THE DEVELOPMENT OF THE FEMALE GAMETOPHYTE AND FLOSS IN *BOMBAX MALABARICUM* D.C.

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Bombax malabaricum commonly known as the "silk cotton tree", is a native of the tropics. The tree sheds its leaves towards the end of the year and the bright red flowers appear next February or March, followed by the appearance of new leaves. The plant is grown in India chiefly for its floss which is used for stuffing cushions. According to Kirtikar and Bose[7] different parts of the plant are of medicinal importance.

The genus *Bombax* has been placed under the family *Bombacaceæ* by Hutchinson[5] and also by Engler and Prantl.[3] This family has not received the same attention from embryologists as the nearly related ones. Recently Thirumalachar and Khan[8] have given an account of the megasporogenesis and endosperm formation in *Eriodendron anfractuosum*. Our knowledge of the embryology of the other members of the family is as yet incomplete.

Material for this investigation was obtained from a tree growing in the University College compound. Ovaries in various stages of development were carefully dissected out from the flower buds and fixed either in Navaschin's or Allen's modified Bouin's fluid. For the study of the development of the floss ovaries from opened flowers and young bolls were fixed. It was necessary to trim away the superfluous tissue before fixation. The customary practice of dehydration, clearing, etc., was followed and sections were cut 8 to 16 microns thick. Sections were stained in Heidenhain's iron-alum hæmatoxylin.

Observation

(*a*) *The development of the female gametophyte*.—The ovary of *Bombax malabaricum* is pentalocular. The ovules arise as minute papillate processes from the axile placenta and very soon curvature is initiated. By the time the macrospores are in diakinesis the ovules become typically anatropous in form. They are bitegmic, the tips of the integuments are somewhat massive. Both the integuments take part in the formation of the micropyle which is not straight but somewhat zig-zag (Text-Fig. 10).

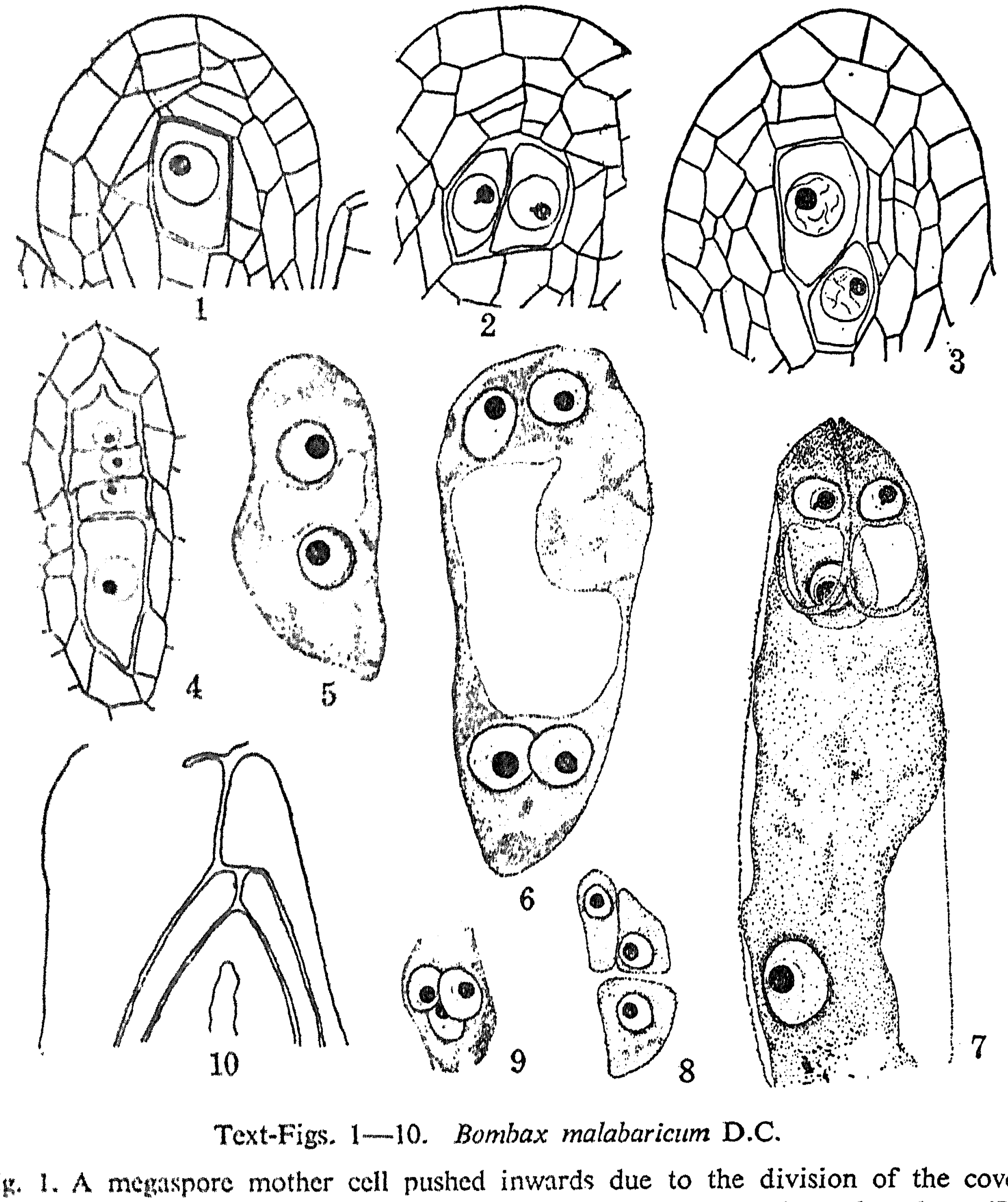
The archesporial cell is hypodermal in origin. More than one archesporial cell have been noted in some preparations. Generally one of them develops. Two megaspore mother cells lying either side by side, or one above the other have been noted in some preparations (Text-Figs. 2 and 3). The 'cover cells' undergo repeated divisions as a result of which the megaspore mother cell is pushed considerably inside the nucellus (Text-Fig. 1). The megaspore mother cell increases in size before division. After the completion of division I, the protoplast passes through an interkinetic stage and then dyads are produced. The II division results in the formation of a linear tetrad of megaspores (Text-Fig. 4). The chalazal megaspore functions and the rest degenerate. The functional megaspore by three sucessive divisions produces an eight-nucleate embryo-sac, which is very much elongated and shows distinct polarity. The nucellar cells surrounding the embryo-sac show signs of degenration from the four-nucleate stage onwards. Thus the mature embryo-sac comes to lie a few layers below the nucellar cells and is closely surrounded by the integuments.

The mature embryo-sac is of the normal angiospermous type. The synergids are somewhat pear-shaped and have distinct vacuoles at their bases. The egg is elongated, it lies below the synergids and shows the usual structure. The secondary nucleus lies at the centre of the embryo-sac (Text-Fig. 7). The antipodals have cytoplasmic membranes; they are small in size, ephemeral and three in number (Text-Fig. 8).

The pollen tube enters the embryo-sac through the micropyle. The synergids degenerate after the entry of the pollen tube. The egg becomes very much elongated. The development of the embryo appears to be initiated long after endosperm formation. The primary endosperm nucleus divides very soon after fertilisation and a large number of free nuclei are produced which become distributed along the pheriphery of the sac. Wall formation takes place at a late stage. The endosperm nuclei show the presence of two or more nucleoli.

The process of fertilisation has not been observed, but a triple fusion nucleus was observed in one preparation, from this it might be inferred that in some ovules the fusion of the polar nuclei is not complete before fertilisation (Text-Fig. 9).

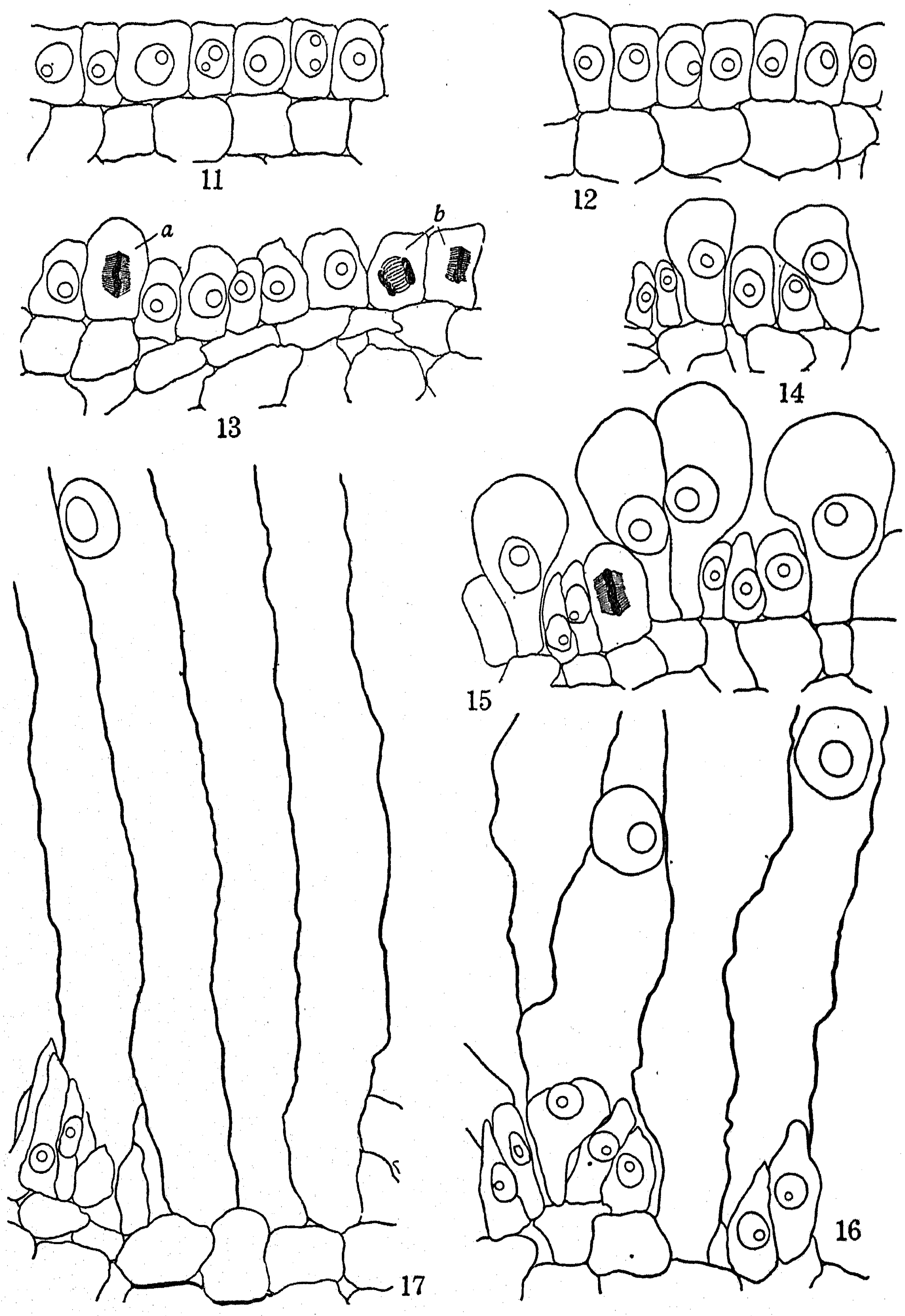
(*b*) *The development of the floss.*—It is interesting to note at the outset that the floss develops entirely from the epidermal layer of the inner carpellary wall of the fruit and the cells lining the radial walls take no part in the process. Fibre development is generally initiated within a week after anthesis; at this time the endosprem cells form a lining layer around the embryo-sac, but the egg remains undivided. The cells destined to give rise to the fibres, lose their rectangular shape, become somewhat elongated and



Text-Figs. 1—10. *Bombax malabaricum* D.C.

Fig. 1. A megaspore mother cell pushed inwards due to the division of the cover cells. Figs. 2 and 3. Two megaspore mother cells lying side by side and one above the other. Fig. 4. A linear tetrad of megaspores. Fig. 5. Binucleate stage of the embryo-sac. Fig. 6. Quadrinucleate embryo-sac. Fig. 7. The mature embryo-sac showimg the egg apparatus and the secondary nucleus. Fig. 8. The three antipodal cells. Fig. 9. Triple fusion. Fig. 10. Section of the top of the ovule showing the zig-zag micropyle. Figs. 1 to 9. × 775. Fig. 10. × 75.

show the presence of dense cytoplasm and a single nuclues (Text-Fig. 12). Differentiation of these cells appears to be simultaneous throughout the epidermal layer of the inner carpellary wall, a few cells, however, remain



Text-Figs. 11—17. × 775. *Bombax malabaricum* D.C.

Fig. 11. The outer cells of the inner carpellary wall before initiation. Fig. 12. The form of the cells at the initial stages of fibre development. Fig. 13. Anticlinal division of the nuclei of the protruding fibre cells (*a*) and the 'non-fibre cells' (*b*). Fig. 14. Fibre cells and undeveloped cells lying side by side. Fig. 15. A later stage in the development of the fibre. Note the undeveloped cells as also the anticlinal division in one of them. Fig. 16. Well developed fibre cells with groups of undeveloped cells at the base. Fig. 17 Illustrates the unconstricted nature of the base of the fibre cells.

inactive and interspersed in between groups of developing fibre cells (Text-Figs. 14 and 15). The initiation of fibre development is seen in the protrusion of the tips of the cells and the gradual increase in size of their nuclei. Vacuoles are commonly noted in the cells at this stage. Some of the elongating cells are also seen to divide anticlinally and result in the production of daughter cells (Text-Fig. 13 *a*). It appears that such cells soon become arrested in development. Division of the ' non-fibre cells ' is also noted at this stage, and as a result the fibre cells are pushed apart (Text-Fig. 13 *b*). These cells could be made out by the comparatively small size of their nuclei. Further development of the fibre cells takes place and along with it the cells become longer and their nuclei larger (Text-Fig. 15). Conspicuous vacuoles are noted above the nucleus at this stage. During the later stages of development of the fibres it becomes difficult to trace their outline as they overlap one another at their free ends. The nuclei of these cells are large and lie a little above the base of the cell (Text-Fig. 16). The mature fibres are uninucleate and unconstricted at the base (Text-Fig. 17).

The basal region of the mature fibres appears to be multicellular due to the anticlinal division and non-development of some of the epidermal cells of the inner carpellary wall (Text-Fig. 16). Evidence in this direction is obtained on examintion of fibres situated close to the radial walls of the carpel. In these fibres it is possible to trace their point of insertion and also their length for some distance. Text-Fig. 17 illustrates such a condition.

Discussion

The development of the female gametophyte in *Bombax malabaricum* shows no unusual features and appears to agree closely with the observations of Thirumalachar and Khan[8] on *Eriodendron anfractuosum*. Difference is noted, however, in the arrangement of the macrospores, but this cannot be considered to be of any significance, as in recent years both "T-shaped" and linear arrangement of macrospores have been observed in many plants. It is interesting to note that the micropyle shows similar orginization in both the genera. This might be a charesteristic feature of the family *Bombacaceæ*.

The development of the cotton fibre (*Gossypium* sp.) has been studied in detail by Gulati[4], Barritt[2] and others. It is only very recently that such investigation has been made in the family *Bombacaceæ* by Thirumalachar and Khan.[8] Their observations on *Eriodendron*, though agreeing in general with that observed in *Bombax*, differ in a few fundamental points. According to them, the cells of the floss are binucleate, the division of the nucleus takes place during the early stages of the development of the fibre. Division of the nucleus of the elongating fibre cells of *Bombax* has been observed in many preparations, but the plane of division is always anticlinal and results in the production of daughter cells and not binucleate cells.

The presence of undeveloped cells at the basal region of the fibres has not been observed by Thirumalachar and Khan.[8] This appears to be a characteristic feauture of the present material. A reference to Fig. 12 in the paper of the above-mentioned authors, however, shows that some of the cells lying in between the incipient fibre cells are undeveloped. The next figure represents a group of uniformly developed binucleate fibre cells. It thus appears that all the cells of the inner epidermal layer of the carpel develop into floss in *Eriodendron anfractuosum*.

Another important observation made in the course of the present study is that fibre initiation and development take place simultaneously in all the five loculi of the ovary, with slight local differences. In this respect it differs from *Gossypium* sp. in whcih according to Ayyar and Ayyangar[1] the differentiation of the hairs proceeds for a number of days after flowering.

Jacob[6] has recently made an interesting observation in *Gossypium*. sp. According to him the outer cells of the ovule which give rise to the fibres are binucleate in the early stages. After the fusion of the nuclei the fibre cells develop, *i.e.*, it is only the tetraploid cells that give rise to the fibres. Careful examination of the cells of the epidermal layer of the inner carpellary wall of the ovule and the boll during various stages of growth failed to reveal such a condition in *Bombax malabaricum.*

Summary

The paper gives an account of the development of the female gametophyte and floss in *Bombax malabaricum.*

1. The ovules are anatropus and bitegmic. Both the integuments take part in the formation of the micropyle which is somewhat zig-zag.

2. The archesporial cell is hypodermal in origin. Two megaspore mother cells have been noted in many preperations. A normal linear tetrad of megaspores is produced of which the lowermost one becomes functional and produces a seven-nucleate embryo-sac of the normal angiospermous type. The antipodals are ephemeral. The development of the embryo is very much delayed. Endosperm development is of the nuclear type.

3. The floss develops from the cells of the epidermal layer of the inner carpellary wall of the boll. All the cells, however, do not develop. The

'non-fibre' cells as also some of the fibre cells divide anticlinally during the early stages of the development of the fibre. The growth of the latter seems to be arrested after division. The mature fibres are uninucleate and have an unconstricted base.

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