Plasmodesmen.

By Frank Marion Andrews.

It has been shown by W. Gardiner,[1] Strasburger,[3] Kohl,[2] and others that plasmodesmen are not confined to the pits in the cell walls but that they may also penetrate the cell walls themselves at other places. Excellent names for the plasmodesmen penetrating the cell wall in the places above mentioned have been chosen by Kohl.[4] Those which pass through the pit membrane he calls aggregated and these which pass through the unpitted membrane solitary. Strasburger[5] has recommended for all these protoplasmic connections the term plasmodesmen. It has also been shown that the plasmodesmen arise independently of cell division, for in the dermatogen of a phanerogam, in which only anticlinal and radial walls are formed these plasmodesmen are present in the walls between the dermatogen and the next inner layer of cells.

The plasmodesmen arise, according to Strasburger, secondarily in a very early stage in the formation of the membranes, before the beginning of their secondary thickening. Pfeffer[6] states—according to reports—that a subsequent formation of very thin plama connections is just as possible, as the larger fusion of protoplasts, which is made possible by dissolution of adequate parts of the cell wall.

I have investigated the occurrence of plasmodesmen to some extent in the endosperm of Phoenix dactylifera, and find both the solitary and aggregate forms present in large numbers.

Fig. 1 represents a cross-section of a cell of the endosperm of this plant before treating with any reagent. The pits are large and numerous and are generally somewhat enlarged where the ends come together with the corresponding ones of contiguous cells. The walls are rather thick and hard. Fig. 2 is a longitudinal section of the endosperm of Phoenix

[1]Gardiner W. Arbeiten des Botanischen Institutes in Wurzburg 1888, Bd. 3, p. 52.

[3]Strasburger Ueber Plasmaverbindungen pflanzlicher Zellen Jahr für wis. Bot. 1901, Band 36, p. 493.

[2]Kohl-Ber. d. Deutsch botan. Gesellsch. 1900, p. 364.

[4]Kohl-Ber. d. Deutsch botan. Gesellsch. 1900, p. 364.

[5]Strasburger-Ueber Plasmaverbindungen pflanzlicher Zellen Jahr für wis. Bot. 1901, Band 36, p. 503.

[6]Pfeffer-Pflanzenphysiologie zweite Auf. 1904, Bd. II, p. 219.

dactylifera in which the wall has been greatly swollen and the plasmodesmen stained to make them more plainly visible. In this case I treated the specimens according to Gardiner's method first by allowing them to lie for a while in iodine and potassium iodide and then adding chloriodide of

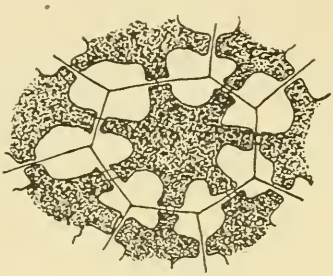

Fig. 1.

zinc and allowing it to act for twelve hours. The sections were then carefully washed in water. The walls were found to be strongly swollen to at least twenty-five times their original thickness where the pits occurred. In only a few instances were any of the aggregate plasmodesmen

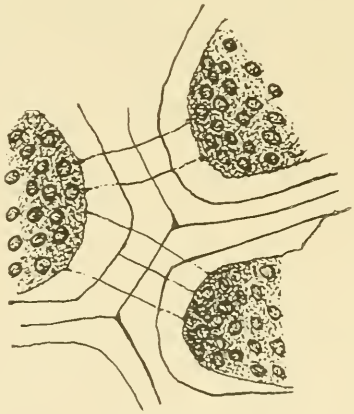

Fig. 2.

found broken where they entered the pit of the cell. Sometimes this occurred, especially in the solitary plasmodesmen, and a small filament could be seen as in Fig. 2. Attempts were made to bring these plasmodesmen more plainly to view by the use of Hoffman's blue, but this did not succeed very well. I found after considerable experimentation that

a solution of clove oil eosin stained them densely and then made them plainly visible. The solution I used was made by adding a small quantity of eosin to the pure clove oil. This stains very quickly and must therefore only be allowed to act a few seconds. The aggregate plasmodesmen did not show themselves in this specimen to be perfectly smooth threads of protoplasm but were coarsely granular or appeared considerably thickened at irregular intervals. (Fig. 2.) The solitary plasmodesmen, however, were more uniform. This appearance of the plasmodesmen was only to be seen to good advantage under very high magnification. The plasmodes-

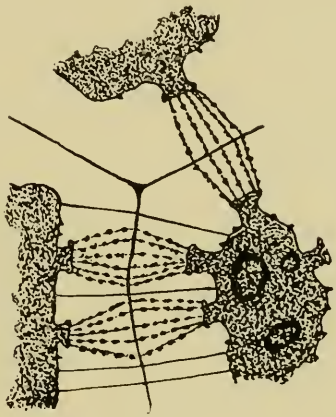

Fig. 3.

men shown in Fig. 2, for example, were magnified 2,250 times. The enlarged ends of the pits above referred to are better shown here than in Fig. 1.

The plasmodesmen in the cortex of Aesculus flava were also examined. To do this I removed the outer layers down to the green tissue, and the thin sections obtained there were treated in the same way as those of the endosperm of Phoenix dactylifera, except that instead of using chloriodide of zinc, sulphuric acid was employed for swelling. Clove oil eosin was also used here with good results. Hoffman's blue was also more effective than in the first case mentioned. The plasmodesmen of both kinds were made visible here, although the solitary ones were, as usual, more difficult to distinguish than the aggregate ones. Some experiments in demonstrating the plasmodesmen in moss leaves were also performed. This was done by plasmolysis. The leaves of Funaria hygrometrica, and often whole

plantlets as well, were placed in a 17 per cent. solution of cane sugar and left for a few minutes. This was sufficient to bring about a plasmolysis in all the cells and make the plasmodesmen evident when stained. This is shown in Fig. 3. The fine strands of protoplasm ran from the protoplasts to pits in the wall and from there through the wall to the opposite protoplasts. If the protoplasts were contracted too much by plasmolysis they were broken and the fragments could often be seen (Fig. 3).

When moss-cells were plasmolized in the way above mentioned they were fixed in a 1 per cent. solution of chromic-acetic acid, then washed in water and the walls swollen in the usual way.

The walls must be swollen considerably in Funaria hygrometrica to locate exactly the passage of the plasmodesmen. Although the protoplasmic fibers running from the contracted protoplasts were visible even directly after plasmolyzing they were made much more evident by staining with clove oil or Hoffman's blue.

The importance of plasmodesmen uniting the various protoplasts of a plant is evident in several ways. Experiments have been made to show[1] that stimuli may be transmitted through them. Even certain nutrient substances[2] may pass through them in mass or by diffusion, and Miehe[3] has even observed that nuclei may under certain conditions pass from one cell to another by means of the pores of the plasmodesmen.

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[1]Townsend, Jahr. f. wiss. Bot. 1897, Bd. 30, p. 484.
[2]Pfeffer, Pflanzenphysiologie zweite Auf. Bd. II, p. 225.
[3]Miehe, Flora, p. 115.