Pollination and Embryo Development

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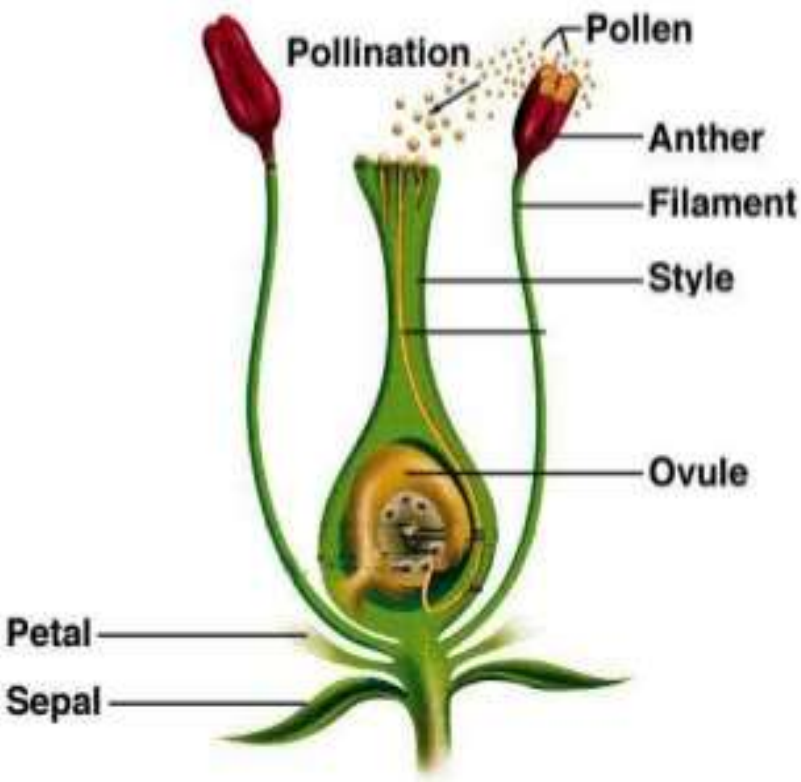
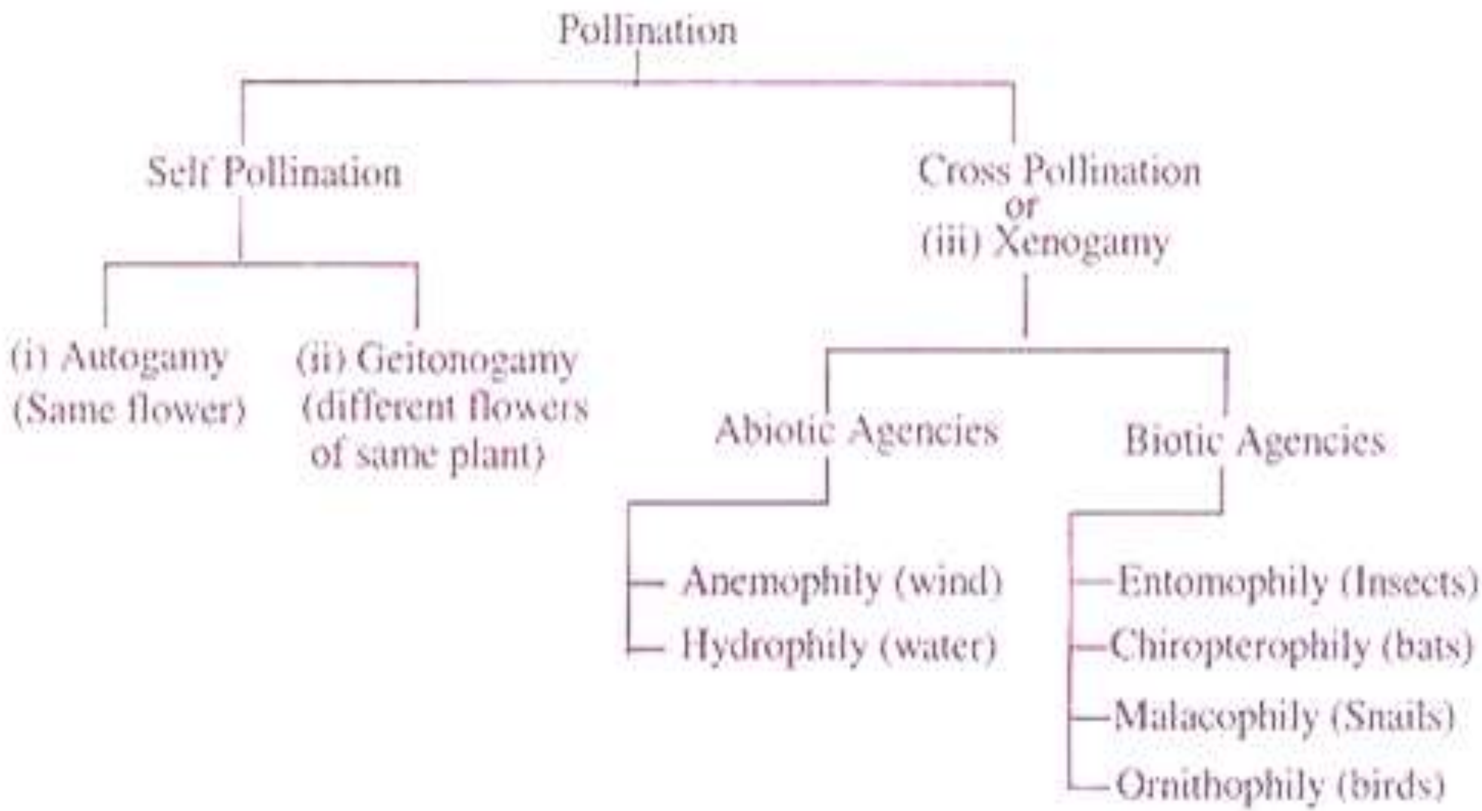
Pollination

- Matured pollen grains have to reach the appropriate stigma.
- Pollinators can be animals – mainly insects – wind or even water.
- It is important to transport the pollen grains onto the stigma of the same species.
- In low diversity ecosystems, wind-pollination can be effective, but those species that scattered in large area, the animal-pollination is more efficient.

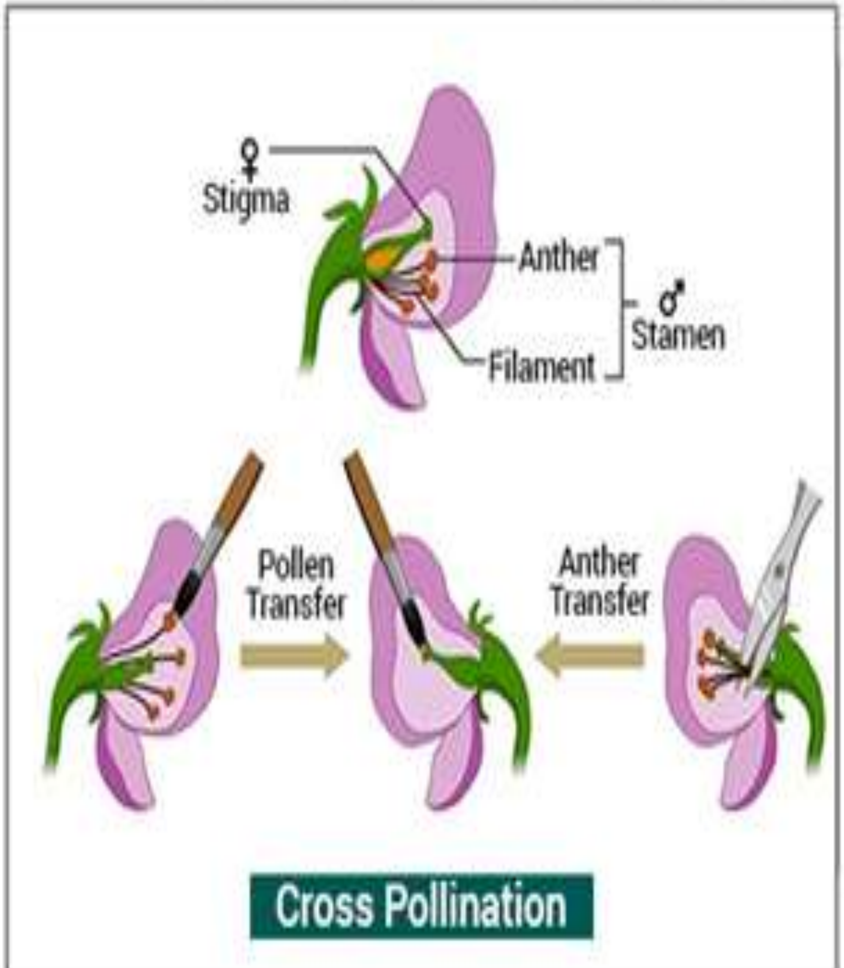
Pollination

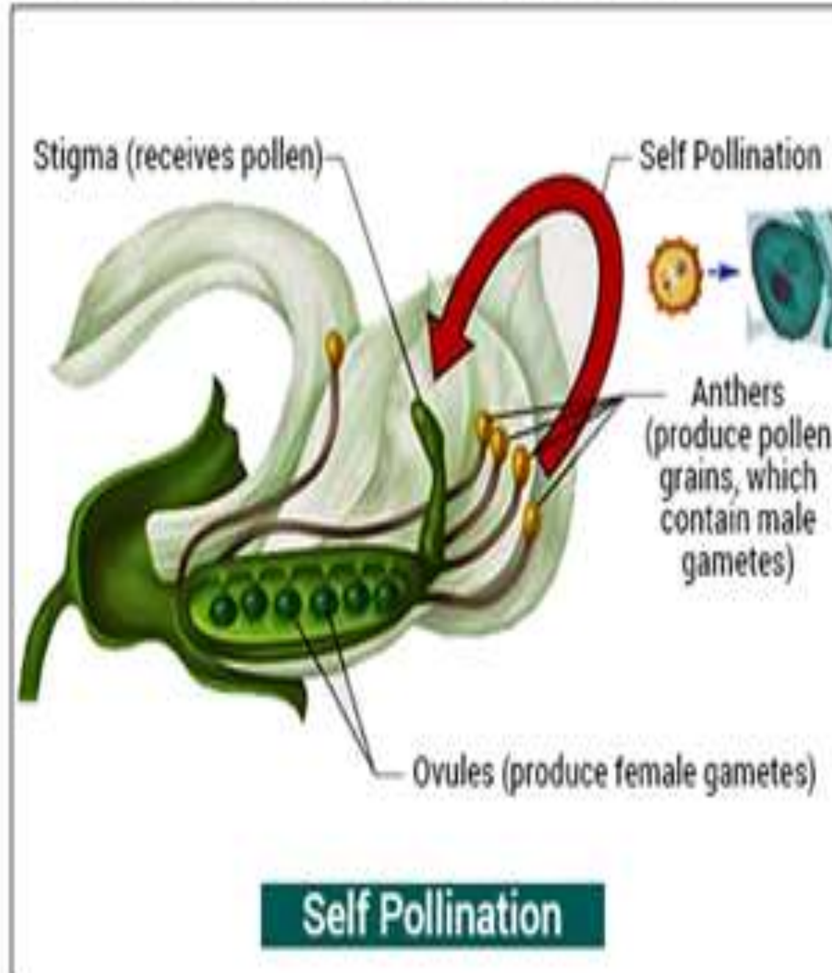


Pollination: the transfer of pollen from the anther to the sticky stigma by wind, animals/insects or water.


Pollination
Self Pollination
Cross Pollination
or
(iii) Xenogamy
(i) Autogamy
(Same flower)
(ii) Geitonogamy
(different flowers
of same plant)
Abiotic Agencies
Biotic Agencies
Anemophily (wind)
Hydrophily (water)
Entomophily (Insects)
Chiropterophily (bats)
Malacophily (Snails)
Ornithophily (birds)

Cross Pollination vs. Self Pollination





Development of Pollen Wall

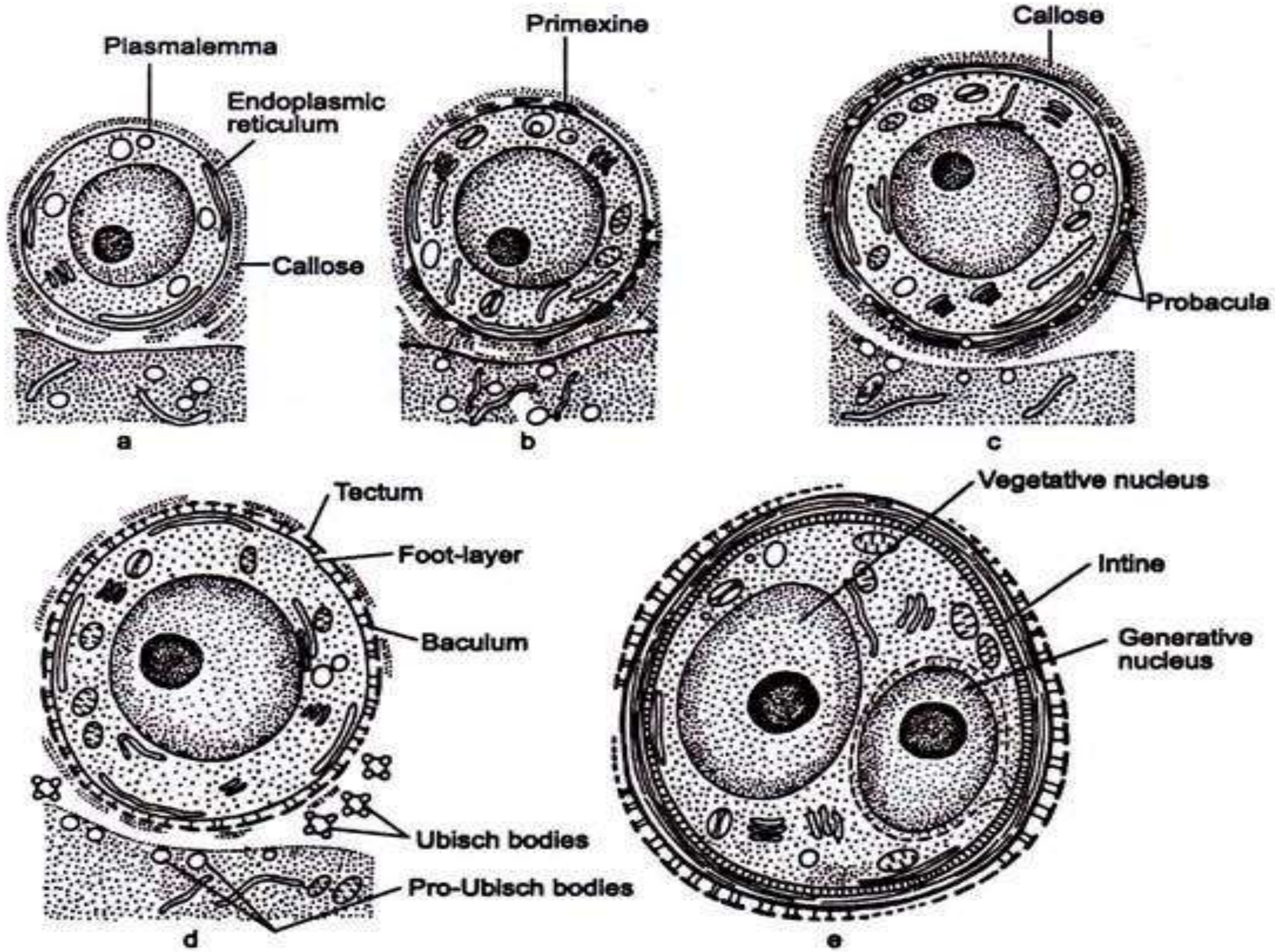


Fig. 2.1 : Ubisch bodies formation and the development of pollen wall.
a. Callose wall surrounds the plasmalemma; b. Discontinuous primexine; c. Appearance of probaculae in the primexine; d. Formation of baculae and tectum; e. Synthesis of intine and innermost layer of exine.

Development of Pollen Wall

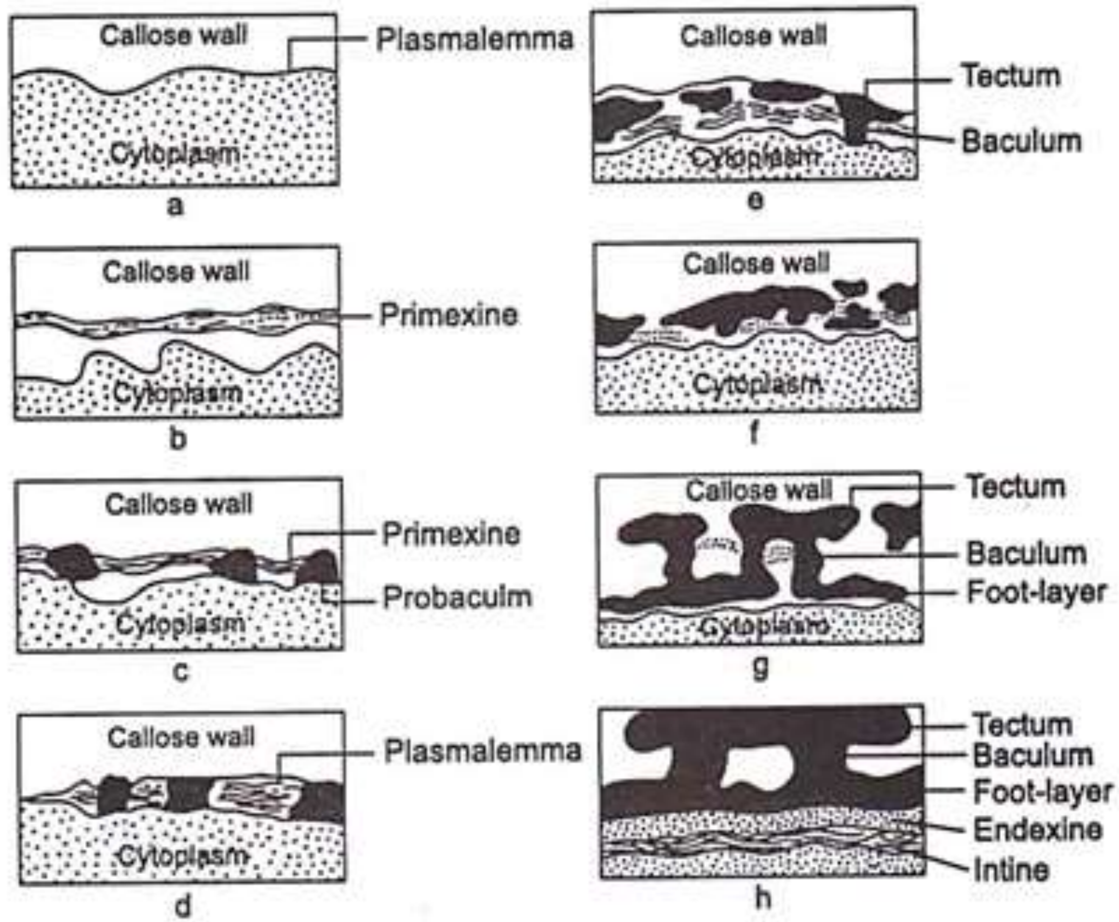
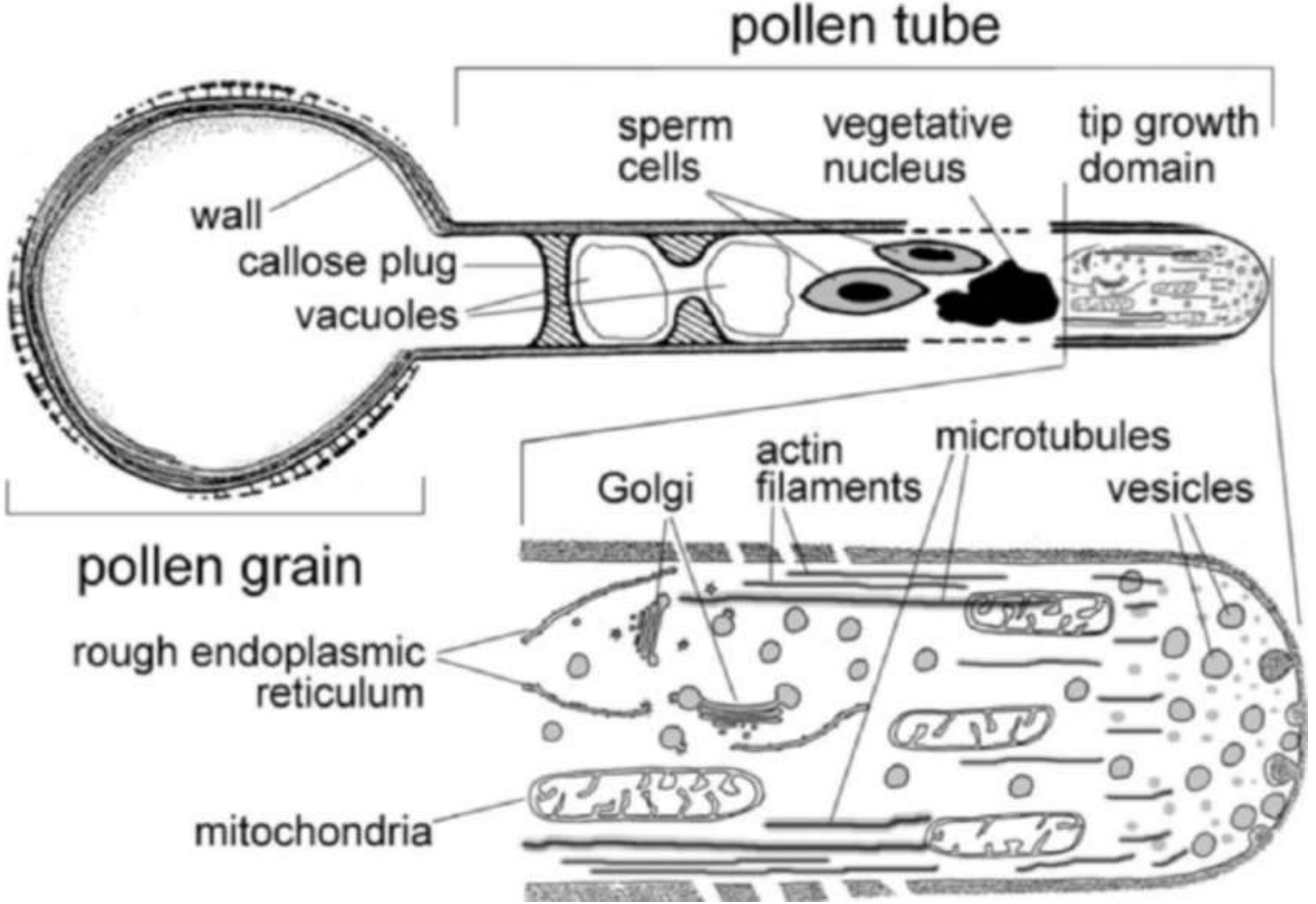


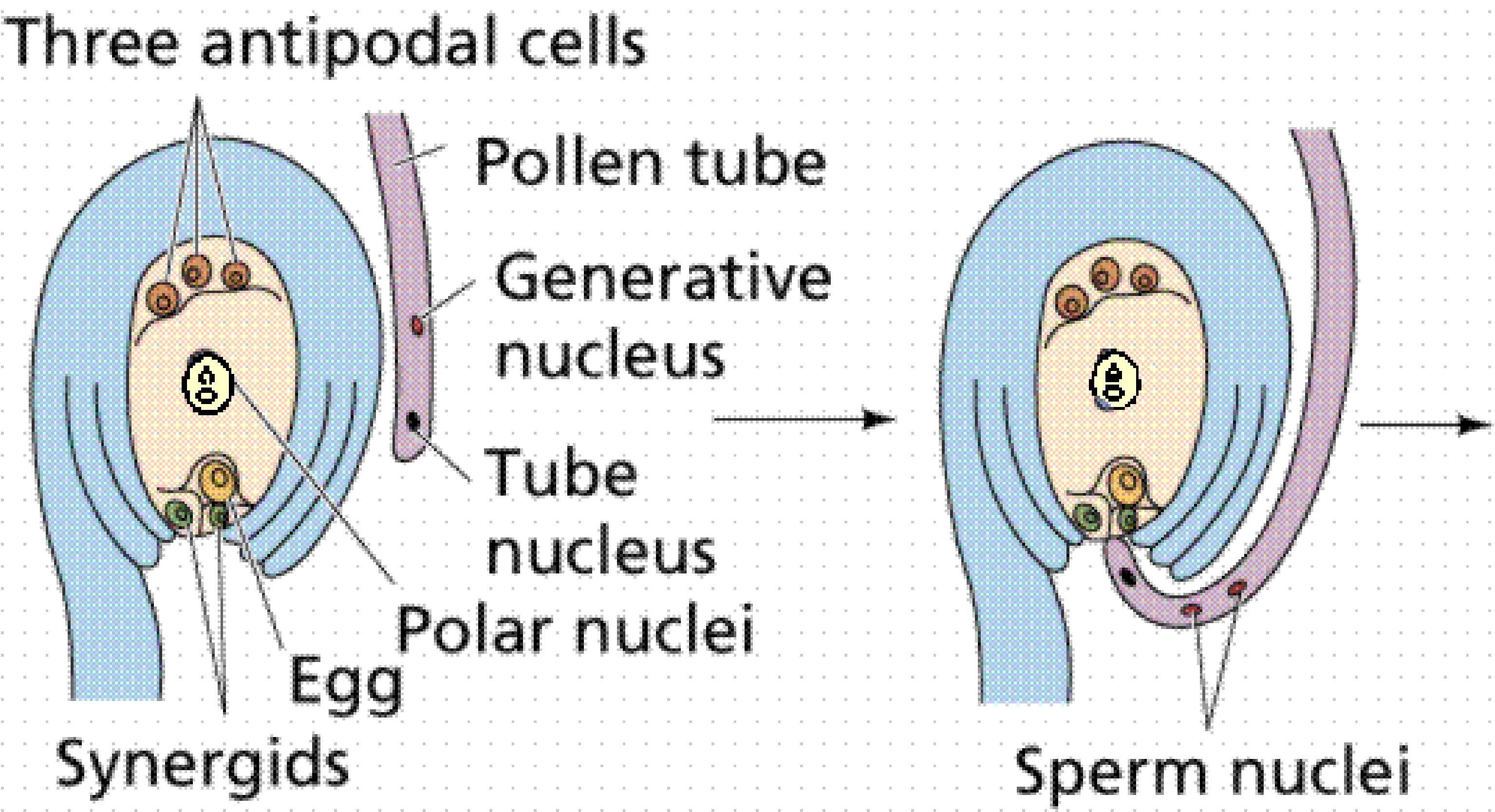
Fig. 2.2 : Diagrammatic development of the pollen wall. a. Callose wall surrounds the plasmalemma; b. Deposition of primexine between the callose wall and the plasmalemma; c and d. Appearance and penetration of probaculae in the primexine; e. Formation of the baculae and tectum; f and g. Disappearance of the callose wall and the formation of well developed ektexine; h. Fully developed wall.

Pollen tube grows

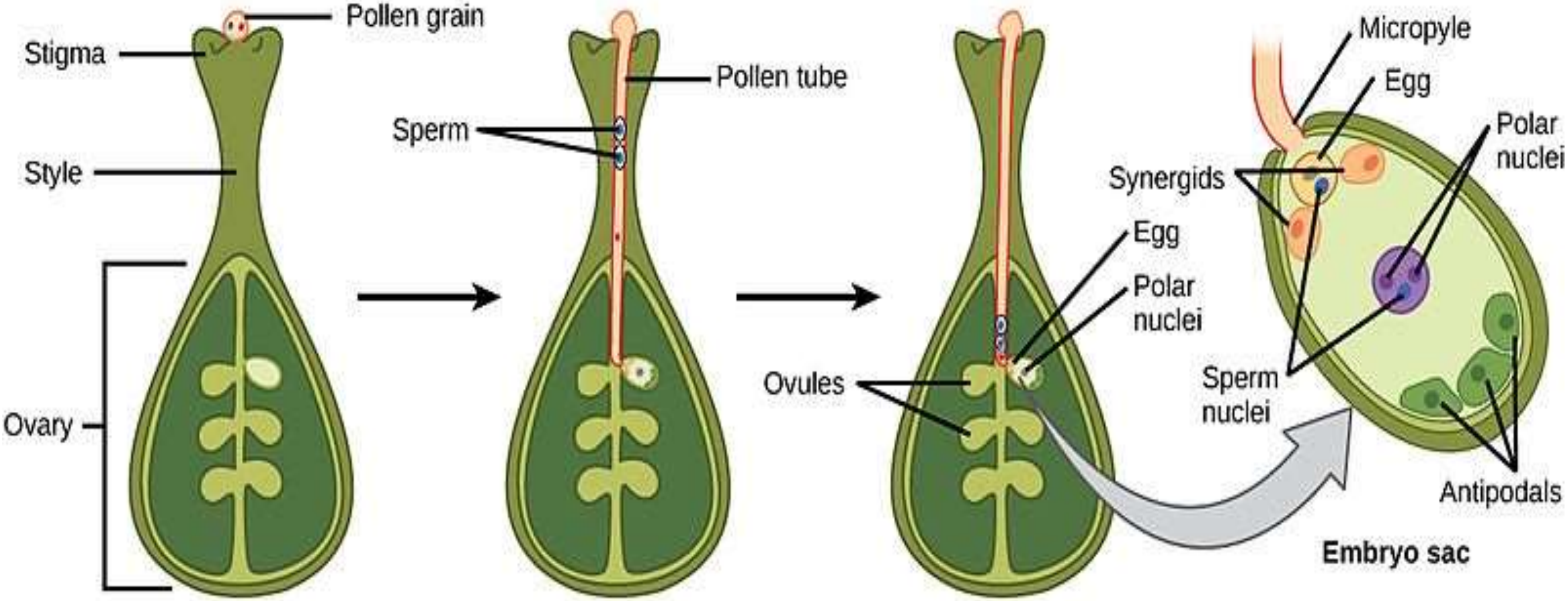
- As a result of successful pollen stigma interaction, an intimate connection is established between the stigma papilla and the pollen wall.
- Pollen grains take up water and other compounds provided by stigma papillae.
- Due to the swelling of pollen grains, the pores or slits – that the germinating places of the pollen tube – are exposed, and pollen germination can start.
- The intine layer protrudes and pollen tube grows onto the surface of the stigma.
- The vegetative cell enters into the tube with the vegetative nucleus first, and generative cell or sperm cells behind it.
- The pollen tube enters the tissue of stigma and grows downward in the intercellular space or loose walls of the transmission tissue.


pollen tube
sperm cells
vegetative nucleus
tip growth domain
wall
callose plug
vacuoles
pollen grain
microtubules
actin filaments
Golgi
vesicles
rough endoplasmic reticulum
mitochondria

- Reaching the end of the style, pollen tubes enter into the ovary and continue their way on the inner surface of the ovary or on the central axis, if any.
- The guidance of tube is partially mechanical (elongated cells in the transmission tissue) and partially chemical.
- The latter is more important near the ovules where pollen tubes are attracted by chemical signals toward the micropyle.


Three antipodal cells
Pollen tube
Generative nucleus
Tube nucleus
Polar nuclei
Egg
Synergids
Sperm nuclei

Pollination and Fertilization



The pollen grain adheres to the stigma, which contains two cells: a generative cell and a tube cell.

The pollen tube cell grows into the style. The generative cell travels inside the pollen tube. It divides to form two sperm.

The pollen tube penetrates an opening in the ovule called a micropyle.

One of the sperm fertilizes the egg to form the diploid zygote. The other sperm fertilizes two polar nuclei to form the triploid endosperm, which will become a food source for the growing embryo.

Fertilization

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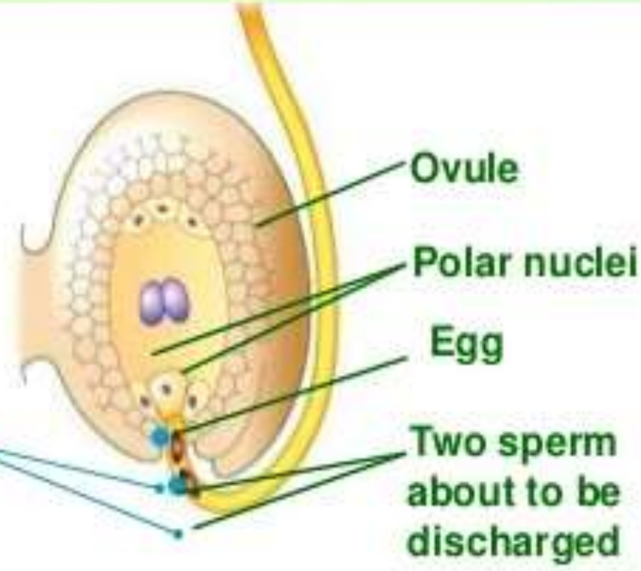
The pollen tube discharges two sperm into the female gametophyte (embryo sac) within an ovule.



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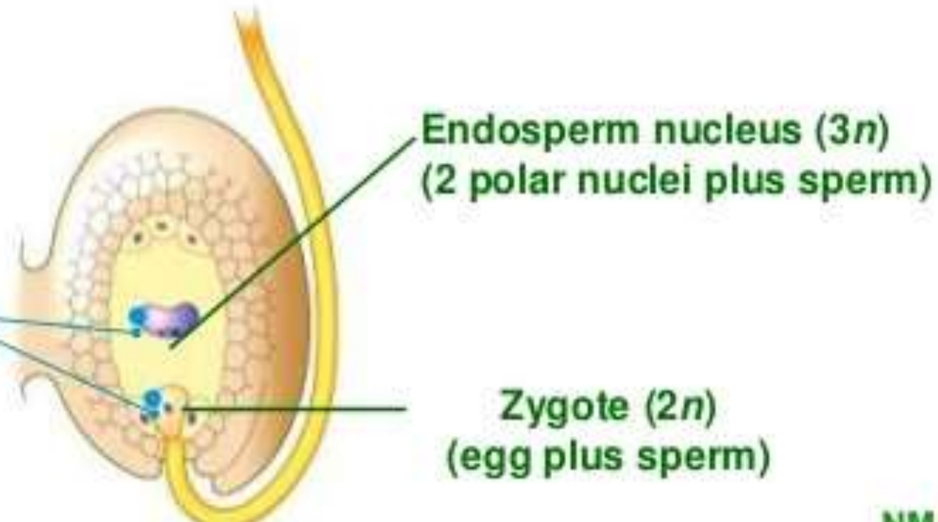
One sperm fertilizes the egg, forming the zygote. The other sperm combines with the two polar nuclei of the embryo sac's large central cell, forming a triploid cell that develops into the nutritive tissue called endosperm.



NM Spirit

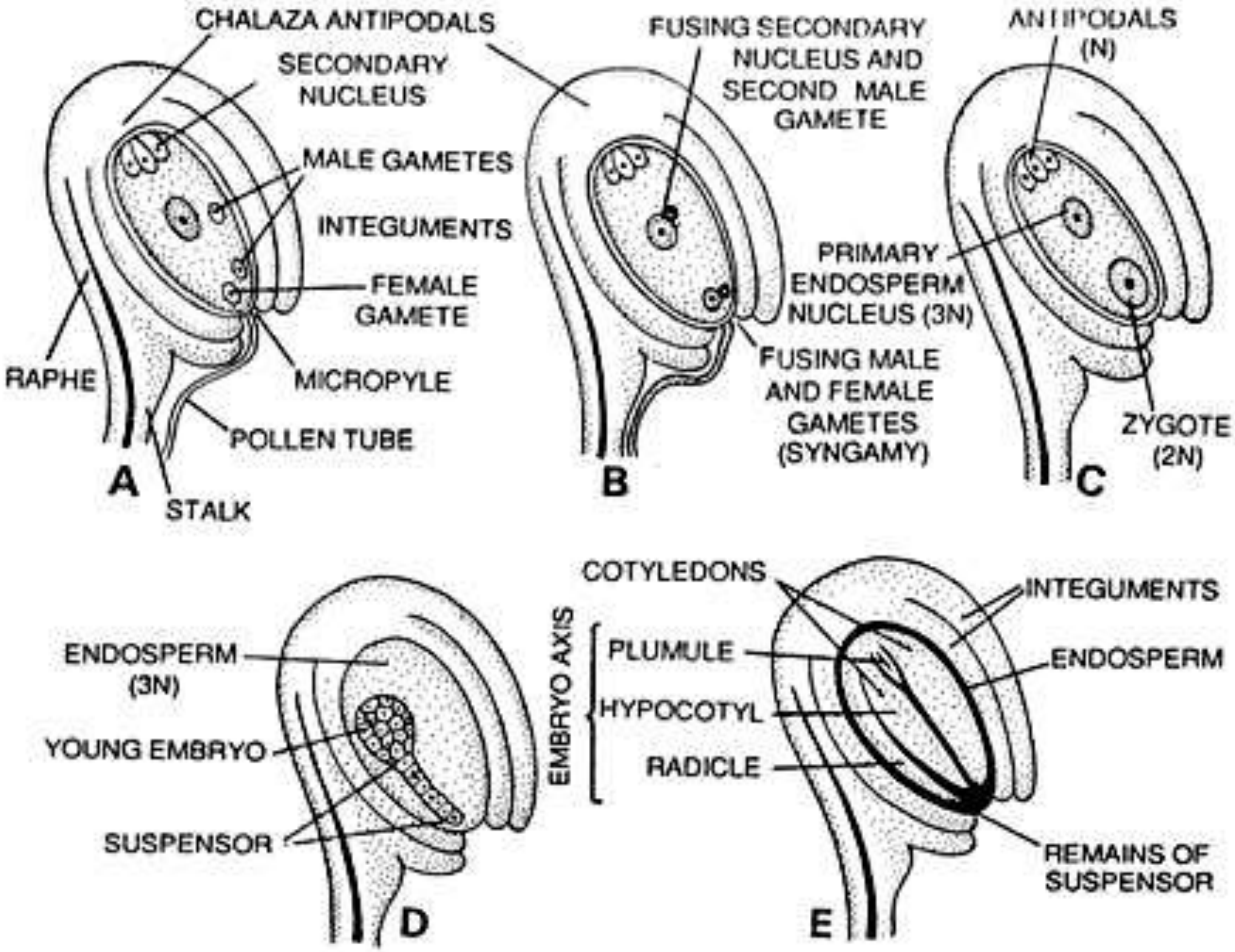
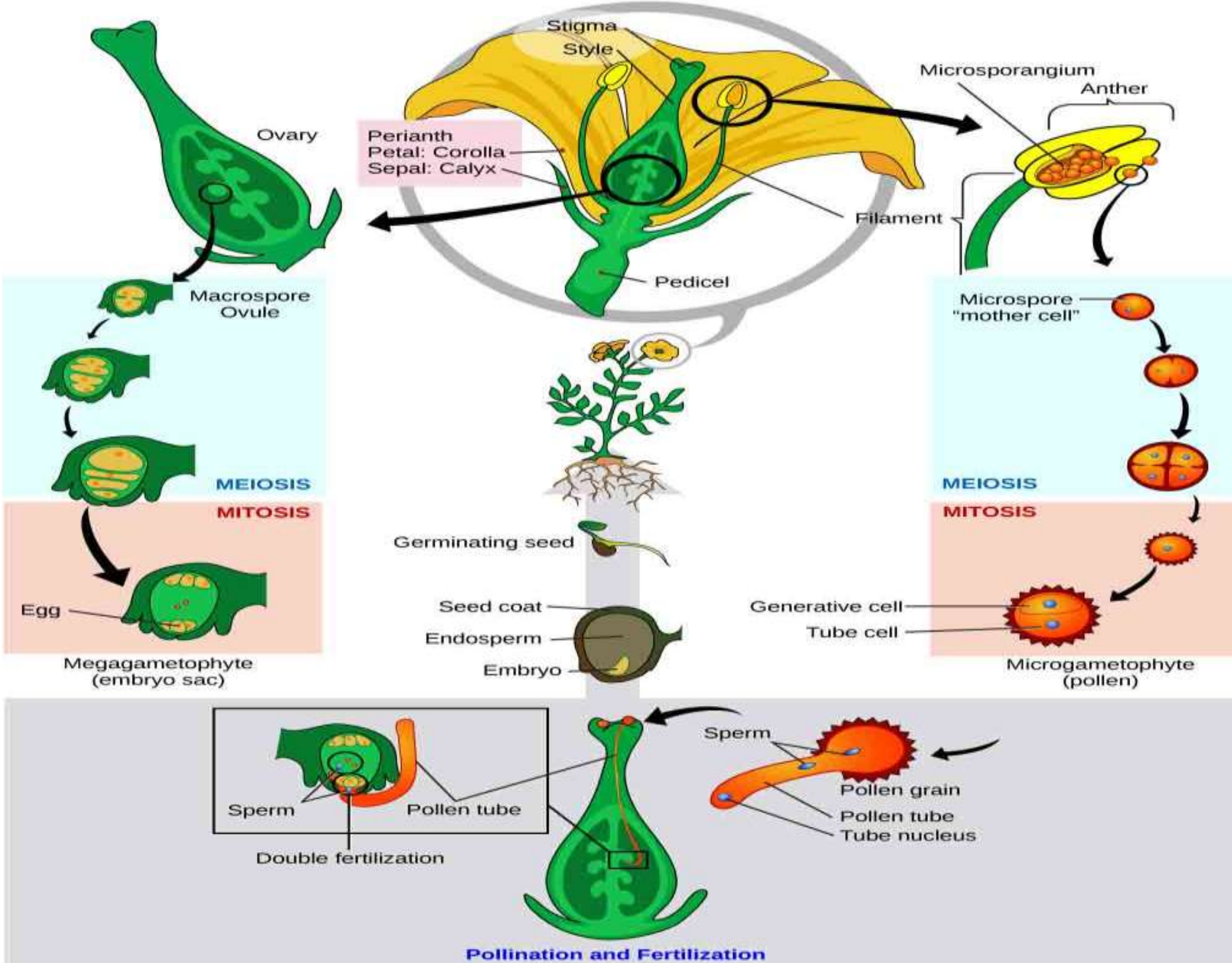
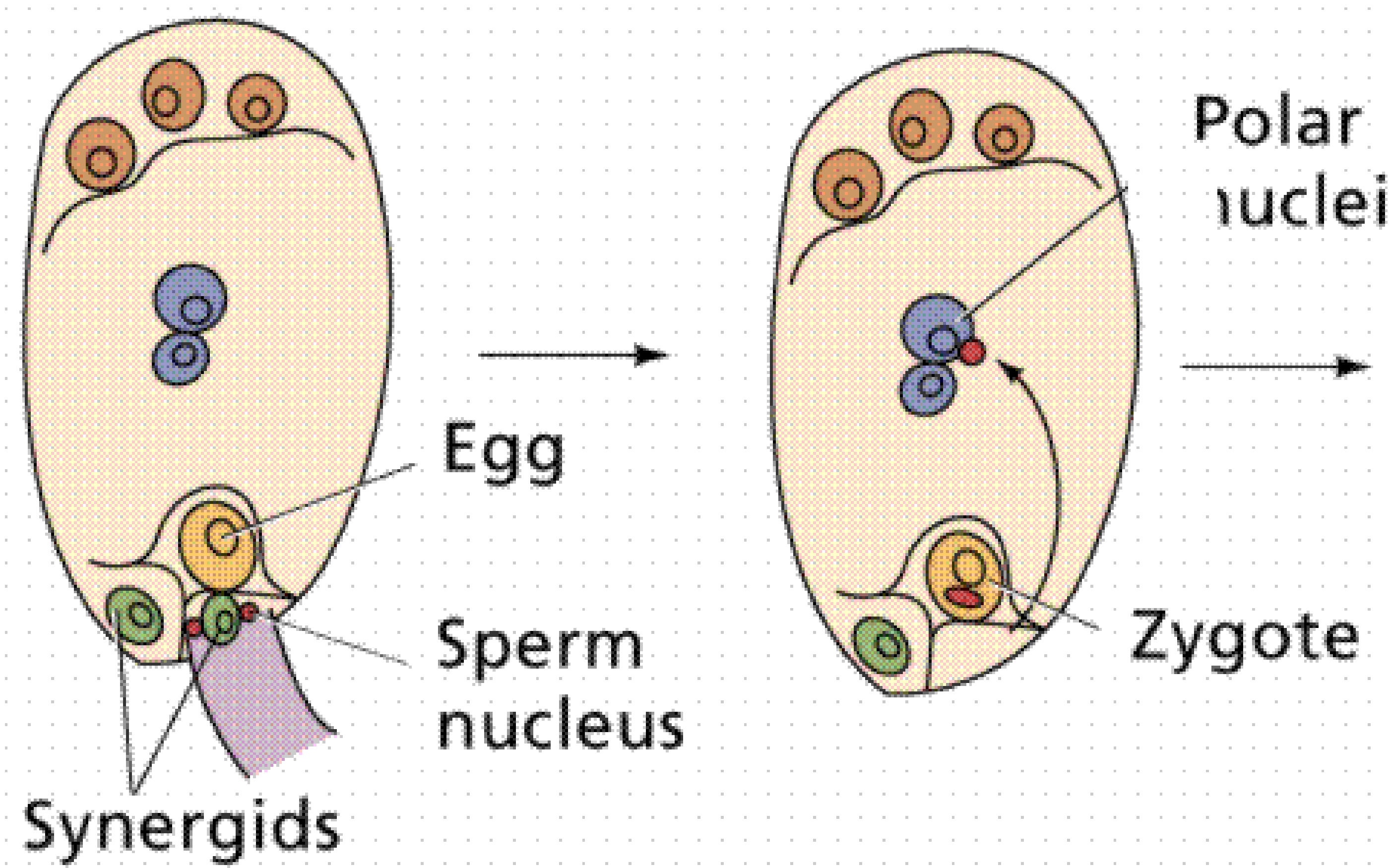


Fig. 46.38. Fertilization and post-fertilization changes. A, two male gametes discharged in the embryo sac; B, syngamy and double fertilization; C, formation of zygote (2n) and primary endospern nucleus (3n); D-E, post fertilization changes.


Stigma
Style
Microsporangium
Anther
Ovary
Perianth
Petal: Corolla
Sepal: Calyx
Filament
Pedicel
Macrospore
Ovule
Microspore
"mother cell"
MEIOSIS
MITOSIS
MEIOSIS
MITOSIS
Germinating seed
Egg
Seed coat
Endosperm
Embryo
Generative cell
Tube cell
Megagametophyte
(embryo sac)
Microgametophyte
(pollen)
Sperm
Sperm
Pollen tube
Pollen grain
Pollen tube
Tube nucleus
Double fertilization
Pollination and Fertilization

Double fertilization

- One sperm nucleus fertilizes the egg, generating a **2N diploid zygote.**
- Another sperm nucleus fertilizes a polar cell with two 1N nuclei, generating a 3N **triploid endosperm**, which provides nutrients to the developing embryo.


Polar
ıuclei
Egg
Sperm
nucleus
Synergids
Zygote

Embryo

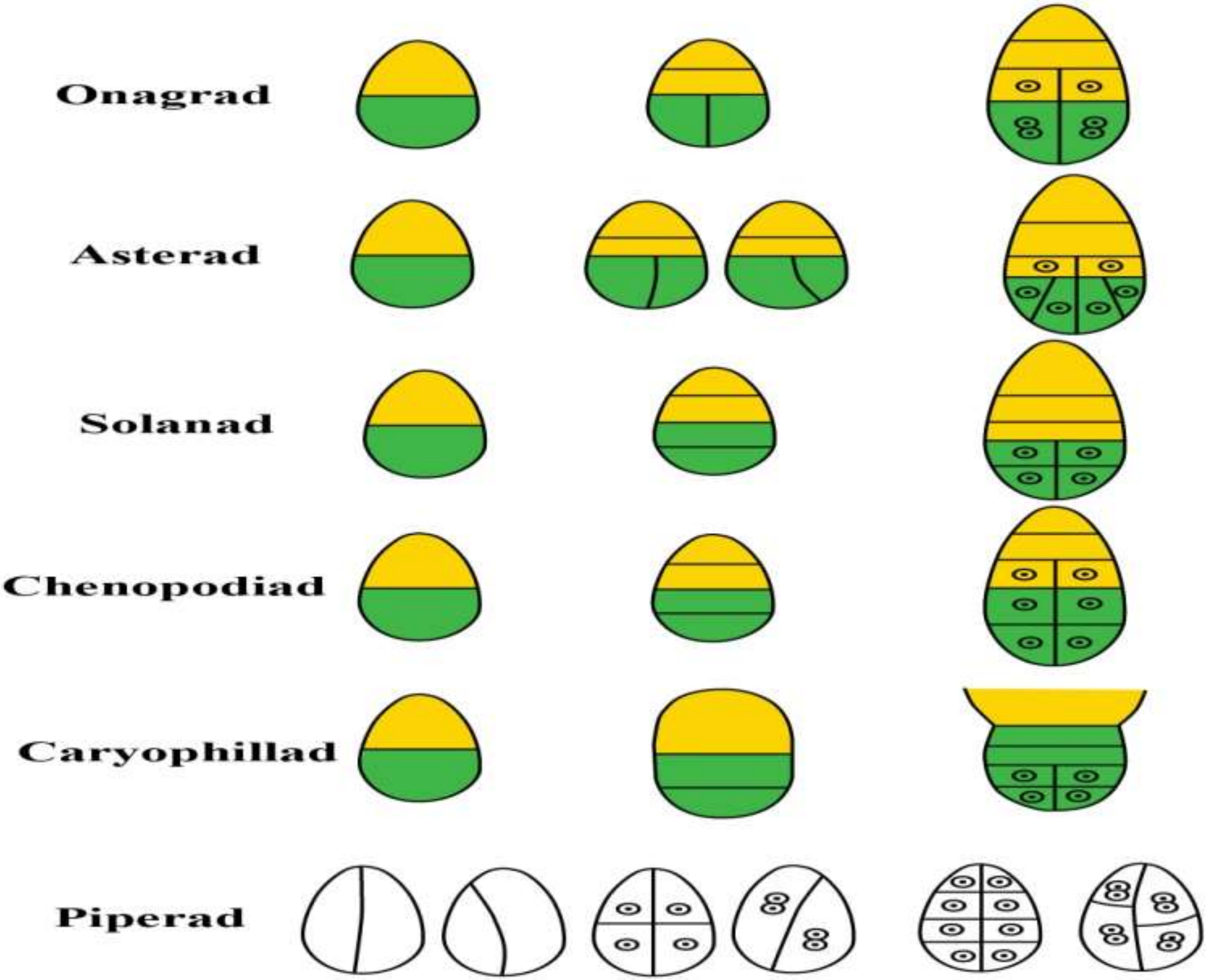
- After fertilization, the fertilized egg is called zygote or oospore which develops into an embryo.
- The oospore before it actually enters into the process undergoes a period of rest which may vary from few hours to few months.
- Generally the zygote (oospore) divides immediately after the first division of the primary endosperm nucleus.
- Practically there are no fundamental differences in the early stages of the development of the embryos of monocots and dicots.
- But in late stages, there is a marked difference between the embryos of dicotyledonous and monocotyledonous plants, hence their embryogenesis has been considered here separately.

Development of Embryo in Dicots

- According to Soueges, the mode of origin of the four-celled pro-embryo and the contribution made by each of these cells makes the base for the classification of the embryonal type.
- However, Schnarf (1929), Johansen (1945) and Maheshwari (1950) have recognized five main types of embryos in dicotyledons.
- **They are**
- **(i) Crucifer type**
- **(ii) Asterad type**
- **(iii) Solanad type**
- **(iv) Caryophyllod type**
- **(v) Chenopodiad type**

- The terminal cell of the two-celled pro-embryo divides by longitudinal wall.
- **Crucifer type:** Basal cell plays little or no role in the development of the embryo.
- **Asterad type:** Basal and terminal cells play an important role in the development of the embryo.
- The terminal cell of the two-celled proembryo divides by a transverse wall, Basal cell plays a little or no role in the development of the embryo.
- **Solanad type:** Basal cell usually forms a suspensor of two or more cells.

- **Caryophyllod type:** Basal cell does divide further.
- **Chenopodiad type:** Both basal and terminal cells take part in the development of the embryo.
- **Development of dicot embryo in Capsella bursa-pastoris (Crucifer type):**
- For the first time Hanstein (1870) worked out the details of the development of embryo in Capsella bursa- pastoris, a member of Crucifeae.
- The oospore divides transversely forming two cells, a terminal cell and basal cell.
- The cell towards the micropylar end of the embryo sac is the suspensor cell (i.e., basal cell) and the other one makes to the embryo .cell (i.e., terminal cell).


Onagrad
Asterad
Solanad
Chenopodiad
Caryophillad
Piperad

Structure of Dicot Embryo:

- A typical dicotyledonous embryo consists of an embryonal axis and two cotyledons.
- The part of embryonal axis above the level of cotyledons is called epicotyl.
- It terminates with the stem tip, called plumule (future shoot).
- The part below the level of cotyledons is called hypocotyl which terminates in the root tip called radicle (future root).
- The root tip is covered with a root cap (calyptra).

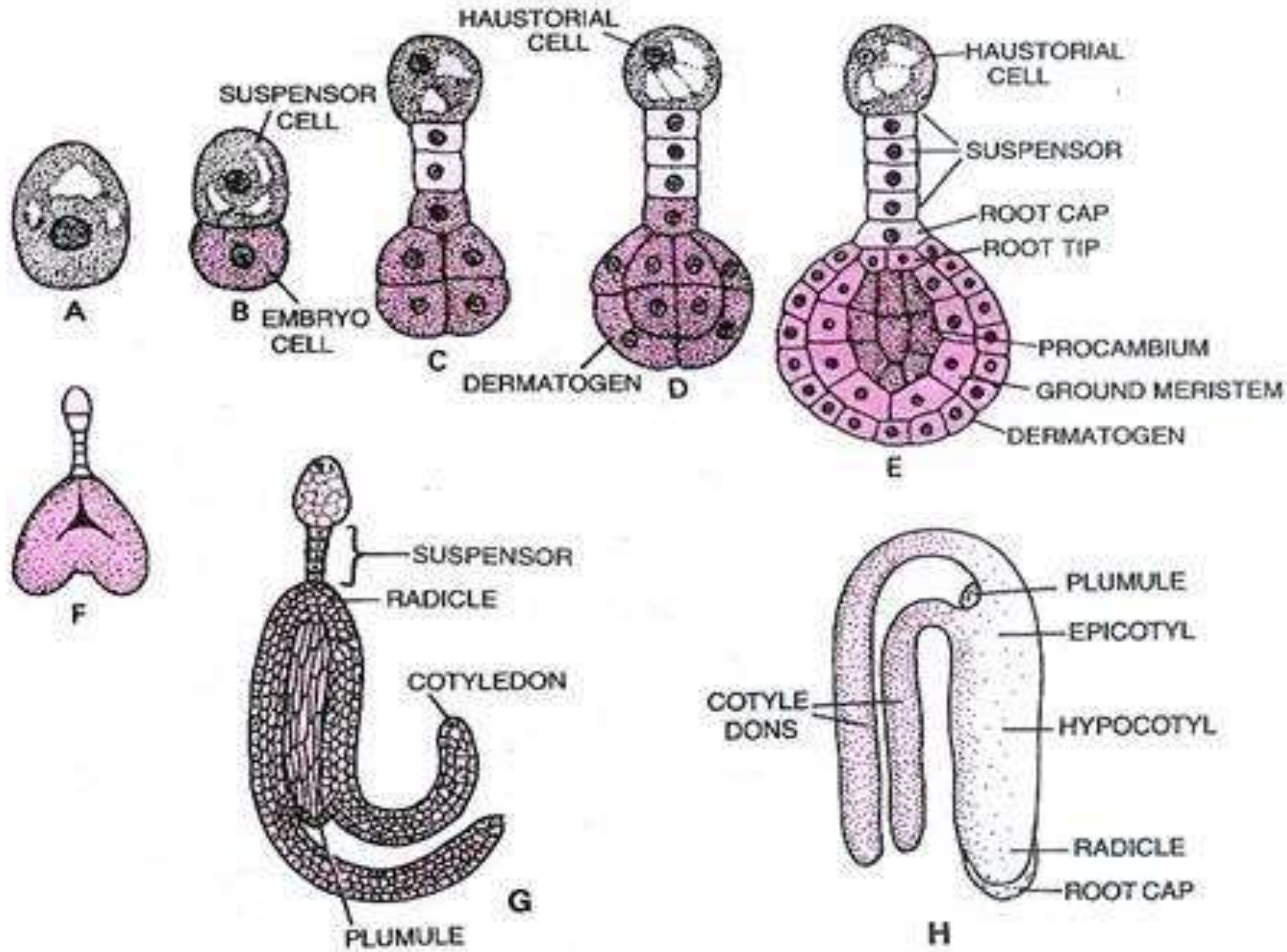


Fig. 2.30. Stages in the development of a dicot embryo. A, Zygote or oospore. B, Division of zygote into suspensor and embryo cells. C, Formation of suspensor and embryo octant. D, Periclinal divisions of embryo octants to form outer dermatogen. E, Globular embryo showing regions of radicle, procambium, ground meristem and dermatogen. F, Heart-shaped embryo. G, Mature dicotyledonous embryo. H, a typical dicot embryo.

- The four cells next to the suspensor are termed the hypo-basal or posterior octants while the remaining four cells make the epibasal or anterior octants.
- The epibasal octants give rise to plumule and the cotyledons, whereas the hybobasal octants give rise to the hypocotyl with the exception of its tip.
- Now all the eight cells of the octant divide periclinally forming outer and inner cells.
- The outer cells divide further by anticlinal division forming a peripheral layer of epidermal cells, the dermatogen.
- The inner cells divide by longitudinal and transverse divisions forming periblem beneath the dermatogen and plerome in the central region.
- The cells of periblem give rise to the cortex while that of plerome form the stele.

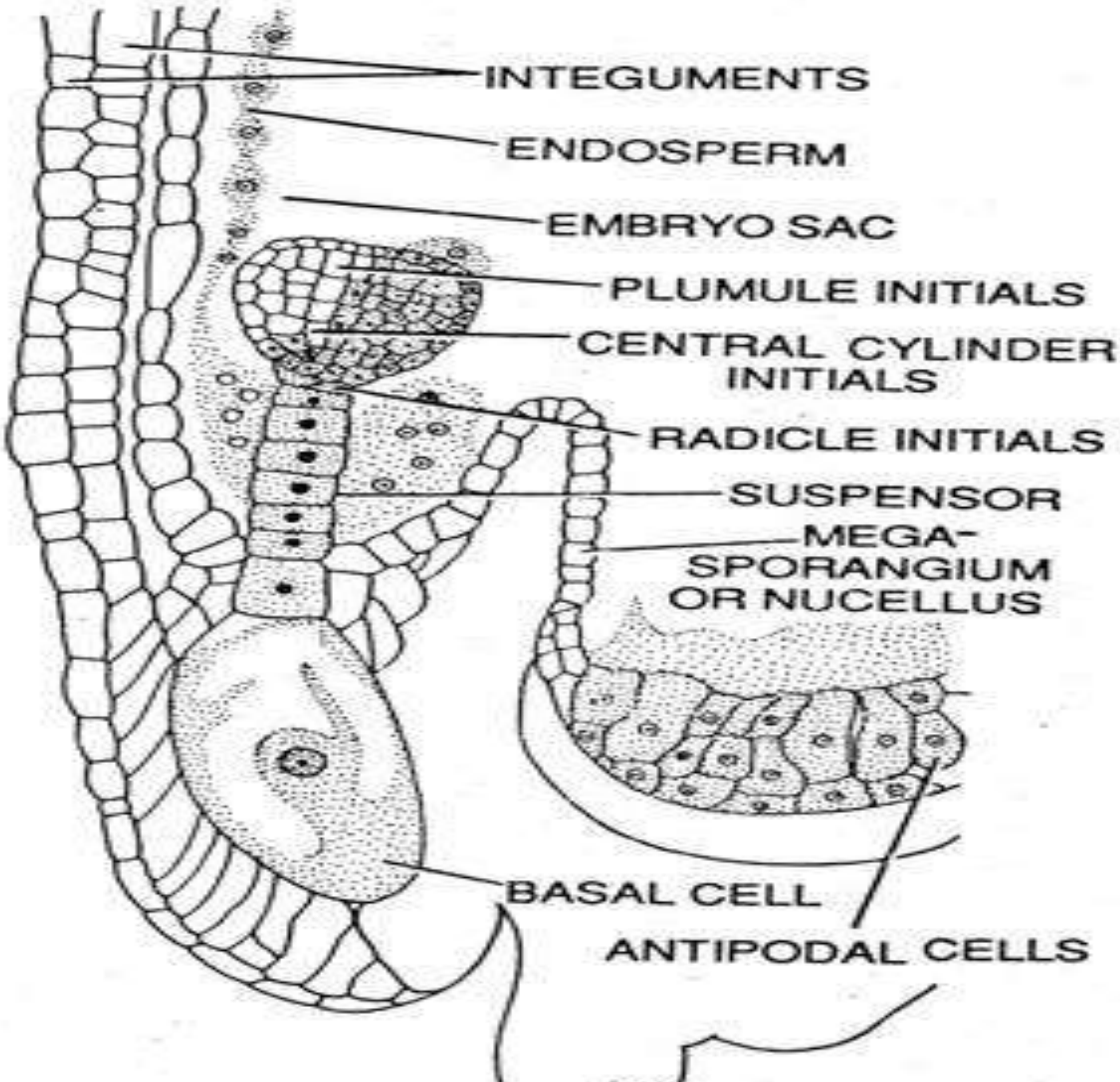


Fig. 46.43. The embryo. L.S. showing differentiation of embryo in *Capsella*.

Development of Embryo in Monocots

- There is no essential difference between the monocotyledons and the dicotyledons regarding the early cell divisions of the proembryo, but the mature embryos are quite different in two groups.
- Here the embryogeny of Sagittaria sagittifolia has been given as one of the examples.
- The zygote divides transversely forming the terminal cell and the basal cell.
- The basal cell, which is the larger and lies towards the micropylar end, does not divide again but becomes transformed directly into a large vesicular cell.
- The terminal cell divides transversely forming the two cells. of these, the lower cell divides vertically forming a pair of juxtaposed cells, and the middle cell divides transversely into two cells.

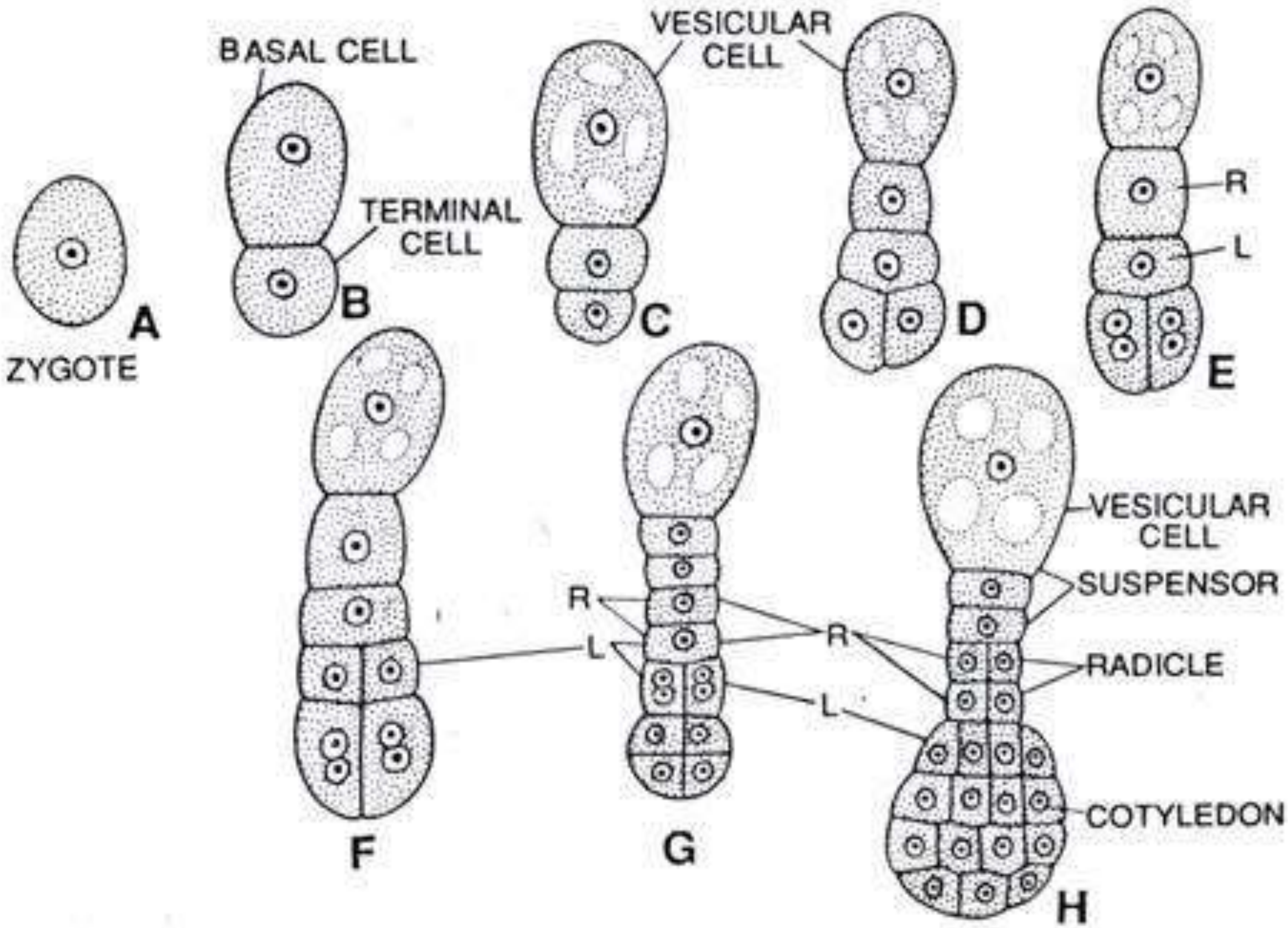


Fig. 46.44. Stages in the development of a typical monocot embryo in *Sagittaria*.

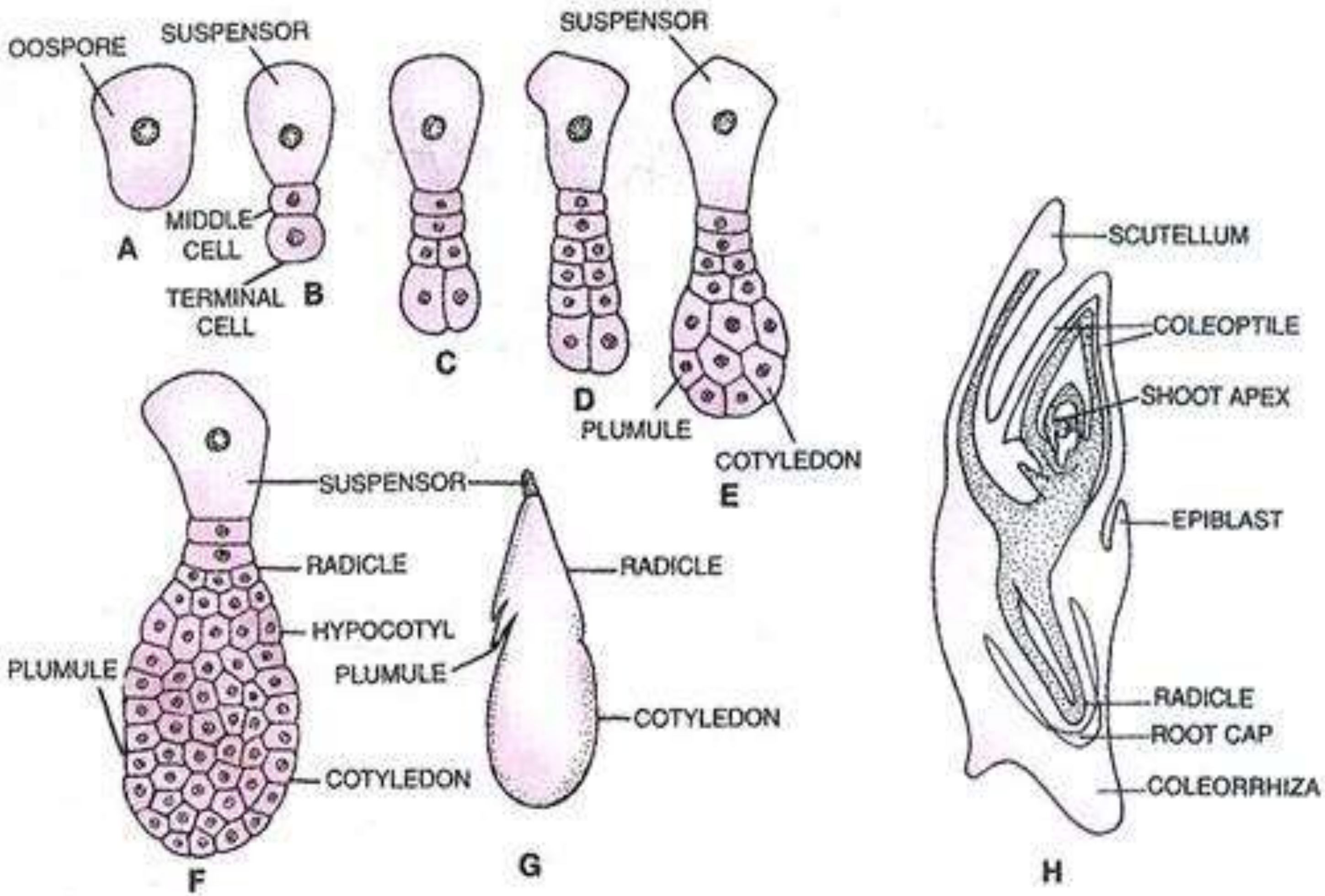
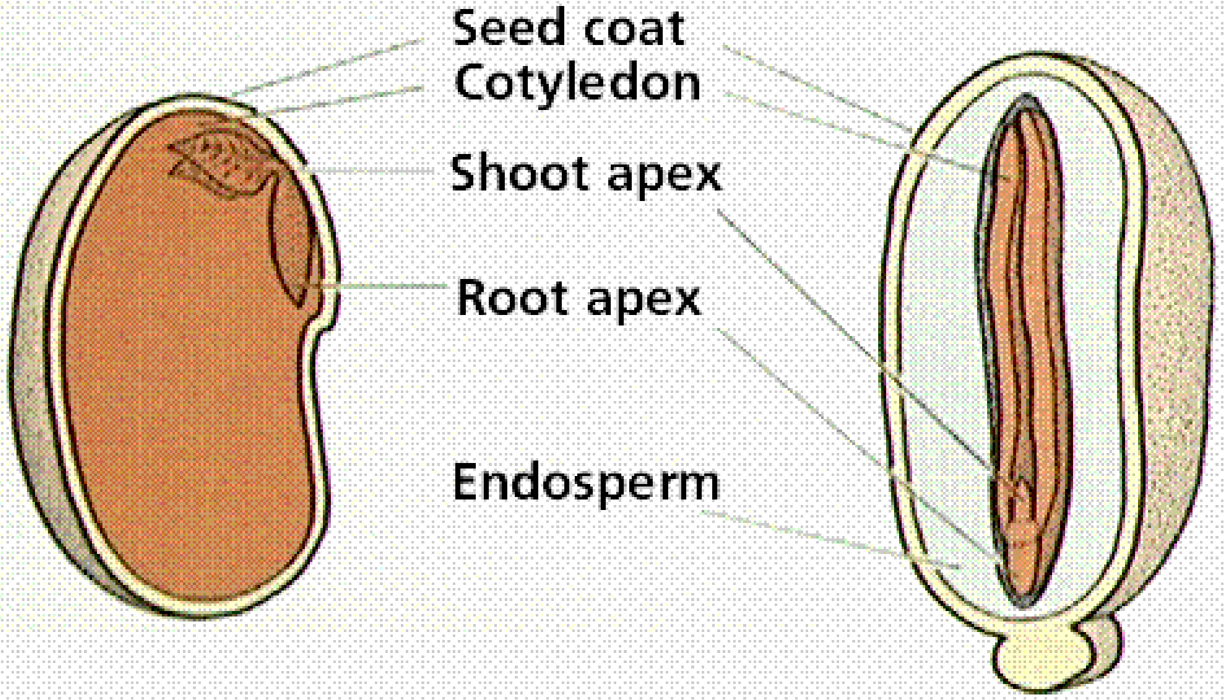


Fig. 2.31. A–G; Stages in development of a monocot embryo. H, a monocot embryo of a grass.

- **Scutellum** is the cotyledon of a grass embryo. It is flattened and in intimate contact with the endosperm acting as an absorptive organ.
- Scutellum plays a key role in absorption of degraded material during germination from the endosperm and transfers it to the growing axis.
- **Coleoptile** is the pointed protective sheath covering the emerging shoot in monocotyledons.
- **Epiblast** is a flap of tissue in an embryo or seedling arising opposite to the insertion of the cotyledon/scutellum.
- **Coleorrhiza** is the sheath investing the radicle in some monocotyledonous plants through which the roots emerge.

Endosperm



- Endosperm forms a food-storage tissue in the seed. It not only promotes growth and longevity for the seed, but can also facilitate dispersal, as an attractant to animals.
- Mature endosperm typically consists of tightly-packed cells that contain food-reserve materials such as starch grains or protein bodies.
- Endosperm is typically a triploid tissue formed by fusion of one sperm cell with two female polar nuclei.
- It is present in most angiosperm seeds but in greatly contrasting amounts; for example, endosperm formation is negligible in orchid seeds but extensive in grass seeds, in which it forms an important economic crop.

Types of endosperm

Nuclear

Common type of endosperm. Nucleus divides to form many nuclei but cytokinesis does not take place.

Freely suspended triploid nuclei are formed in cytoplasm. eg. Maize, Rice, Wheat, Sunflower, Coconut, *Capsella*

Cellular

Every division of PEN is followed by cytokinesis. Endosperm development occurs in cellular form.

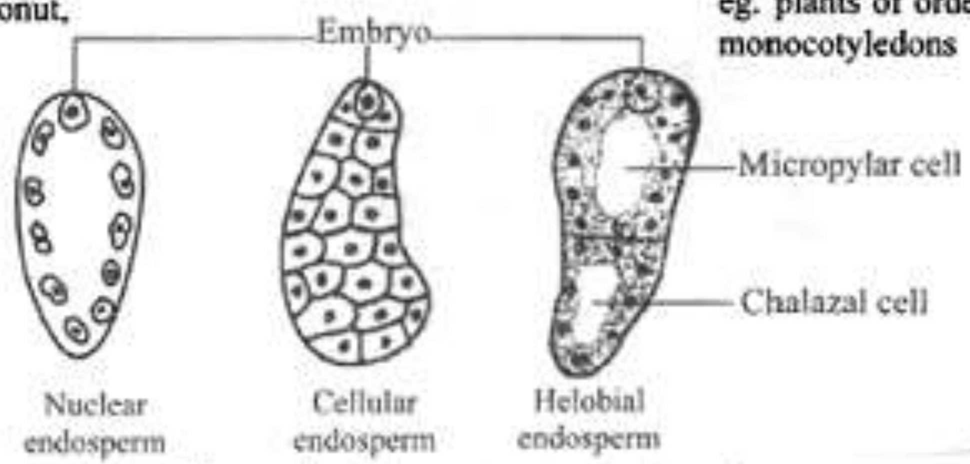
eg. *Datura, Balsam, Petunia*

Helobial

It is intermediate between cellular and nuclear types. First division of nucleus is followed by cytokinesis.

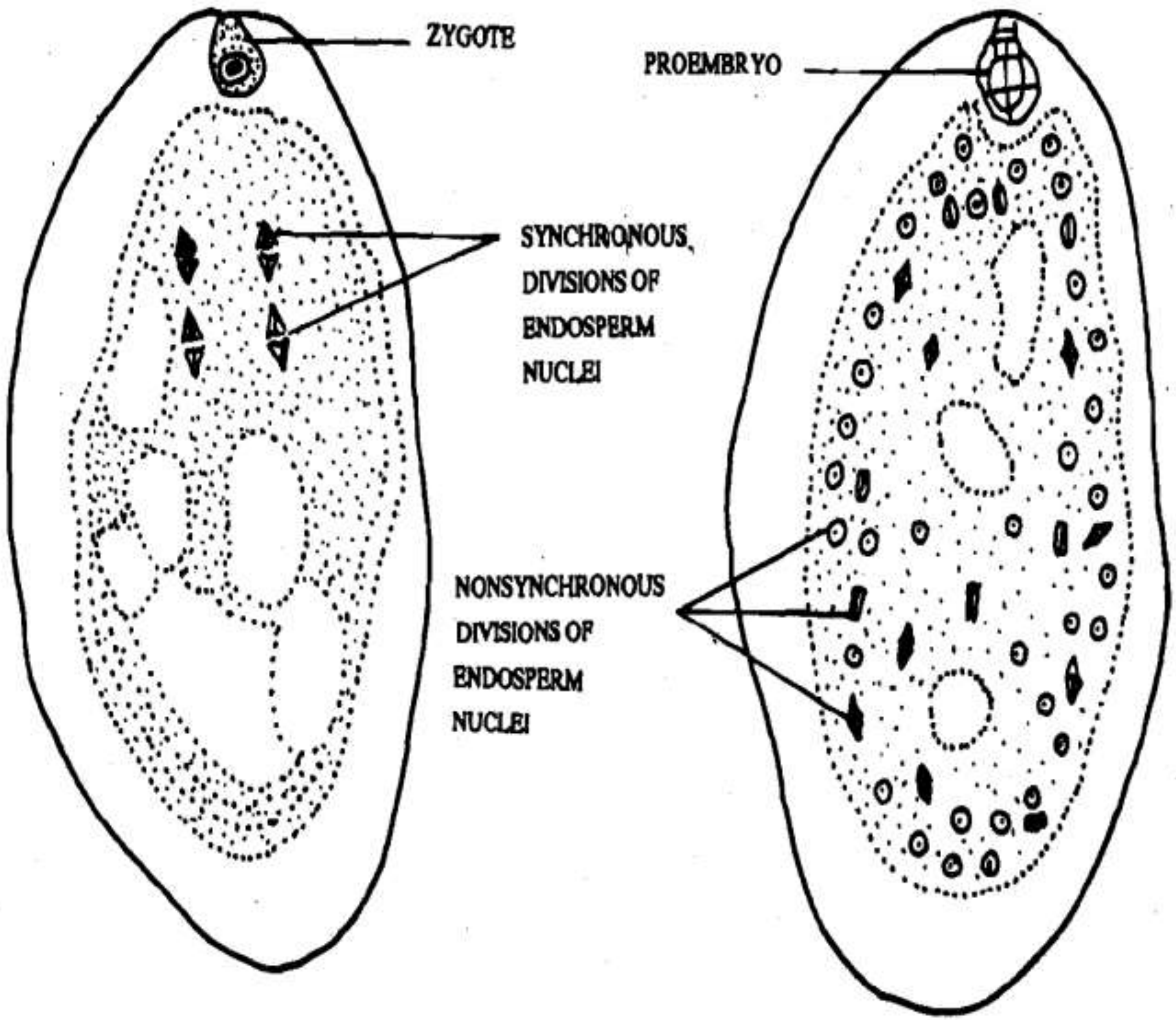
As a result, two cells a smaller chalazal cell and a larger micropylar cell are formed.

eg. plants of order Helobiae of monocotyledons

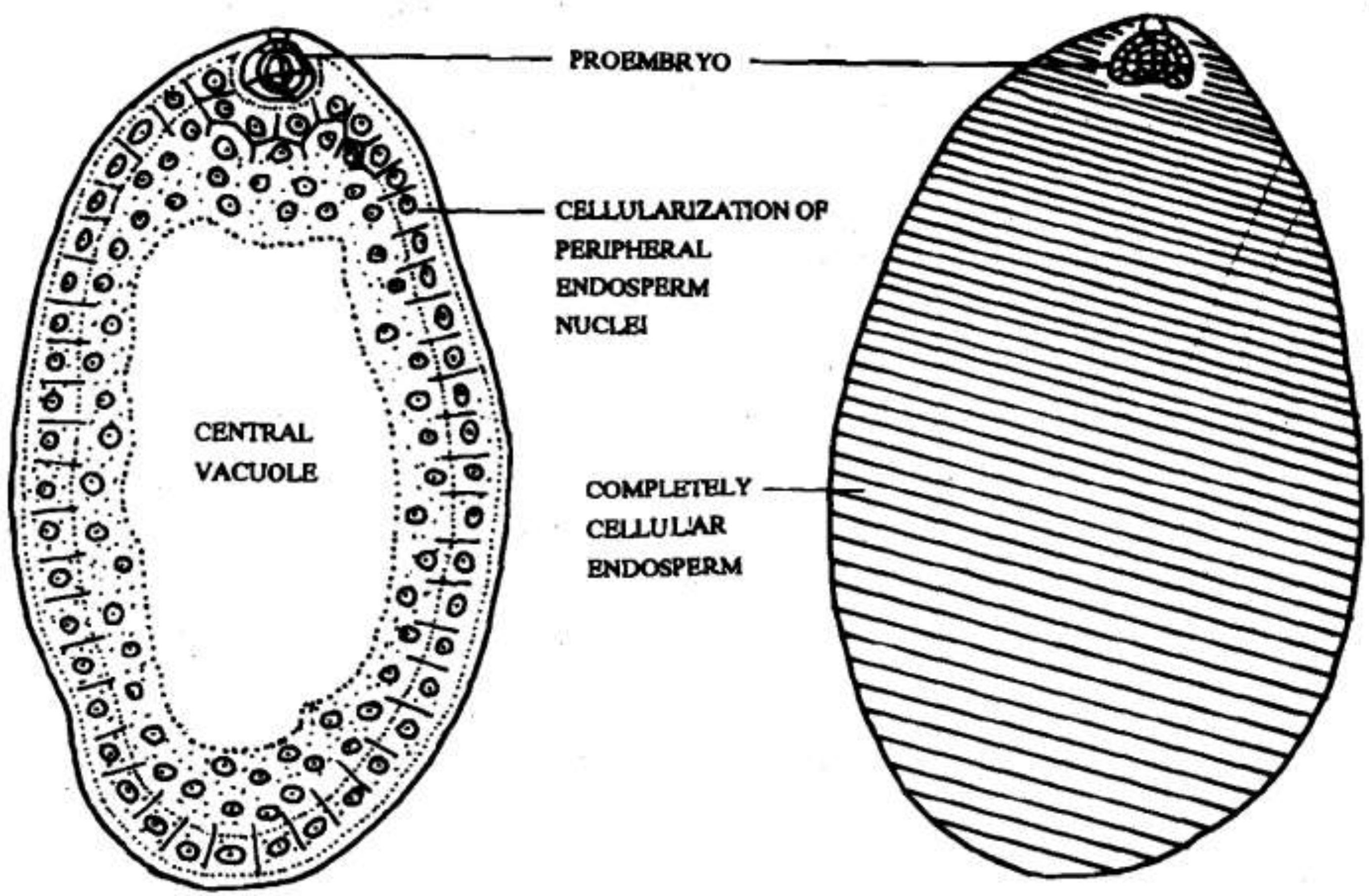


Types of endosperm

- **Nuclear endosperm** is the most common type, and occurs in many eudicots (e.g. Arabidopsis thaliana).
- Nuclear endosperm possesses both a syncytial (free-nucleate) phase and a cellular phase.
- Early cell divisions are not followed by cell wall formation, and the nuclei are initially free in the cytoplasm of the embryo sac, usually surrounding a central vacuole.

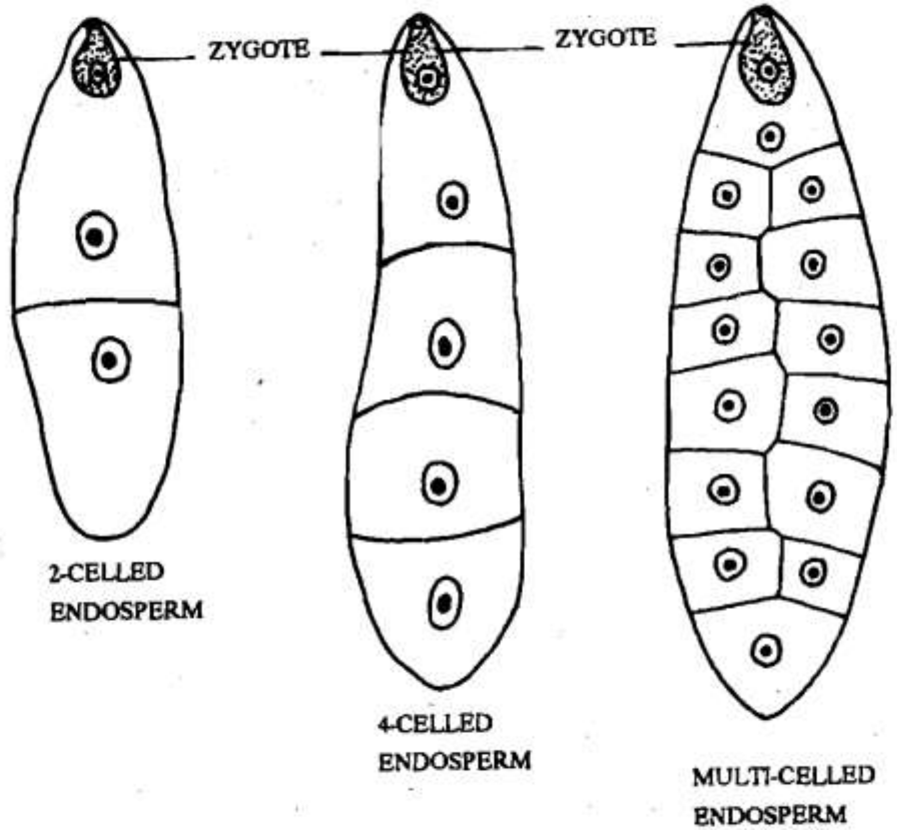


Embryo sac showing synchronous divisions of endosperm nuclei



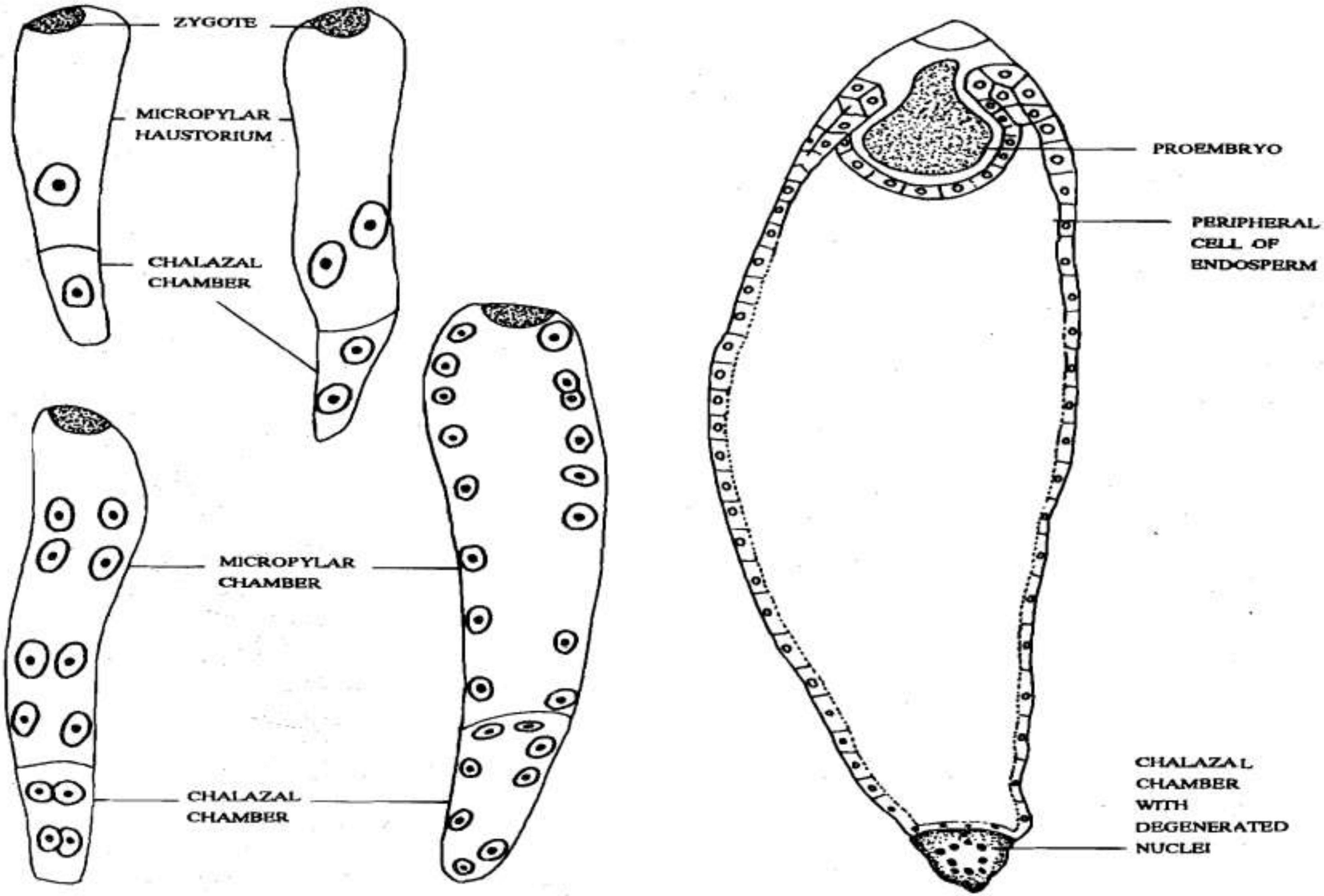
Endosperm has become fully cellular, embryo is heart shaped.

- **Cellular type** of endosperm formation, which occurs in some eudicots (e.g. Acanthaceae), even the earliest nuclear divisions are followed by cell-wall formation.
- In this type, as the name indicates, the division of the primary endosperm nucleus is immediately followed by the laying down of a wall, which is usually transverse but may be sometimes vertical or oblique.
- Subsequent nuclear divisions are immediately followed by wall formation.
- As a result the embryo sac contains cellular endosperm from the very beginning and no free nuclear stage occurs.



Cellular endosperm: Two celled endosperm formed by transverse wall. Four celled endosperm.
Multi cellular endosperm.

- **Helobial endosperm type**, which is restricted to some monocots, the primary endosperm nucleus undergoes division to form two unequal chambers, normally a small chalazal chamber and a large micropylar chamber.
- The nucleus of the micropylar chamber migrates to the top of the embryo sac, and its initial divisions are not accompanied by cell wall formation, though cell walls are formed with later mitosis.
- The chalazal chamber has far fewer nuclear divisions, and its nuclei remain free in the cytoplasm; it typically has a haustorial role.



'igs. 4.9-4.13 : Helobial Endosperm. Fig. 4.9 : Two-celled endosperm with large micropylar chamber and small chalazal chamber. Figs. 4.10-4.13 : Later stages of Helobial Endosperm.

THANK YOU