From *Microscopic Investigations* (1839) by Theodor Schwann

The young cells contained within the cartilage-cells (see plate I, fig. 8, ff) may be regarded as the elementary form of the tissues previously considered, and may be described as round cells having a characteristic nucleus, firmly attached to the internal surface of the wall. As the above were proved to correspond with the vegetable cells, it follows, that it is only necessary to trace back the elementary structure of the rest of the tissues to the same formation, in order to show their analogy also with the cells of plants. In some tissues this proof is easy, and immediately afforded; in others, however, it is obtained with much difficulty, and it would frequently be altogether impossible to demonstrate the cellular nature of some, if the connection between the different steps in this investigation were lost sight of. The difficulty arises from the following circumstances: 1st. The minuteness of the cells; in consequence of which it is not only necessary to use a power magnifying from 400 to 500 diameters, but it is also frequently, indeed generally found impossible to press out their contents. 2dly. The delicate nature of the cell-membrane. When this has a certain density, its external as well as internal outline may be recognized, and the distinction between it and the cell-contents may thus be placed beyond a doubt. But if the cell-membrane be very delicate, the two outlines meet together in one line, and this may readily be regarded as the boundary line of a globule, not enclosed by a special enveloping membrane. 3dly. The similar power of refraction possessed by the cell-wall and cell-contents, in consequence of which the internal outline of the former cannot be observed. 4thly. The granulous nature of the cell-membrane, which when the contents are also granulous, cannot be distinguished from them. Lastly, the variety of form presented by the cells, for they may be flattened even to the total disappearance of the cavity, or elongated into cylinders and fibres. From these circumstances, many of the cells which now come before us for consideration, have been described as mere globules, or granules, terms which do not express their true signification, and even when they were spoken of as cells, or cells furnished with a nucleus, the description rested only upon a slight analogy, since but very few of them (for example, the pigment-cells), were proved to be actually hollow cells. But—as the precise signification of the nucleus is unknown, and as the cell-membrane is not proved to be anything essential to those cells (and this follows from their accordance with vegetable cells), upon the analogy with which the proof of the cellular nature of the rest of the globules provided with a nucleus will be based,—there is no contradiction involved in the supposition that a nucleus may be contained in a solid globule as well as in a cell. globules under examination, in which it lies, and those cells, consequently the existence of a spherical cell-membrane in the globules, extremely probable. More than nine tenths of the globules in question

present such a nucleus; in many the special cell-membrane is indubitable, in most it is more or less distinct. Under such circumstances, we may be permitted to conclude that all those globules which present a nucleus of the characteristic form and position, have also a cell-membrane, although, from the causes before specified, it may not be perceptible. The different tissues will also afford us many instances of other circumstances which tend to prove the existence of an actual cell-membrane. An example of what is referred to would be afforded by an instance, in which a certain corpuscle (furnished with a nucleus), about the cellular nature of which a doubt existed, could be proved to be only a stage of development, or modification in form, of an indubitable cell. The cell-nuclei and their distance from each other when scattered in a tissue, also serve as indications, when the outlines of the cells have to be sought for. They likewise serve to guide conjecture as to the earlier existence of separate cells, in instances where they have coalesced in the progress of development. When a globule does not exhibit a nucleus during any one of the stages of its development, it is either not a cell, or may at least be preliminarily rejected, if there be no other circumstances to prove it such. Fortunately, these cells devoid of nuclei are rare.

From the difficulties of this investigation above detailed, it will be seen that a given object may really be a cell, when even the common characteristics of that structure, namely, the perceptibility of the cell-membrane, and the flowing out of the cell contents, cannot be brought under observation. The possibility that an object may be a cell, does not, however, advance us much; the presence of positive characteristics is necessary in order to enable us to regard it as such. In many instances these difficulties do not present themselves, and the cellular nature of the object is immediately recognized; in others, the impediments are not so great but that the distinction between cell-membrane and cell-contents is at-least indicated, and in such cases other circumstances may advance that supposition to a certainty. The most important and abundant proof as to the existence of a cell is the presence or absence of the nucleus. Its sharp outline and dark colour render it in most instances easily perceptible; its characteristic figure, especially when it encloses nucleoli, and remarkable position in the globule under examination, (being within it, but eccentrical, and separated from the surface only by the thickness of the assumed cell-wall,) all combine to prove it the cell-nucleus, and render its analogy with the nucleus of the young cells contained in cartilage, and with those of vegetables, as also the analogy between the globules under examination, in which it lies, and those cells, consequently the existence of a spherical cell-membrane in the globules, extremely probable. More than nine tends of the globules in question present such a nucleus; in many the special cell-membrane is indubitable, in most it is more or less distinct. Under such circumstances, we may be permitted to conclude that all those globules which present a nucleus of the characteristic form and position, have also a cell-membrane, although,

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In addition, however, to the cellular nature of the elementary structures of animal tissues, there are yet other points of accordance between them and the cells of plants, which may generally be shown in the progress of their development, and which give increased weight to the evidence tending to prove that these elementary structures are cells. The exceedingly frequent, if not absolutely universal presence of the nucleus, even in the latest formed cells, proves its great importance for their existence. We cannot, it is true, at present assert that, with regard to all cells furnished with a nucleus, the latter is universally the primary and the cell the secondary formation, that is to say, that in every instance the cell is formed around the previously existing nucleus. It is probable, however, that such is the case generally, for we not only meet with separate nuclei in most of the tissues, distinct from those which have cells around them, but we also find that the younger the cells are, the smaller they are in proportion to the nucleus. The ultimate destiny also of the nucleus is similar to that of the vegetable cells. As in the last named, so in most animal cells it is subsequently absorbed, and remains as a permanent structure in some few only. In plants, according to Schleiden, the young cells are always developed within parent cells, and we have also seen such a development of new cells within those already formed in the chorda dorsalis and cartilage. If, however, any doubt existed as to whether the primary cells of these tissues were formed within previously existing parent cells, none such can arise in reference to many of the tissues next to be considered. We shall indeed frequently meet with a formation of young cells within older ones, but it is not the rule, and does not occur at all with regard to many of them. The following admits of universal application to the formation of cells; there is, in the first instance, a structureless substance present, which is sometimes quite fluid, at others more or less gelatinous. This substance possesses within itself, in a greater or lesser measure according to its

chemical qualities and the degree of its vitality, a capacity to occasion the production of cells. When this takes place the nucleus usually appears to be formed first, and then the cell around it. The formation of cells bears the same relation to organic nature that crystallization does to inorganic. The cell, when once formed, continues to grow by its own individual powers, but is at the same time directed by the influence of the entire organism in such manner, as the design of the whole requires. This is the fundamental phenomenon of all animal and vegetable vegetation. It is alike equally consistent with those instances in which young cells are formed within parent cells, as with those in which the formation goes on outside of them. The generation of the cells takes place in a fluid, or in a structureless substance in both cases. We will name this substance in which the cells are formed, cell-germinating material (Zellenkeimstoff), or cytoblastema. It may be figuratively, but only figuratively, compared to the mother-lye from which crystals are deposited. We shall refer to this point at greater length hereafter, and only anticipate our subject with this result of the investigation, in order to facilitate the comprehension of what follows.

In the previous section of this work we have discussed in detail the course of development of some of the animal cells, having taken the chorda dorsalis and cartilage for our examples. We are now required to prove, as far as is possible, that all the tissues either originate from, or consist of cells. We separate this investigation into two divisions. The first treats of the Ovum and Germinal membrane, in so far as they form the common basis of all the subsequent tissues. The second division embraces the permanent tissues of the animal body, with the omission of the two already described.