in the thickened cell-walls. The cell-contents also remain clear after the thickening of the walls. At the base of the branchial ray, it is scarcely possible to distinguish between the different cell-walls, and the cartilage presents the appearance of a homogeneous substance, in which separate small cavities only are seen.

Cells in all Tissues

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 significance of those particles, but that they are everywhere arranged according to the same laws; so that whether a muscular fiber, 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 endeavored 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. . . .

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.

Theodor Schwann was born at Neuss, Prussia, December 7, 1810, and died at Liége January 11, 1882. He studied physiology under Johannes Müller at the University of Berlin, from which he was graduated in 1834. Three years later he was discussing with his friend Schleiden the structure of plants when it occurred to him that the cells which he had seen in animal fibers must be like those which Schleiden was studying in plants. He at once began a series of researches, whose results were published as "Microscopic Investigations" in 1839, when the author was 29 years old. Schwann in the meantime had accepted the chair of anatomy in the Roman Catholic University at Louvain. In 1847 he went as Professor to Liége, where he taught for the remainder of his life.