A CONTRIBUTION TO THE EMBRYOLOGY OF *CHLOROPHYTUM ATTENUATUM* BAK.

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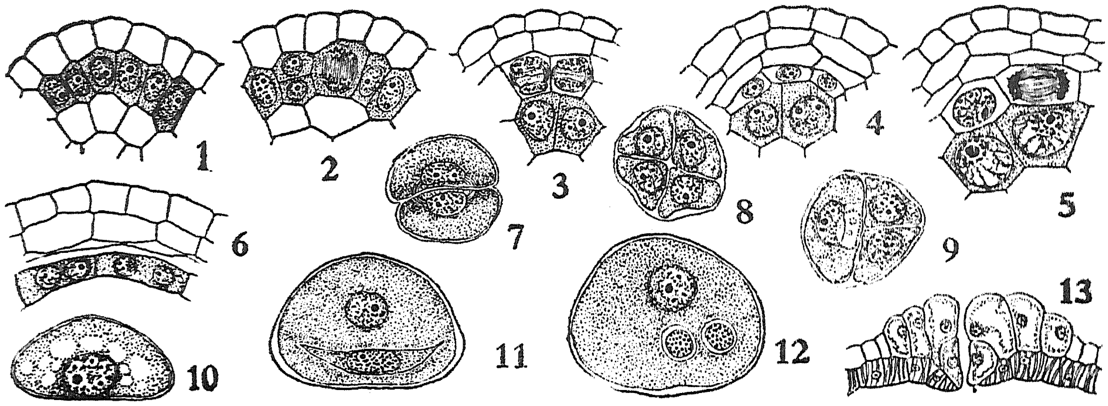
Introduction

The Liliaceæ is a very interesting family for it shows five distinct types of embryo sac development, *viz.*, Polygonum type, Allium type, Drusa type, Fritillaria type and Adoxa type. Eunus (1950) has drawn attention to this feature and an exhaustive review on these types of embryo sac development has recently been presented by Maheshwari (1948). The genus *Chlorophytum* is placed in the third sub-tribe Asphodeloideæ by Engler (1888) in the family Liliaceæ. In South India eight species of this genus are recorded (Gamble, 1925). *Chlorophytum attenuatum* is a perennial herb with cylindric, frequently tuber-like, roots. The inflorescence is a scape on which the white racemose flowers are arranged. The material was collected at Nandi Hills, a hill station about 35 miles from Bangalore, and fixed in formalin-acetic-alcohol. Sections were cut at a thickness of 14–18 microns and stained in Heidenhain's iron-alum hæmatoxylin with eosin as a counter stain.

Microsporangium and Male Gametophyte

The flower has six stamens arranged in two whorls of three each. A transverse section of the young anther lobe shows the hypodermal archesporium made up of a plate of six to eight cells (Fig. 1), with prominent nuclei and dense cell contents. They divide transversely forming the primary parietal layer and primary sporogenous layer (Fig. 2). The primary parieta layer by further divisions forms the wall of the anther (Figs. 3–6) and the sporogenous cells after undergoing a few more divisions become converted into spore mother cells (Figs. 3–5). The outermost layer in the young anther is the epidermis, next comes the endothecium, then a middle layer which soon becomes flattened and crushed (Figs. 4–6) and finally the glandular tapetum. The tapetal cells are uninucleate at first but later become binucleate (Figs. 5–6).

The microspore mother cells round up and undergo the usual reduction divisions. The first division is followed by the formation of a cell plate



FIGS. 1–13.

Fig. 1. Portion of cross-section of young anther showing archesporial cells, × 270. Fig. 2. Formation of primary parietal and primary sporogenous cells, × 270. Figs. 3 & 4. Stages in formation of anther wall, × 270. Fig. 5. Portion of young anther showing epidermis, endothecium, middle layer, uninucleate tapetum, and sporogenous cells; note division in one of the tapetal cells, × 270. Fig. 6. Same at a later stage showing crushed middle layer and binucleate tapetum, × 270. Fig. 7. Microspore Dyad, × 450. Fig. 8. Isobilateral tetrad of microspores, × 485. Fig. 9. Decussate opposite arrangement of microspores, × 485. Fig. 10. Uninucleate microspore, × 679. Fig. 11. Two-celled pollen grain, × 679. Fig. 12. Pollen grain showing tube nucleus and two male cells, × 679. Fig. 13. Portion of mature anther to show stomium and fibrous endothecium, × 120.

(Fig. 7); after the second division a cell plate is laid down in each of the dyad cells resulting in the formation of isobilateral tetrads (Fig. 8). Sometimes the microspores show a decussate arrangement (Fig. 9). A young microspore has a prominent nucleus surrounded by vacuolate cytoplasm (Fig. 10). Its wall is composed of a thin intine and a thick smooth exine with a single germinal furrow. The nucleus of the microspore divides to form an elongated generative cell and a rounded tube nucleus (Fig. 11). This is the shedding stage of the pollen grain, but occasionally the generative cell divides producing two male cells (Fig. 12).

In the mature anther, the tapetum and middle layer completely disorganise; only the epidermis and the endothecium persist and the latter develops characteristic fibrous thickenings. At the line of dehiscence some of the epidermal cells enlarge conspicuously and constitute the stomium (Fig. 13).

OVARY

The ovary is superior, tricarpellary, syncarpous and trilocular with two rows of axillary anatropous bitegmic ovules in each locule. The wall of the ovary consists of an uniform group of five to seven layers of thin-walled parenchymatous cells. In the mature fruit the cells of the innermost layer of the ovary wall develop lignified thickenings on their inner and tangential walls (Fig. 14). Prominent septal nectaries are present (Fig. 15).

Megasporangium and Female Gametophyte

Stages in the growth and curvature of the anatropous ovule are shown in Figs. 16–19. The micropyle is formed by the inner integument (Fig. 19) and it always grows earlier than the outer integument (Figs. 17, 18). The inner integument consists of two layers of cells except in the region of the micropyle where it is three to four layered. The outer integument consists of three to four layers of cells. The funicular strand ends at the base of the chalaza (Figs. 19, 20). To start with it consists of elongated cells (Fig. 20) which later show the characteristic thickenings of xylem (Fig. 21). At about the four-nucleate stage of the embryo sac, a biseriate row of nucellar cells at the chalaza connects the lower end of the embryo sac with the funicular strand. This row (Fig. 20) functions as a conducting strand for transporting food materials from the funicular strand to the antipodal end of the embryo sac.

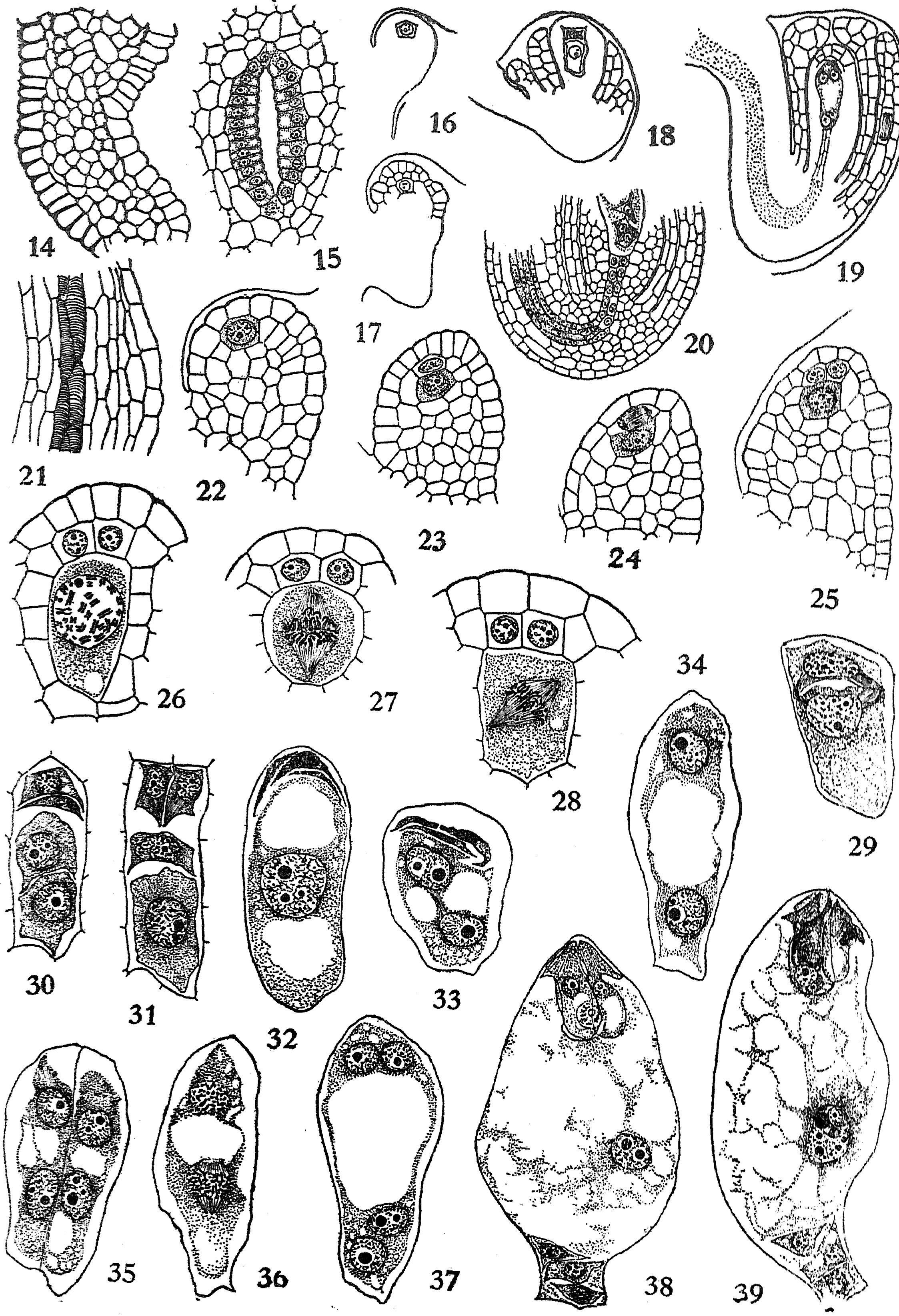
The hypodernal archesporium (Fig. 22) divides periclinally producing the parietal cell and the megaspore mother cell (Fig. 23). The parietal cell usually divides anticlinally (Fig. 24) producing two cells (Fig. 25). The megaspore mother cell soon enlarges in size (Fig. 26) and divides (Figs. 27) to produce the dyad. Sometimes the spindle is obliquely oriented (Fig. 28). Of the two cells of the dyad the upper is frequently smaller than the lower (Fig. 29). Both the cells divide again forming the linear tetrad (Fig. 30). A T-shaped tetrad is also met with (Fig. 31). The upper three megaspores degenerate and the chalazal megaspore (Fig. 32) undergoes three more divisions to produce the mature embryo sac which is of the Polygonum type (Figs. 33, 34, 36, 37 and 38). Fig. 35 shows two binucleate embryo sacs lying side by side.

The mature embryo sac (Fig. 38) is elongated and broad in the middle. Its chalazal end is in the form of a pouch. The synergids are hooked and sometimes exhibit a filiform apparatus. The pear-shaped egg is situated between them. The two polar nuclei fuse in the centre of the embryo sac to form the secondary nucleus which soon moves down. The antipodals are organised as cells and they lie in the chalazal pouch-like portion of the embryo sac.

The entry of the pollen tube is porogamous and double fertilisation occurs (Fig. 39).

Endosperm

The primary endosperm nucleus divides near the lower end of the embryo sac by a transverse or slightly oblique wall to form two chambers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FIGS. 14–39

Fig. 14. Portion of mature ovary wall, × 30. Fig. 15. Section of septal nectary × 60. Figs. 16–19. Stages in development of anatropous ovule, × 120 × 129; × 129; × 129. Fig. 20. Chalazal portion of ovule enlarged showing conducting strand, × 129. Fig. 21. A portion of funiculus enlarged showing thickening in funicular strand, × 296. Fig. 22. L.S. young nucellus showing primary archesporial cell, × 270. Fig. 23. Primary parietal cell and megaspore mother cell, × 270. Fig. 24. Anticlinal division in primary parietal cell, × 270. Fig. 25. Two parietal cells and megaspore mother cell, × 270. Fig. 26. Megaspore mother cell in diakinesis, × 485. Fig. 27. Megaspore mother cell in metaphase, × 450. Fig. 28. Oblique division in megaspore mother cell, × 485. Fig. 29. Formation of dyad, × 485. Fig. 30. Linear tetrad, × 485. Fig. 31. T-shaped tetrad, × 485. Fig. 32. Uninucleate embryo sac, × 450. Fig. 33. Formation of two-nucleate embryo sac, × 450. Fig. 34. Two nucleate embryo sac, × 450. Fig. 35. Two binucleate embryo sacs lying side by side, × 450. Fig. 36. Formation of four-nucleate embryo sac, × 450. Fig. 37. Four-nucleate embryo sac, × 450. Fig. 38. Mature embryo sac showing synergids with filiform apparatus, egg, secondary nucleus and antipodal cells, × 679. Fig. 39. Double fertilisation, × 301.

of which the micropylar is larger than the chalazal (Fig. 40). The nuclei in both these chambers divide again (Fig. 41). At this stage the cytoplasm in the lower chamber is very dense and later it completely disorganises. Free nuclear divisions occur rapidly in the micropylar chamber (Fig. 42) and the nuclei become parietally placed by the formation of a central vacuole. After wall formation sets in, further growth is centripetal and a massive cellular endosperm is produced. A Helobial type of endosperm has also been reported in other species of *Chlorophytum* (Stenar, 1949). In the mature seed its cells become densely filled with starch grains (Fig. 57).

Embryo

Stages in the development of the embryo are shown in Figs. 43–55. The mature embryo is elongated and monocotyledonous, with a terminal cotyledon, lateral stem tip and the root covered by a root cap (Fig. 55).

Seed Coat

During the development of the seed, the inner integument gets completely crushed. The external wall of the epidermal layer of the outer integument gets gradually thickened (Fig. 56), while the inner layers become more or less compressed by the developing endosperm. Finally only the epidermal layer persists; its cells become filled with dense contents which take up a deep stain (Figs. 55, 57).

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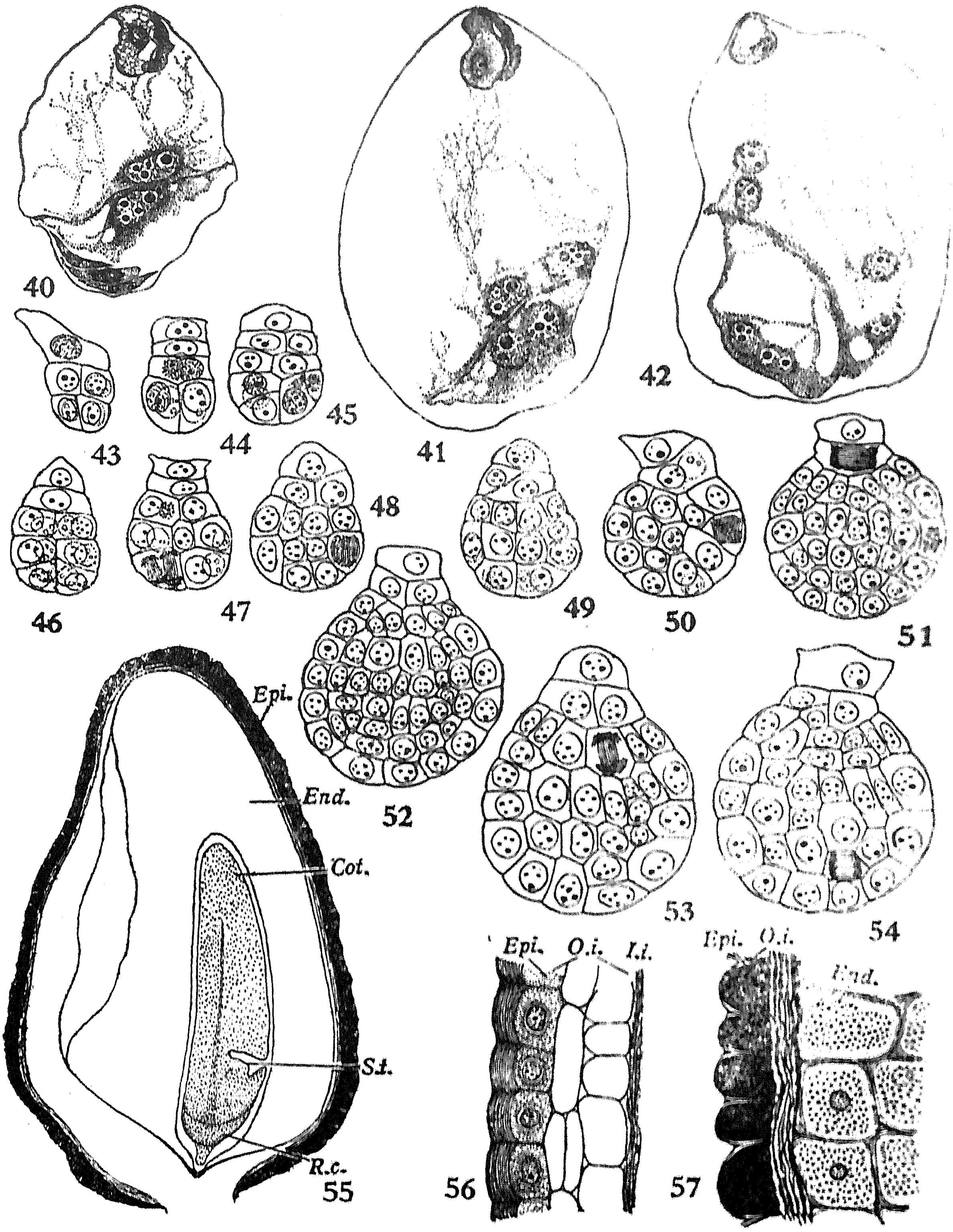

FIGS. 40–57.

Figs. 40–42. Early stages in development of endosperm according to Helobial type, × 291; × 291; × 215. Figs. 43–54. Stages in development of embryo, × 291. Fig. 55. L.S. mature seed, × 30. *Cot.*, cotyledon; *End.*, Endosperm; *Epi.*, Epidermis. ***R.c.***, Root cap; *S.t.*, Stem tip. Figs. 56, 57. Stages in development of seed coat, × 270; × 450. ***End.***, Endosperm; ***Epi.***, Epidermis; *I.i.*, Inner integument; *O.i.*, Outer integument

SUMMARY

The wall of the young anther is made up of four layers of cells. The tapetal cells are binucleate and are of the glandular type. A stomium is organised at the line of dehiscence. The microspores are arranged in an isobilateral manner. The mature pollen grain is two-celled.

Septal nectaries are present on the ovary wall. The ovules are anatropous and bitegmic, and the micropyle is formed by the inner integument. A conducting strand consisting of a biseriate row of cells is seen at the chalazal end of the ovule and this connects the base of the embryo sac with the funicular strand.

The development of the embryo sac follows the Polygonum type. Double fertilisation is observed.

The endosperm is Helobial and its cells are full of starch.

The mature embryo is monocotyledonous. Only epidermal layer of the outer integument persists in the mature seed.

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