B.Sc. Botany

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Paper-IV: EMBRYOLOGY

GROUP-B

MICROSPOROGENESIS

&

MALE GAMETOPHYTE

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MICROSPOROGENESIS AND MALE GAMETOPHYTE

In considering the course of events leading to the origin of the embryo, Embryology first deal with the development of the micro- and megasporangia. It is the microsporangium which produces the microspores and eventually the male gametophyte. Similarly, the megasporangium, or ovule, is the place of formation of the megaspores and the female gametophyte. The latter, after fertilization, produces the embryo and endosperm, while the entire megasporangium with its enclosed structure becomes the seed and the progenitor of the next generation.

MICROSPOROGENESIS

A typical anther comprises four elongated microsporangia, but at maturity the two sporangia of each side become confluent owing to the breaking down of the partition between them . A cross section of a very young anther shows a mass of homogeneous meristematic cells surrounded by the epidermis. It soon becomes slightly four-lobed, and rows of hypodermal cells, become differentiated in each lobe by their larger size, radial elongation, and more conspicuous nuclei. These form the archesporium.

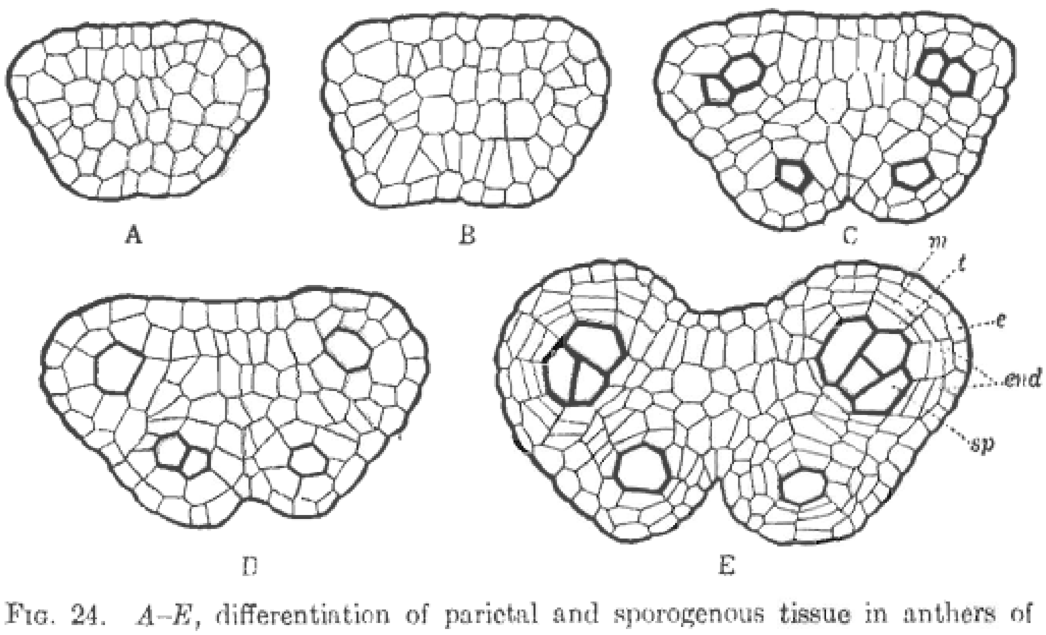


FIG. 24. *A–E*, differentiation of parietal and sporogenous tissue in anthers of *Chrysanthemum leucanthemum* (*e* = epidermis; *end* = endothecium; *m* = middle layer; *t* = tapetum; *sp* = sporogenous cell). (*After Warming, 1873.*)

i. The archesporial cell divide to form a primary parietal layer toward the out side and a primary sporogenous layer toward the inside. The cells of the former divide by periclinal and anticlinal wall to give rise to a series of concentric layers, usually three to five, composing the wall of the anther.

ii. The primary sporogenous cells either function directly as the spore mother cells or undergo further divisions to form a larger number of cells.

The Wall Layers.

i. **The epidermis**, which is the outermost layer of the anther, undergoes only anticlinal divisions. Its cells become greatly stretched and flattened in order to keep pace with the enlargement of the anther, and in many plants, especially those of dry habitats, they eventually lose contact with each other so that only their withering remains can be seen at maturity.

ii. The layer of cells lying immediately beneath the epidermis is the endothecium. Its maximum development is attained at the time when the pollen grains are about to be shed . The cells become radially elongated, and from their inner tangential walls fibrous bands run upward, ending near the outer wall of each cell.

iii. Next to the endothecium there are usually one to three "middle" layers. As a rule, all of them become flattened and crushed at the time of the meiotic division in the microspore mother cells, but there are a few exceptions.

iv. The innermost wall layer or tapetum is of considerable physiological significance, for all the food materials entering into the sporogenou cell must pass through it. Its cells are full of dense cytoplasm, and at the beginning of meiois the tapetal nuclei may also undergo some divisions .

Sporogenous Tissue. The primary sporogenous cells give rise to the microspore mother cells. In some plant the sporogenous cells undergo several divisions , in others only a few diviions, and rarely there are no division at all, so that the primary sporogenous cells function directly as the microspore mother cells. Alangium, Sansevieria, Knautia, and some members of the Malvaceae and Cucurbitaceae are examples of the third kind, showing a single row of microspore mother cells in each anther lobe.

Although all the sporogenous cells in the anther are potentially capable of giving rise to micro pores, ome of them frequently degenerate and become ab sorbed by the remaining cell.

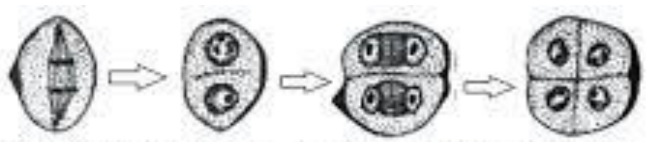
Microspores are formed by reduction division of microspore mother cells and this division is completed in two steps. In the first step, known as meiosis-I, two haploid cells are formed, and the second step, called meiosis-II. It is believed that the stimulus which prompts sporogenous cells to undergo meiosis originates in the vegetative shoot apex.

Cytokinesis. The divisions of the microspore mother cells may be of the successive or the simultaneous type.

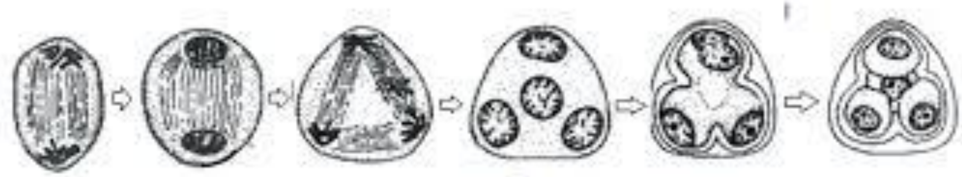
I. Successive type :

In this type a cell plate is laid down immediately after the first meiotic division and another in each of the two daughter cells after the second meiotic division. In the successive type the cell plate is laid down in the center and then extends centrifugally on both sides.

II. Simultaneous type: In this type, no wall is laid down after the first division and the mother cell become separated all at once into four parts after both the meiotic divisions are over. In the simultaneous type, the division usually occurs by centripetally advancing constriction furrows, which meet in the center and divide the mother cell into four parts.



Various stages during successive type of cytokinesis during microsporogenesis



Various stages during simultaneous type of cytokinesis during microsporogenesis

The Microspore Tetrad. The microspores are usually arranged in a tetrahedral or isobilateral fashion. Besides the above two types, sometimes microspores may be arranged in Decussate (e.g., Magnolia, Crocus, Atriplex), T –shaped (e.g., Aristolochia, Butomopsis) or Linear (e.g., Halophila) tetrads.

In Asclepiadaceae all pollens in a pollen sac are united in a single compact mass, known as Pollinia.

The pollinia are also formed in Orchidaceae but in certain members of this family the pollinium is less compact as it comprises smaller groups

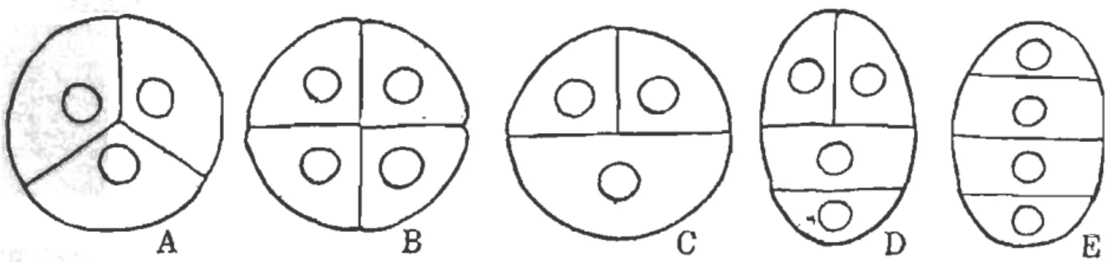


FIG. 35. Diagram showing different types of microspore tetrads. *A*, tetrahedral. *B*, isobilateral. *C*, decussate. *D*, T-shaped. *E*, linear. (*B-E*, *after* Boehm, 1931.)

Fate of the microspores

The callose wall of the tetrad stage is broken down by an enzyme called callase and the freed pollen grains grow in size and develop their characteristic shape.

At the structure level, they form a resistant outer wall called the exine and an inner wall called the intine. The exine is made up of a resistant compound called sporopollenin; the intine made up of cellulose and pectin. The exine often bears spines or warts , or is variously sculptured , and the character of the markings is often of value for identifying genus, soecies, or even cultivar.

In most flowering plants, germination of the microspore begins before it leaves the microsporangium. At maturity, each pollen grain contains a vegetative (non-reproductive) cell and a generative cell containing two nuclei: a tube nucleus and a generative nucleus.

Mature pollens are then transferred by various modes to the compatible stigma. The transfer of pollen grains to the female reproductive structure is called **pollination**.

MALE GAMETOPHYTE

Male Gametophyte Development

The microspore is the first cell of male gametophyte. The germination of microspore starts *in situ*.

1. Microspores divides by asymmetric mitotic division into a large tube cell and small generative cell. The smaller generative cell is completely enclosed within the cytoplasm of the larger vegetative cell.
2. The vegetative nucleus is not always in the distal end of the pollen tube (where it would be most expected if it had any important function in directing the growth of the tube) but frequently lies considerably behind the male gametes.
3. Pollination takes place at this two celled stage in about 70 % of angiosperms. In such examples, the further development of the male gametophyte takes upon stigma.

4. For further development, a mitotic division of the generative cell generates two sperm cells which remain connected by a common extracellular matrix with potential intercellular connections. In about 30 % angiosperms, pollination occurs at three celled stage. It is well studied in families like Brassicaceae and Asteraceae.

Male gametophyte formation

1. Pollen grain expands by absorbing the liquid from the moist surface of stigma. Stigma provides boron, sugar, amino acids etc.
2. The intine comes out in the form of pollen tube, from germ pores: Growth of pollen tube is apical and chemotropic.
3. The pollen grains are either monosiphonous (with one pollen tube) or polysiphonous (with more than one pollen tubes) e.g., members of Cucurbitaceae and Malvaceae.
4. The generative nucleus divides mitotically to form two male gametes called sperm. The male gametes are non-motile and amoeboid. They are slightly unequal in size.

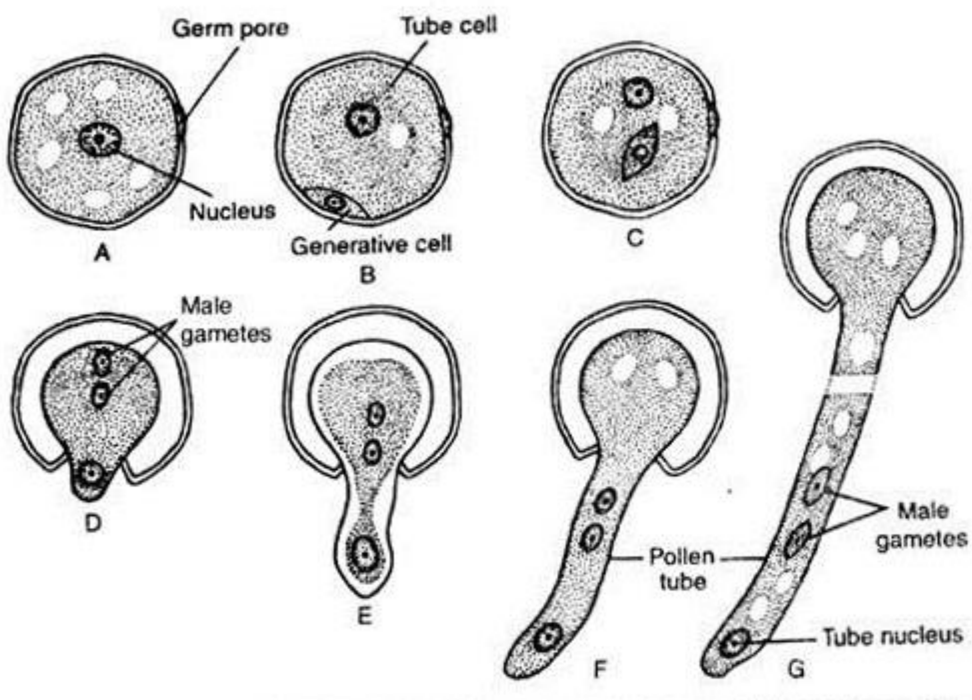


Fig. 3.5 : A-G. Germination of the pollen grain and development of the male gametes

Male germ Unit :- The shared extracellular matrix of the two sperm cells and the physical association of one sperm cell to the vegetative cell nucleus forms a linkage of all the genetic material in the pollen grain, termed the male germ unit.

Pollen Embryo Sacs (Nemec Phenomenon)

Generally the developing male gametophytes are either 2 or 3 nucleated and spherical in form. But Nemec (1898) observed eight nucleated embryosac like male gametophytes in petaloid anthers of *Hyacinthus orientalis.* Such abnormal male gametophytes are called as **pollen embryo sacs.**