"On the Cytology of Apogamy and Apospory.—1. Preliminary Note on Apogamy." By J. B. FARMER, F.R.S., J. E. S. MOORE, and Miss L. DIGBY. Received March 24,—Read March 26, 1903.

The phenomena of apogamy and apospory have always been regarded as "short cuts" in the life history of ferns, and the fact that apparently either generation may be *directly* produced from the other, without the intervention of oosphere or spore respectively, has been taken to indicate that the gametophyte and sporophyte are homologous phases in the life histories of these plants. But since the cytology of the two generations has been carefully studied, it has become recognised that the prothallial generation is composed of cells, the nuclei of which possess only half the number of chromosomes that are characteristic of the alternate sporophyte generation.

In normal cases the doubling of the number of the chromosomes is effected during the transition of the gametophyte to sporophyte by the addition of the chromosomes belonging to the spermatozoid to those of the oosphere, and this double number is retained until they once more become reduced to one half in the formation of the spores that introduce again the gametophyte stage of the life-cycle.

It is obviously therefore of considerable theoretical interest to ascertain how the irregular transitions known as apospory and apogamy are effected. It is with the facts of apogamy that we are here concerned, the details relating to apospory being reserved for a future communication.

Certain species of nephrodium (*e.g.*, *N. pseudo-mas*, var. *polydactylum*) are known to produce prothallia on which the apogamous formation of sporophytes is of normal instead of rare occurrence.* By the kindness of Dr. Lang we received a number of prothallia in all stages of growth in which the special apogamous developments could be perfectly traced. An examination of them has resulted in the discovery of remarkable nuclear changes that appear to be obviously related to the apogamy of the prothallia in question.

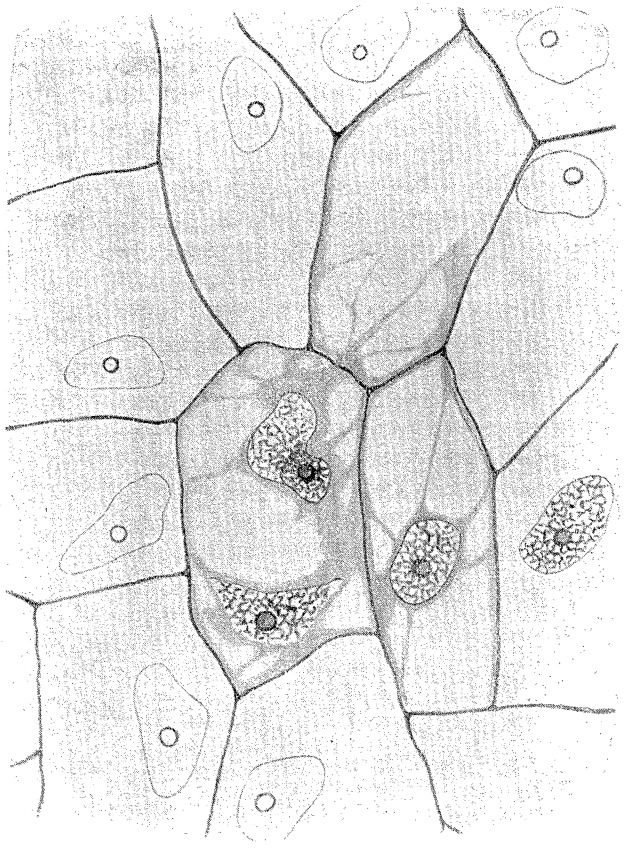
If very young prothallia are examined before any apogamous growths have begun to manifest themselves, it will be seen that cells not unfrequently occur in which two nuclei are present. This fact was recorded by Lang in the case of older prothallia, and was also figured by Heim† in the case of *Doodya caudata*, but he makes no mention of it in the body of his paper.

* Lang, "On Apogamy and the Development of Sporangia upon Fern Prothallia," 'Phil. Trans.,' series B, vol. 190, 1898, p. 214.

† Carl Heim, "Untersuchungen ü. Farn Prothallien," 'Flora,' vol. 82, 1896, p. 338, fig. 7.

Furthermore, it is to be observed that whenever this state of things is seen, there is always, so far as we have observed, at least one contiguous cell which is destitute of a nucleus (see figs. 1, 2, 4). We convinced ourselves of this highly important fact by examining entire prothallia that had been carefully stained, as there was always the

Fig. 1.



risk that in erections the appearance might be due to the displacement of the missing nucleus.

We were further able to trace the migration of the nucleus from one cell into that of its neighbour in a sufficient number of instances to convince us that this affords the explanation of the peculiar circumstances just mentioned (figs. 3, 4). In several instances the nucleus was seen in the act of passing through the wall, and in others the path through which it had traversed was plainly visible as a perfora-

FIG. 2.

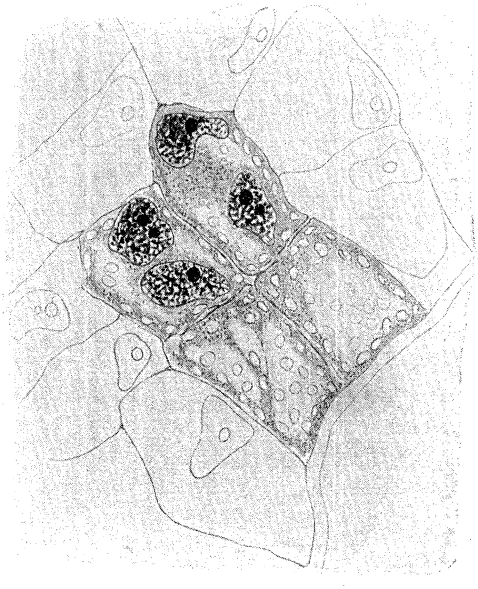
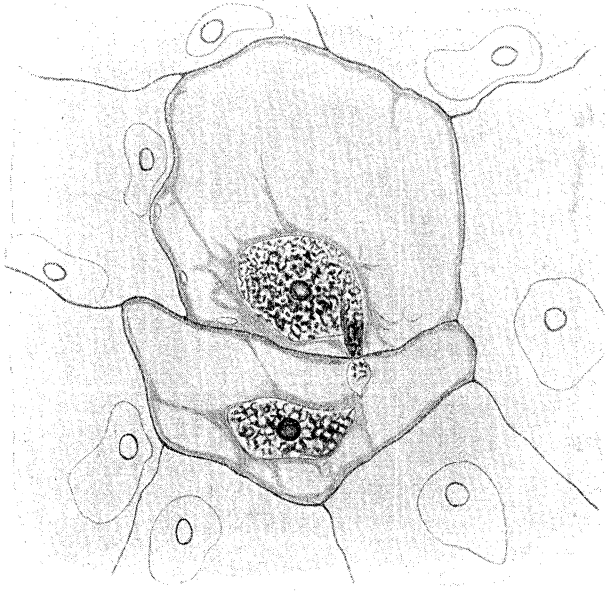


FIG. 3.

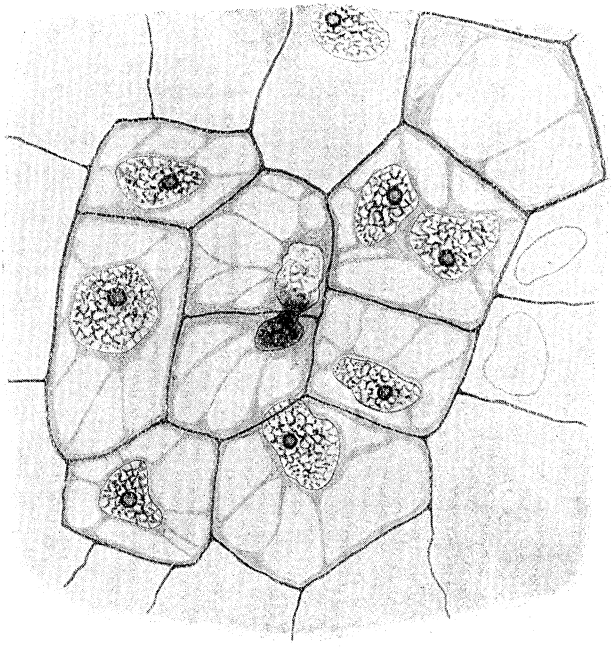


tion through which a strand of cytoplasm was still visible connecting the two cells.

When the migrating nucleus has passed into the neighbouring cell it sometimes fuses at once with the nucleus already present there, but often the two nuclei remain more or less separated for an appreciable interval of time.

It appears then to be clear that the presence of the pair of nuclei is not to be regarded in these cases as resulting from a division of the

FIG. 4.



nucleus proper to the containing cell, but has merely been arrested at a stage short of producing a wall. Such a state of things is very common in the tissue-cells of many plants, but we think that the facts enumerated above suffice to prove that no such simple explanation will fit in the present case.

The migration of the nucleus, as above described, goes on discontinuously in a growing apogamous prothallium. In this way there is provided a cellular aggregate that may possess no very homogeneous character, nor can one cell, or even isolated groups of cells, be defined as the sole parent tissue from whence the apogamous outgrowth may have sprung. And this is quite in harmony with the

irregular growth of the new tissue, and with the sporadic appearance of sporophytic members, on the prothallium already described by Lang.

When the nuclei of the cells in the apogamous regions are examined in course of karyokinesis, they are seen to possess a much larger number of chromosomes than those of the ordinary tissue cells of the prothallium. Owing, however, to the manner in which the very numerous chromosomes are distributed on the spindle, an exact estimation of actual numbers is a task of considerable difficulty. There appear, however, to be forty and eighty in the respective classes of nuclei.

We regard the whole process as a kind of irregular fertilisation. The doubling of the chromosomes receives an explanation strictly analogous to that afforded by the normal fusion of oosphere and spermatozoid. But instead of one cell only (the oospore) serving as the starting point for the new generation, a number of such units loosely co-operate to produce it. And in this connection it is perhaps significant that the young plantlet is commonly borne on, and produced from, a special sporophytic outgrowth, of which the constituent cells may have become homologously differentiated into a sort of pro-embryo.

Instances are not wanting amongst lower animals to show that close cellular in-breeding may occur, and form part of the normal sexual series of events. It is not desired to press the analogy of such cases; but the case of Actinosphærium shows that a process indistinguishable from normal sexual fusion may occur between sister cells that have only lately arisen from the division of a parent cell.

We do not propose to enter on a full theoretical discussion of the bearings of these observations at the present time, but we hope to do so when we are in a position to deal completely with the corresponding cytological features associated with apospory.

FIG. 1.

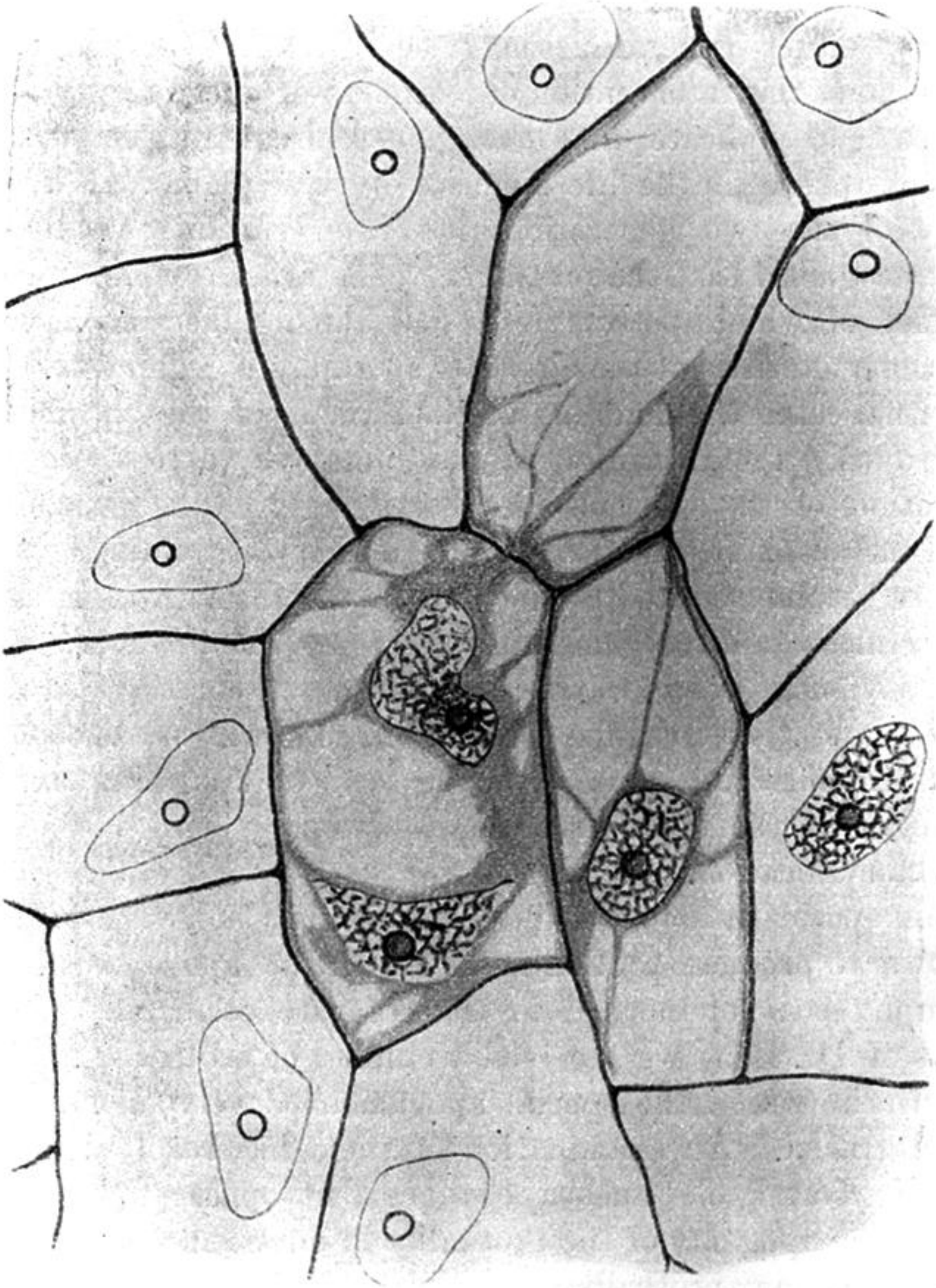


FIG. 2.

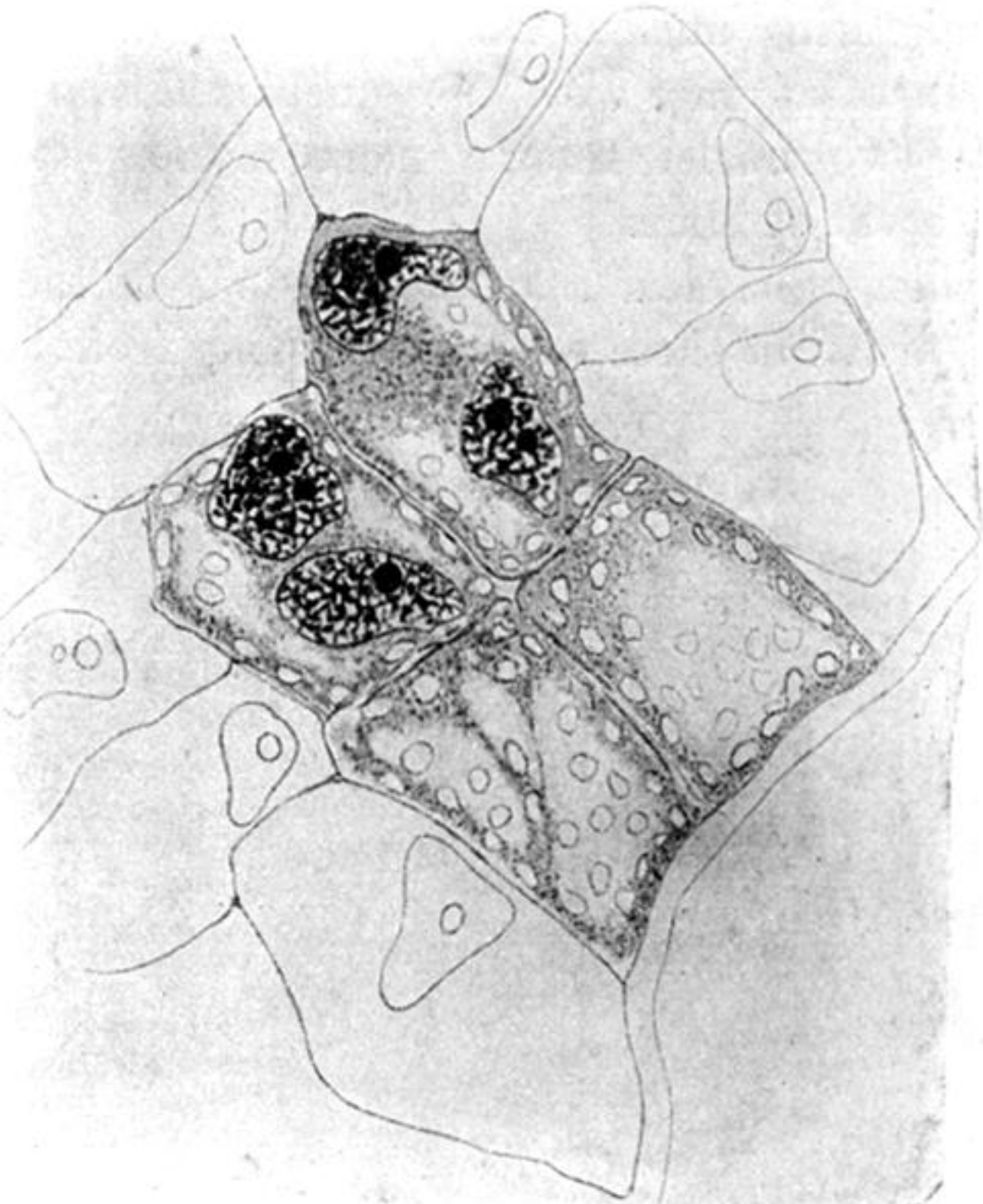


FIG. 3.

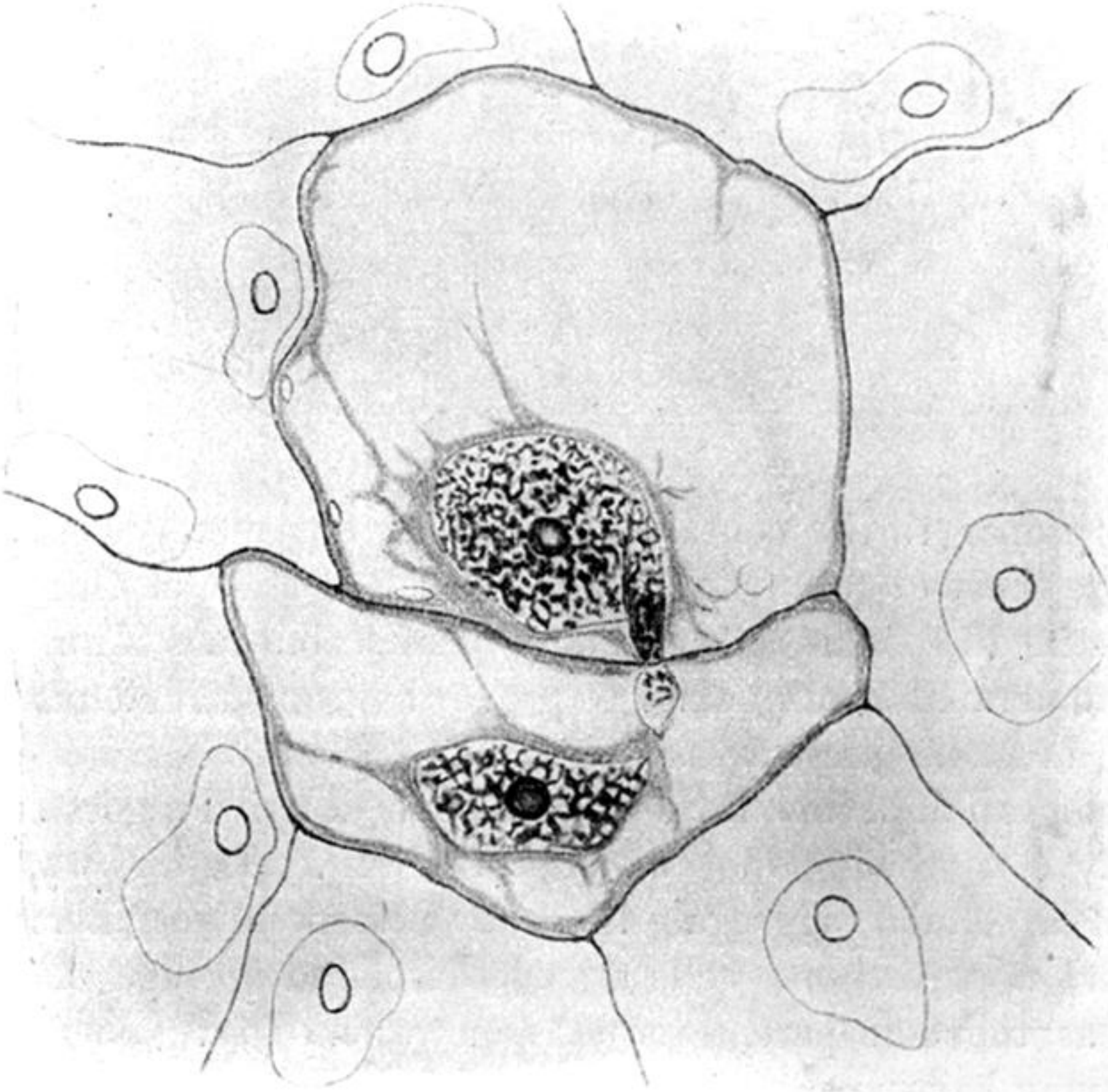


FIG. 4.