KRISHNAGAR ACADEMY

Biology -

CHAPTER-2

Sexual Reproduction In Flowering Plants.

DEVELOPMENT OF OVULE AND THE FEMALE GAMETOPHYTE

(a) The ovule (megasporangium). The **placenta** is a ridge of tissue— a parenchymatous mass—in the inner wall of the ovary to which ovules are attached. The manner in which the placentae are distributed in the cavity of an ovary is called **placentation**. Each ovule is attached to the placenta by a slender stalk called **funicle**. The point of attachment of the body of the ovule to its stalk or funicle is known as **hilum**. In inverted ovule **(anatropous)**, the part of funicle remain attached beyond the hilum alongside of the body of the ovule forming a sort of ridge called **raphe** (Fig. 2.11). The ovule contains a mass of thin walled nutritive parenchymatous cells called **nucellus**. The nucellus is protected by one or two multicellular coats called **integuments**. The basal portion of the nucellus from where the integuments arise is called **chalaza**. In gymnosperms, family Compositae and few other families with gamopetalous corolla, there is one integument. The ovules with one integument are called **unitegmic** and with two integuments are known as **bitegmic**. A small opening is left at the apex of integuments known as **micropyle**. Female gametophyte or **embryo sac** is embedded in the micropylar region of nucellus. Depending upon the thickness of the nucellus, ovules are called **tenuinucellate** (nucellus thin) and **crassinucellate** (nucellus massive). Different types of ovules have been reported in angiosperms on the basis of relationship of funicle with body of the ovule and orientation of the lattter (*e.g.* **orthotropous**—upright or erect ovule and variously curved like **anatropous, campylotropous, amphitropous** and **circinotropous**) (Fig. 2.14).

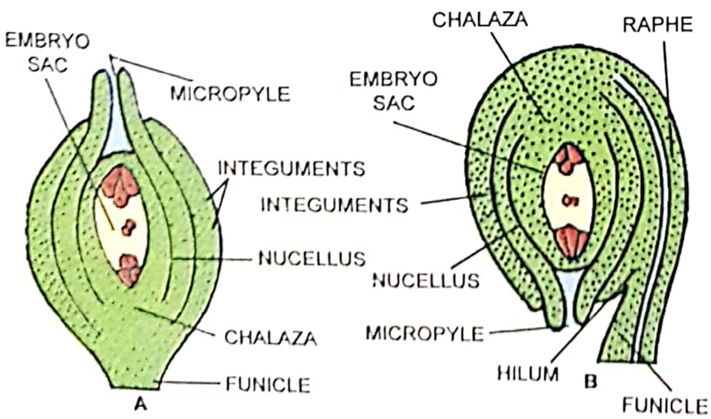

Fig. 2.11. **A.** L.S. Orthotropous, straight ovule; **B.** A curved anatropous ovule in longitudinal section.

(b) Megasporogenesis. In the nucellus, towards the micropylar end, hypodermal distinct archesporial cell is formed. This divides by periclinal division to form an outer **primary parietal cell** and **inner primary sporogenous cell.** Primary parietal cell divides further to form parietal tissue of the nucellus. Primary sporogenous cell forms **megaspore mother cell (MMC)**. The megaspore mother cell undergoes meiosis to form four haploid **megaspores**. The step is called **megasporogenesis**. Out of four megaspores in a linear tetrad, usually the upper three degenerate and lowermost enlarges to become functional megaspore (Fig. 2.12).

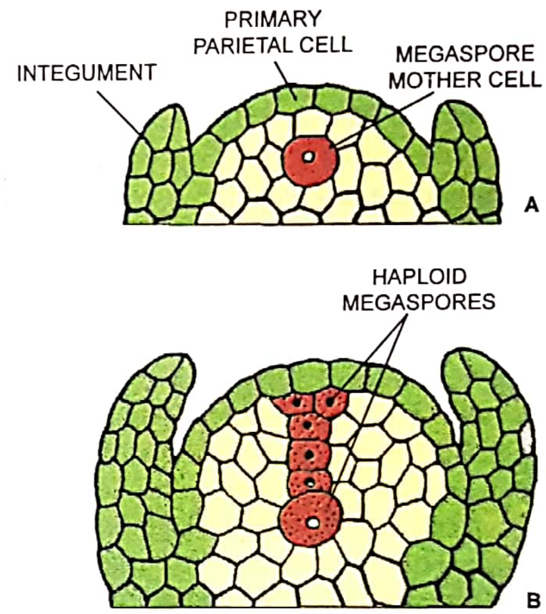

Fig. 2.12. A. Young ovule with megaspore mother cell. **B.** Ovule with megaspore tetrad.

(c) Development of female gametophyte. The functional megaspore forms female gametophyte or embryo sac (Fig. 2.13). The nucleus of megaspore divides into two, four and finally eight daughter nuclei. Four of which are located at each pole. One nucleus from each pole migrates to the centre to form two **polar nuclei** which further fuse to form a diploid **fusion** or **secondary nucleus.** Thus, **central cell** bears two polar nuclei. Three nuclei at the chalazal end of embryo sac form **antipodal cells**. The remaining three nuclei at the micropylar end get surrounded by cytoplasm to form pyriform cells. These three cells together constitute **egg apparatus**, which consists of two cells known as **synergids** or **help cells** and an **egg** or **oosphere** which hangs between them. The synergids bear a special cellular thickenings at the micropylar tip called **filiform apparatus,** which play an important role in guiding pollen tubes into synergids. The egg cell on fertilization gives rise to zygote, while synergids get disorganized soon after fertilization. The **antipodal cells** sooner or later also get disorganized. They may, however, be nutritive in function. **Thus, a typical angiospermic embryo-sac, at maturity though eight nucleate is seven celled. So development of embryo sac is generally monosporic** ***i.e.*** **from one megaspore.**

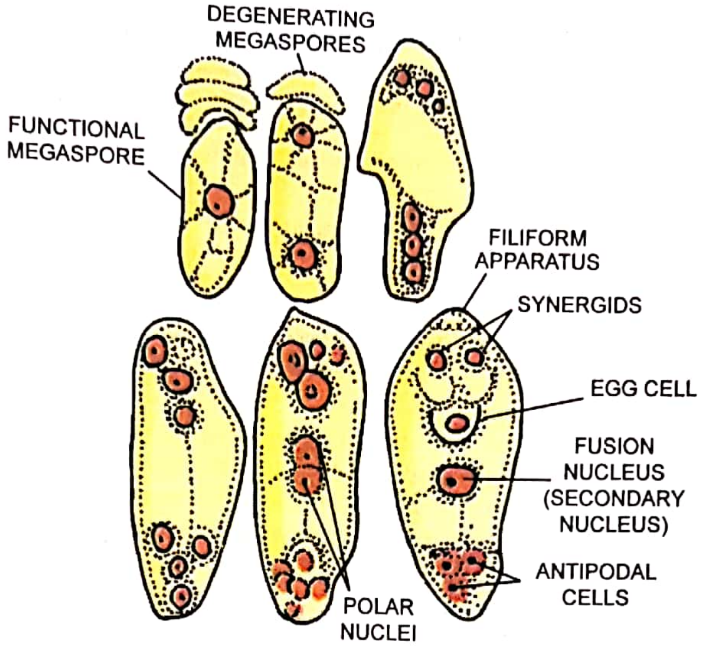

Fig. 2.13. Development of embryo sac.

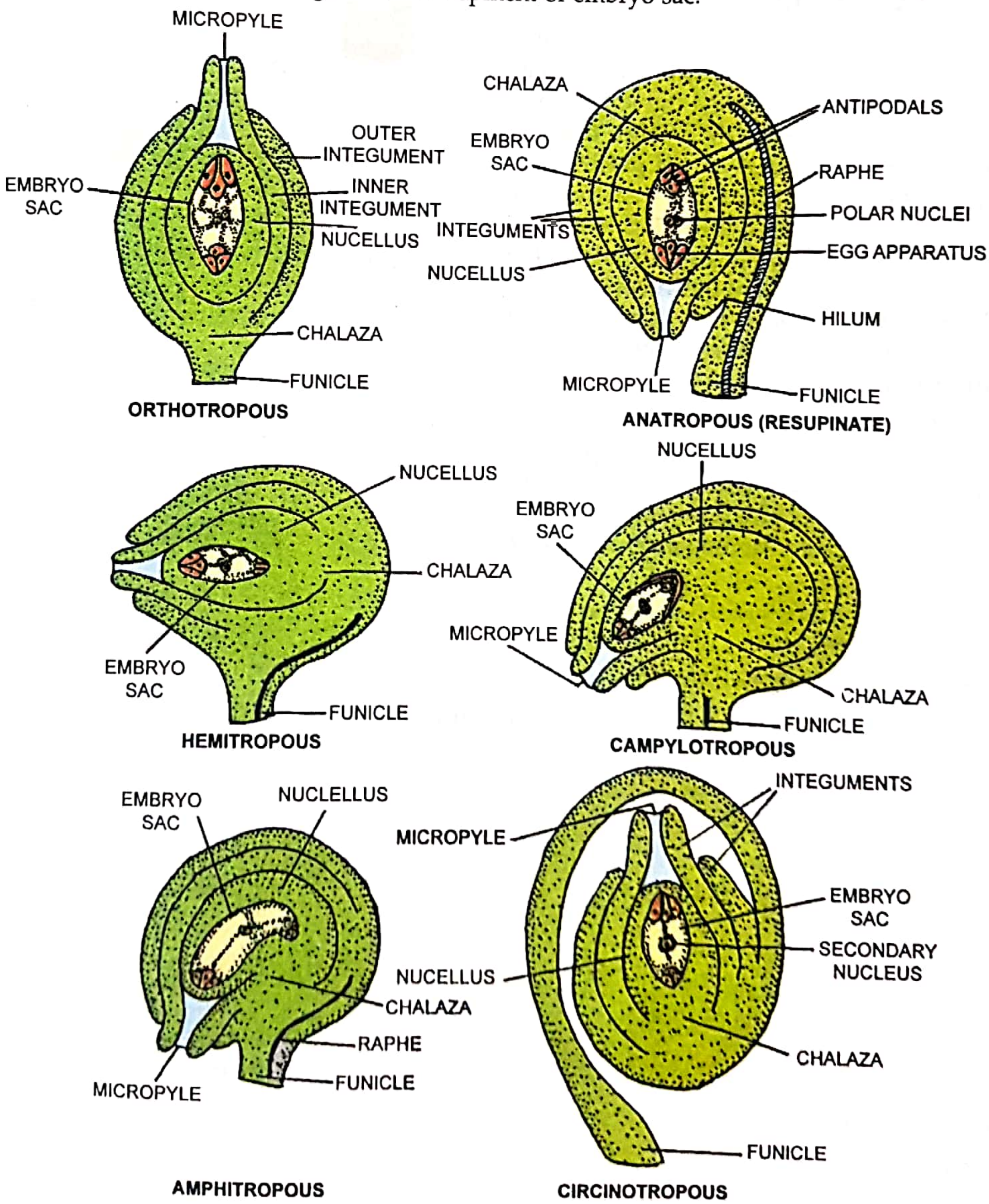

Fig. 2.14. Various forms of ovules.

On the basis of position of micropyle, with respect to the funiculus, ovules are of 6 types :

1. Orthrotropous Ovule

It is atropous or straight, where the micropyle, chalaza and the funiculus, all are in the same line, *e.g.*, *Cycas*, Family Polygonaceae and Piperaceae.

2. Anatropous Ovule

It is of the most common occurrence. In this ovule, the funicle is long and whole body of the ovule is inverted, through 180°. As a result the micropyle comes close to the **funicle,** *e.g.*, Most common in dicots and monocots.

3. Hemianatropous or Hemitropous Ovule

In this case the body of the ovule is inverted only through 90°. As a result the funicle comes to lie at right angle to the nucellus. Micropyle and chalaza, lie in the same plane, *e.g.*, *Ranunculus*.

4. Campylotropous Ovule

When body of the ovule is not completely inverted, but it is bent like 'horse shoe'. The micropyle and chalaza do not lie in the same plane (however the nucellus/embryo-sac remain straight), *e.g.*, Family Capparidaceae, Cruciferae etc.

5. Amphitropous Ovule

It is similar to campylotropous, but in this case the nucellus/embryo sac is also bent like 'horse shoe', *e.g.*, Family Alismaceae.

6. Circinotropous Ovule

It is of a very rare occurrence. Here the body of the ovule is bent through 360°, so that it takes a one complete turn. (Micropyle, chalaza and the nucellus are all in same plane), *e.g.*, *Opuntia*.

. **Pollination:** The process of transfer and deposition of pollen grains from the anther to the stigma of the flower is called **pollination**. It is of two types:

(*i*) *Self-pollination:* It is the transfer of pollen grains from the anther to the stigma of the same flower (**autogamy**) or to another flower of the same plant (**geitonogamy**).

Advantages

(*a*) Less chance of failure of pollination.

(*b*) Purity of race is maintained.

(*c*) No wastage of pollen grains.

Disadvantages

(*a*) Continued self-pollination results in weak progeny.

(*b*) No new species or varieties are produced.

(*ii*) *Cross-pollination:* It is the transfer of pollen grains from the anther of one flower to the stigma of another flower borne on a different plant of the same species (**allogamy**). An external agent is required for pollination.

Xenogamy and allogamy are same and the only type of pollination that brings genetically different types of pollen grains to the stigma.

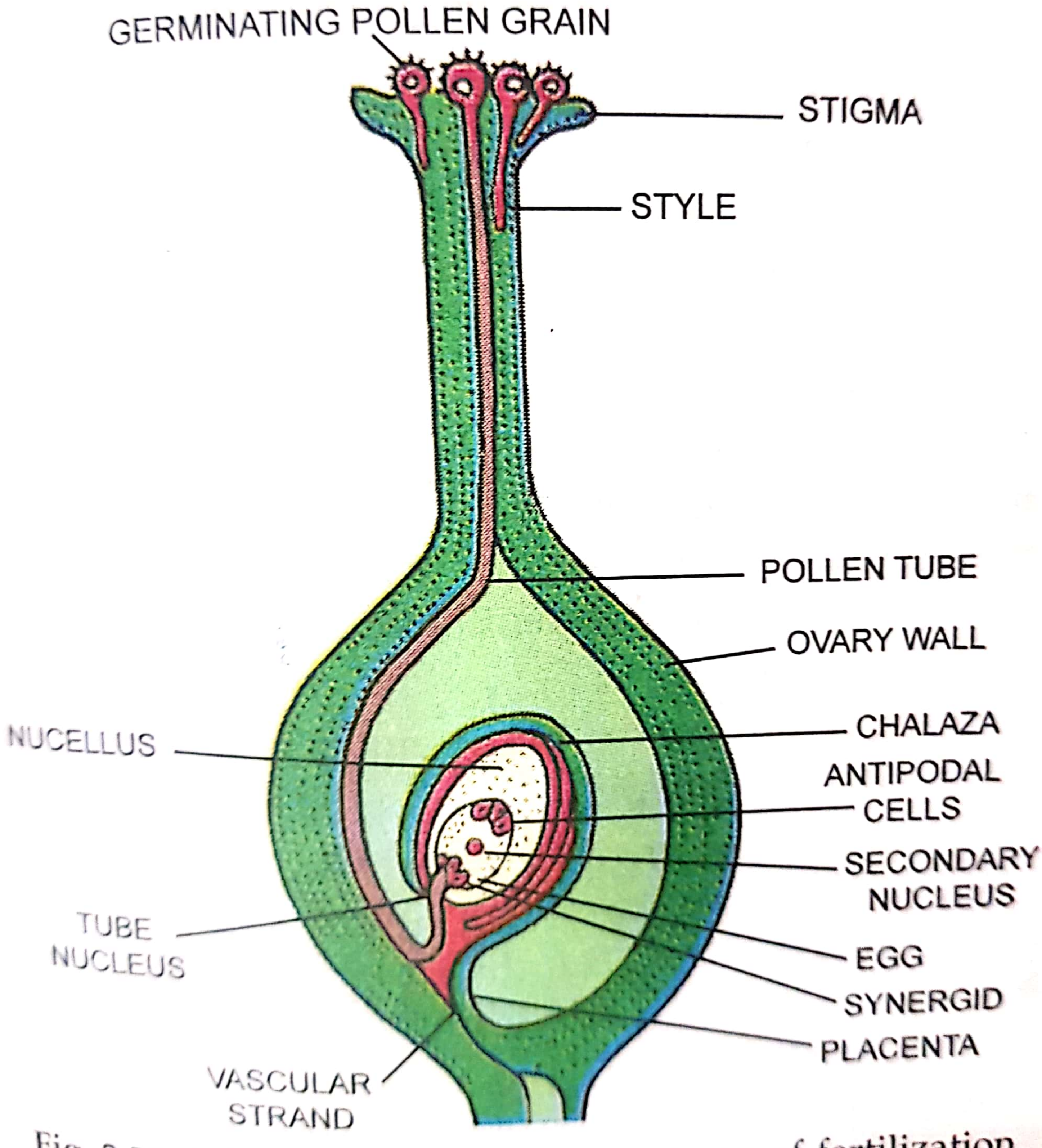

Fig. 2.25. L.S. Ovary showing the process of fertilization.

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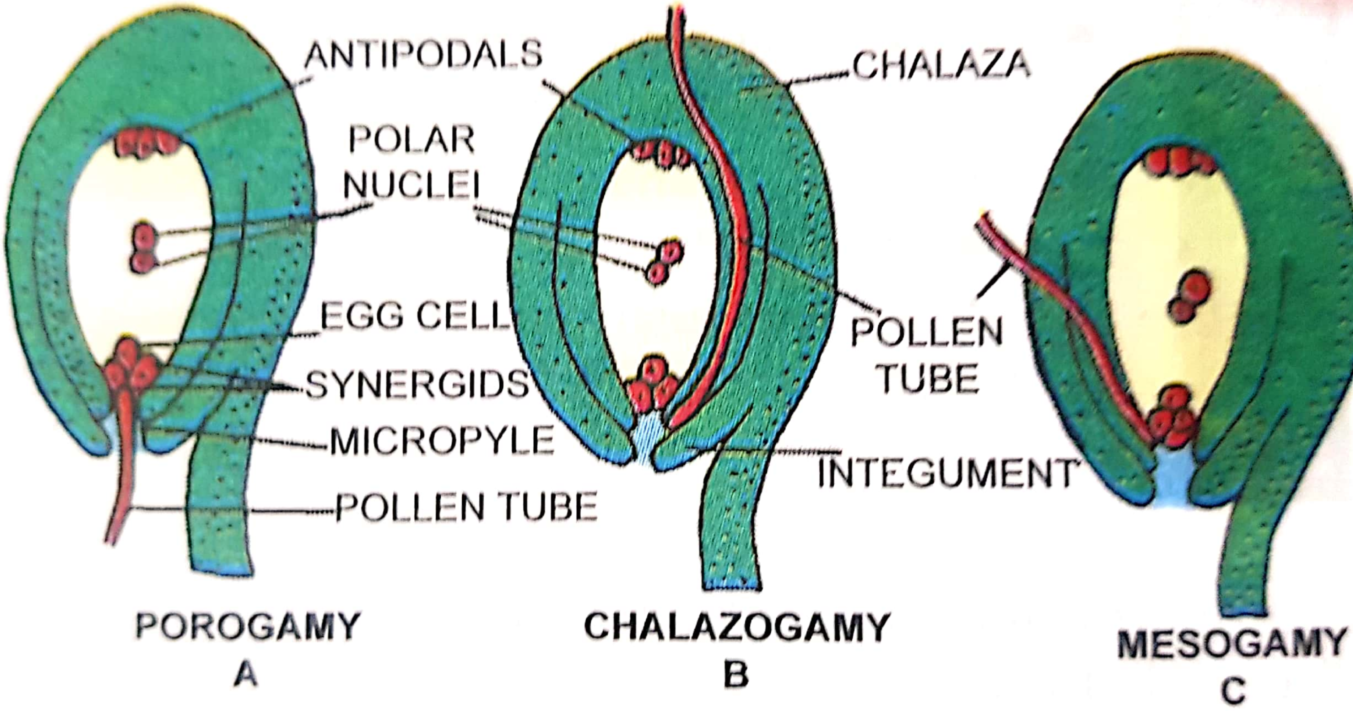

Fig. 2.26. Entry of pollen tube into the ovule : A. Porogamy; **B.** Chalazogamy; **C.** Mesogamy.

Agents of Pollination

(i) *Anemophily or Wind Pollination, e.g.,* maize, coconut, date palm.

(a) Flowers are colourless, inconspicuous and without fragrance.

(b) Pollen grains are smooth, dry and may be winged.

(c) Pollen grains are produced in large quantities.

(d) Stigmas are branched, broad, hairy and well exposed to catch the pollen grains.

(ii) *Hydrophily or Water Pollination, e.g., Vallisneria, Ceratophyllum.* It is of two types:

(a) *Hypohydrophily:* It occurs below the surface of water.

(b) *Epihydrophily:* It occurs above the surface of water.

(iii) *Entomophily or Insect Pollination, e.g., Bougainvillea.*

(a) Flowers are large, brightly coloured and fragrant.

(b) Nectar is produced.

(c) Pollen grains are rough, sticky and provided with spinous outgrowths.

(d) Stigma is also sticky and rough.

(iv) *Zoophily or Animal Pollination.* They are of the following types:

(a) *Ornithophily or Bird pollination, e.g.,* bottlebrush.

(b) *Chiropterophily or Bat pollination, e.g., Adansonia.*

(c) *Malacophily or Snail pollination, e.g.,* snake plant.

Contrivances Governing Cross-Pollination

(i) *Unisexuality, e.g.,* papaya.

(ii) *Dichogamy, e.g.,* sunflower, *Ficus.*

(iii) *Self-sterility, e.g.,* apple, *Passiflora.*

(iv) *Herkogamy, e.g., Calotropis, Salvia.*

(v) *Heterostyly, e.g., Oxalis.*

Outbreeding Devices

- Outbreeding and outcrossing are interchangeable terms.
- Naturally occurring outcrossing is nothing but allogamy.
- Outbreeding is the practice of introducing unrelated genetic material into a breeding line. It increases genetic diversity, thus reducing the possibility of the plant being subject to disease or reducing genetic abnormalities.
- Outcrossing in plants is usually enforced by self-incompatibility.

Pollen-Pistil Interaction

(i) *Recognition of Compatible Pollen*

- The stigma can recognise the right type of pollen, *i.e.,* compatible pollen of the same species.

- The pistil rejects the pollen grain of different species and also incompatible pollen grain of the same species.
- This happens because of the interaction between the chemical components of the pollen and stigma.

(*ii*) *Germination of Pollen Grains*

- If the pollen is compatible, it starts germinating aided by certain secretions of the stigma.
- The intine grows out as a protuberance from one of the germ pores.
- The contents of the pollen— the tube and the generative nucleus move towards the tip of the pollen tube.
- The pollen tube grows through the tissues of stigma and style by secreting enzymes to digest them.
- It enters the ovule through the micropyle.
- It then enters the embryo sac through the filiform apparatus of one of the synergids to liberate the male gamete.
- The events starting from the deposition of pollen grain on the stigma till the pollen tube enters the ovule are collectively referred to as **pollen-pistil interaction.**

Double Fertilisation

- Pollen tube releases two male gametes into the cytoplasm of a synergid.
- One of the male gametes moves towards the egg cell and fuses with it (syngamy). This results in the formation of a diploid zygote which later develops into the embryo.
- The second male gamete fuses with the secondary nucleus (diploid) in the central cell to form a triploid primary endosperm nucleus (PEN). This fusion is called **triple fusion.**
- Since two fusions occur in the embryo sac, it is called **double fertilisation** and is unique to angiosperms.
- The central cell now called **primary endosperm cell** (PEC) develops into the endosperm.

Embryo Formation: The process of development of mature embryo from the zygote is called **embryogenesis.**

(*i*) The zygote develops a cellulose wall and is called **oospore.** The oospore divides by a transverse wall into a basal suspensor cell and a terminal embryo cell. The suspensor cell lies towards the micropyle and the embryo cell towards the antipodal cell.

(*ii*) The suspensor cell divides a few times to give rise to a filamentous suspensor of 6 to 10 cells. This suspensor pushes the developing embryo into the endosperm.

(*iii*) The first cell of the suspensor towards the micropyle becomes swollen and acts as a haustorium and the lowermost cell, next to the embryo, functions as hypophysis. The former gives rise to the epicotyl and plumule, and the latter to the hypocotyl and radicle.

(*iv*) The embryo cell undergoes two vertical and one transverse division to form an eight-celled embryo. These eight cells undergo various divisions to differentiate into proper embryo (Fig. 2.12).

(*v*) In monocotyledons, the early phases of embryogenesis, up to the formation of the globular pro-embryo, is similar to the dicotyledons. After this, about one half of the terminal cell derivatives function as shoot apex, whereas remainder of the cells show a rapid rate of cell division in the formation of single terminal cotyledon.

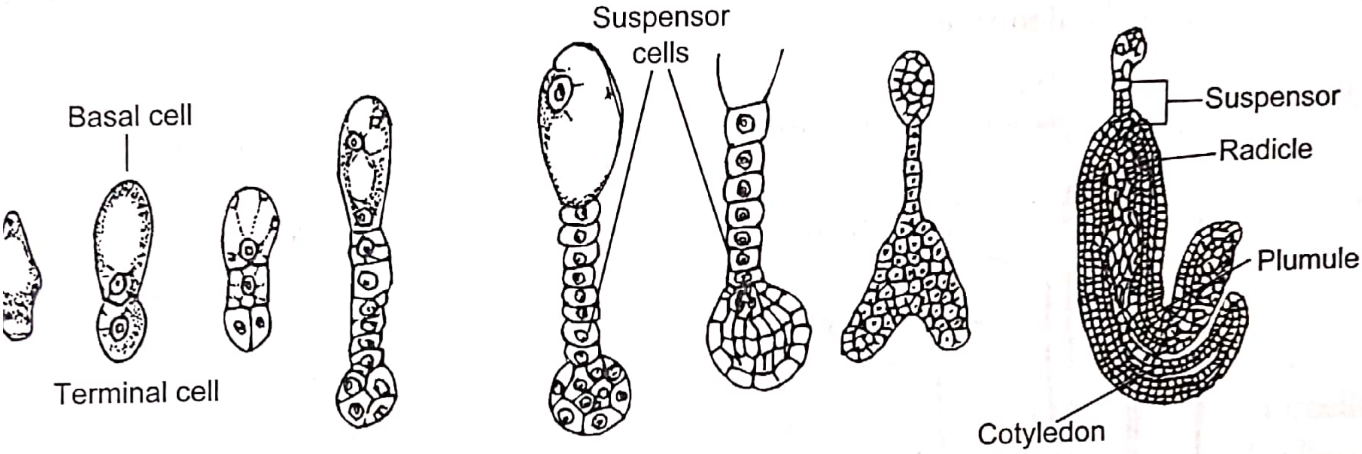

Fig. 2.12: *Development of embryo*

. **Endosperm Formation:** Endosperm develops from the primary endosperm nucleus (3*n*) by repeated mitosis. The endosperm is actually a nutritive tissue that provides nutrition to the developing embryo. It grows by absorbing the nutrients supplied by the parent plant. Depending on the mode of formation, endosperm is of three types:

(*i*) *Nuclear:* Where the nucleus divides a number of times initially, without cytoplasmic division. Later cytokinesis starts from the periphery, *e.g.*, maize.

(*ii*) *Cellular:* Where every nuclear division is followed by a cytoplasmic division, *e.g.*, *Peperomia*.

(*iii*) *Helobial:* Where first mitosis is followed by cytokinesis and subsequent divisions are nuclear type, *e.g.*, *Vallisneria*.

. **Seed Formation:** As a result of the stimulus from fertilisation, a number of changes occur in the tissue outside the embryo sac leading to the formation of seed. The ovule increases greatly in size, integuments dry up—the outer one becomes hard or leathery and forms the outer seed coat or testa while the inner one forms a thin papery tegmen. During development, the nucellus is used up and it disappears. In some cases, however, it persists in the form of a food-storing thin layer called **perisperm.** A scar is visible on one side of the seed coat. It is known as **hilum.** The ovule changes into a seed while the ovary develops into a fruit.

. **Dicotyledenous and Monocotyledenous Embryo**

(*i*) *Dicot Embryo*

- The embryo consists of two cotyledons and the embryonal axis between them.
- The portion of the embryonal axis above the level of attachment of cotyledons is the **epicotyl**—it terminates into the plumule or the shoot meristem.

- The portion below the level of attachment of cotyledon is the **hypocotyl** which terminates in the radicle or root tip, *e.g.*, gram.

(*ii*) *Monocot Embryo*

- Embryo has one cotyledon called the **scutellum** which is pushed towards one side of the embryonal axis.
- The embryonal axis has the radicle on its lower end (hypocotyl). The radicle is covered by an undifferentiated sheath called **coleorhiza.**
- The upper end (epicotyl) has the plumule which is covered by a foliar sheath called **coleoptile.**

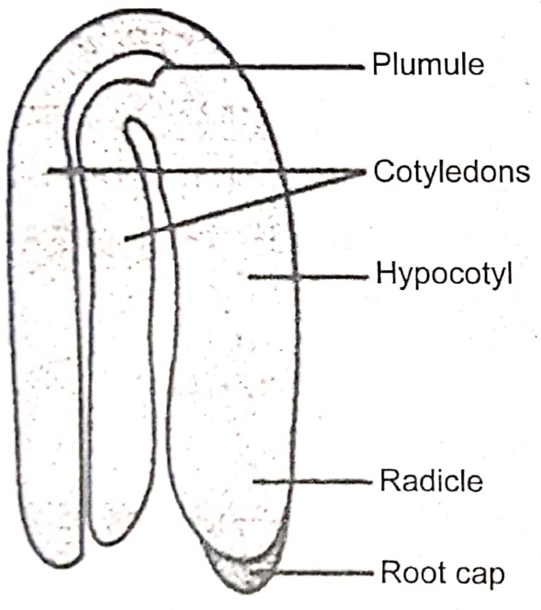

Fig. 2.13(*a*): *A typical dicot embryo*

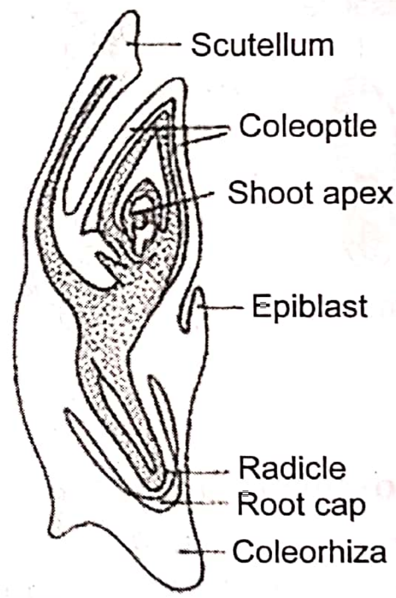

Fig. 2.13(*b*): *A typical monocot embryo*

. **Placentation:** The ovules are attached to the inner surface of locule through placenta. The manner in which placenta are arranged on the ovary wall is called **placentation.** The different types of placentations are: (*i*) *Basal Placentation,* (*ii*) *Apical Placentation,* (*iii*) *Parietal Placentation,* (*iv*) *Axile Placentation,* (*v*) *Free or Central Placentation, and* (*vi*) *Marginal Placentation.*

. **Fruits:** Fruit has a wall or pericarp, which develops from the wall of the ovary. When fully developed, it shows three layers: (*i*) *Outer Epicarp,* (*ii*) *Middle Mesocarp, and* (*iii*) *Inner Endocarp.*

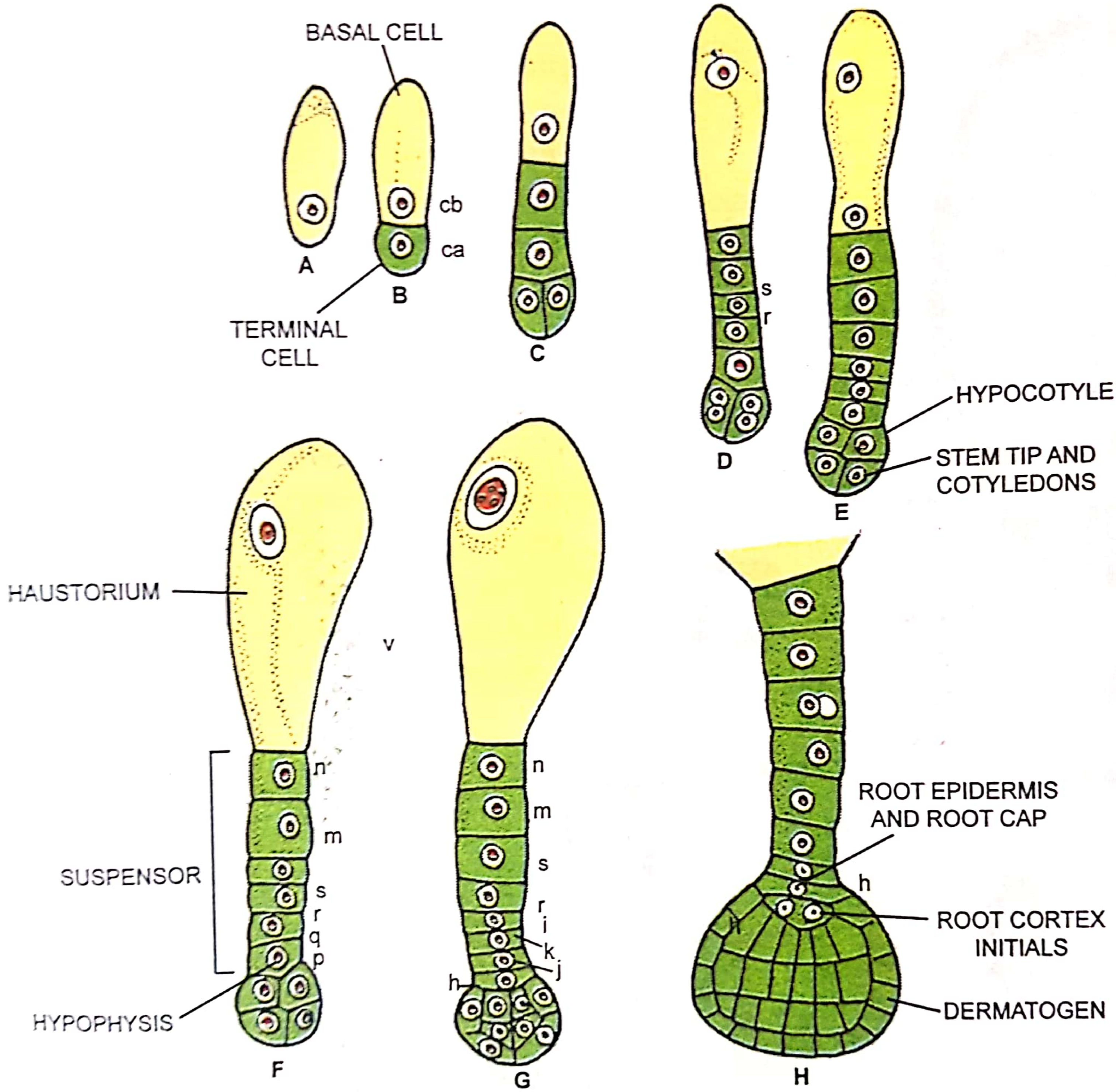

Fig. 2.30. Development of embryo in *Capsella bursa-pastoris*.

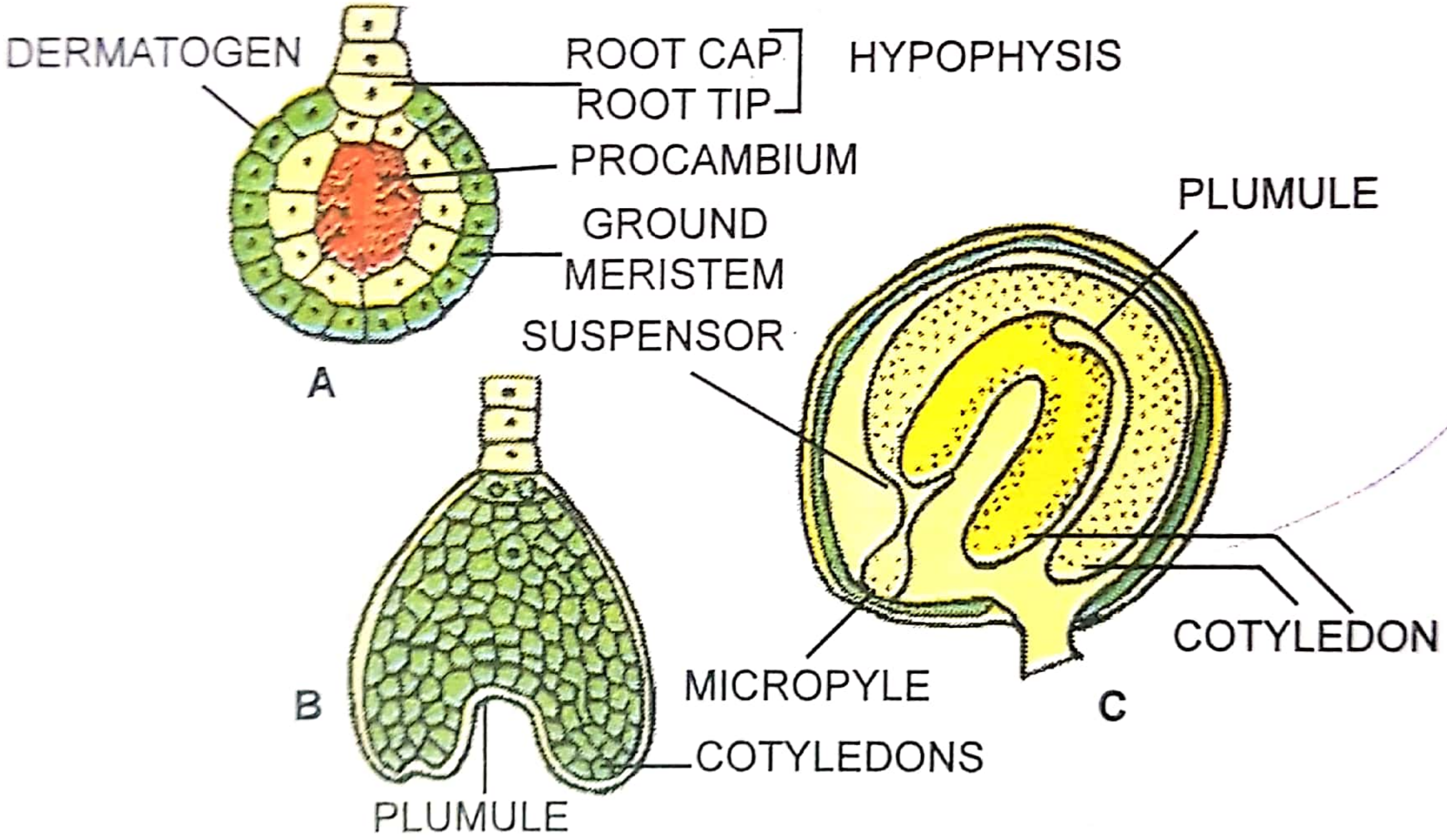

Fig. 2.31. (A-C) A. Globular embryo; **B**. Heart-shaped (cordate) embryo; C. Horse shoe-shaped embryo.

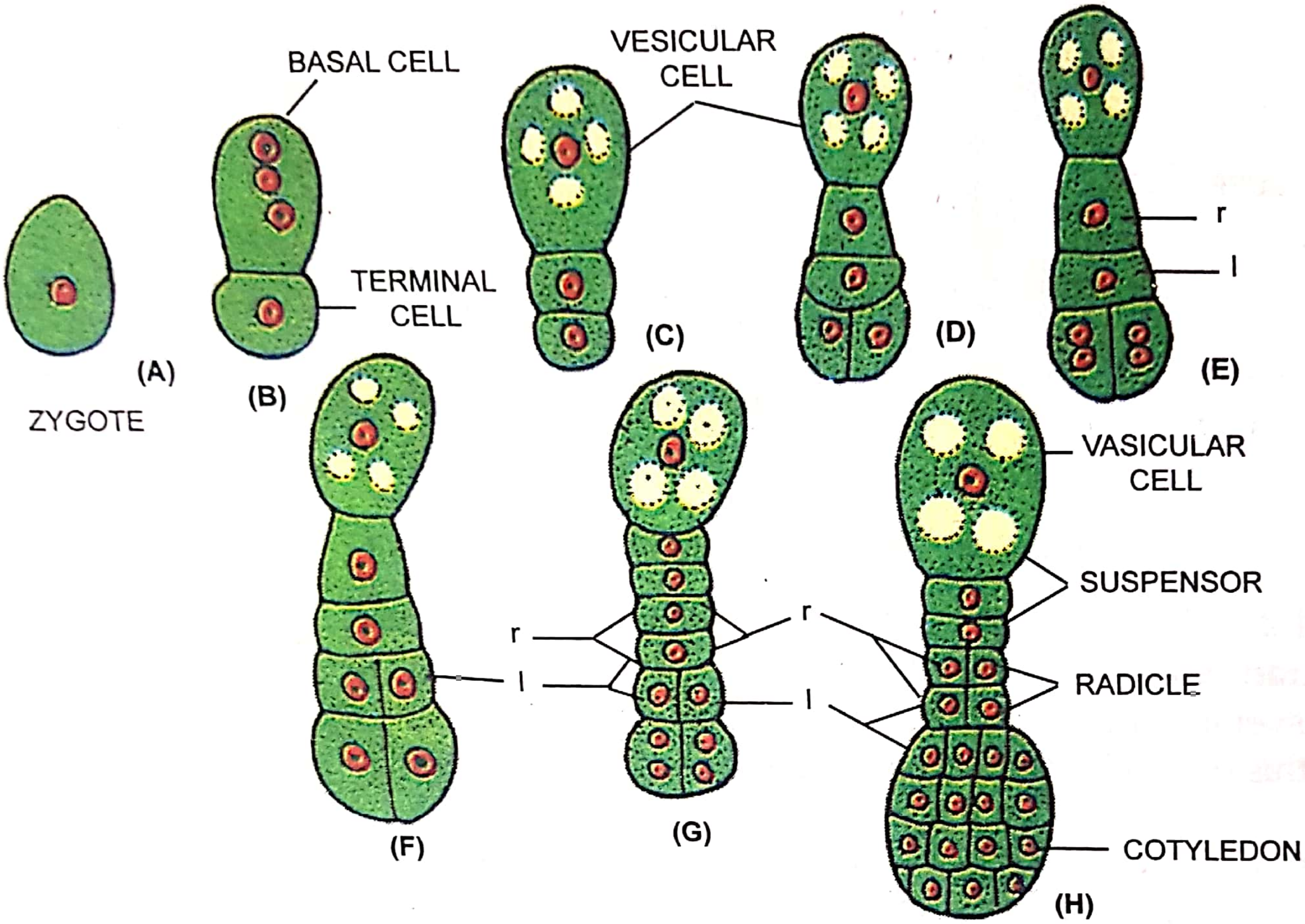

Fig. 2.33. Stages in the development of a typical monocot embryo in *Sagittaria*.

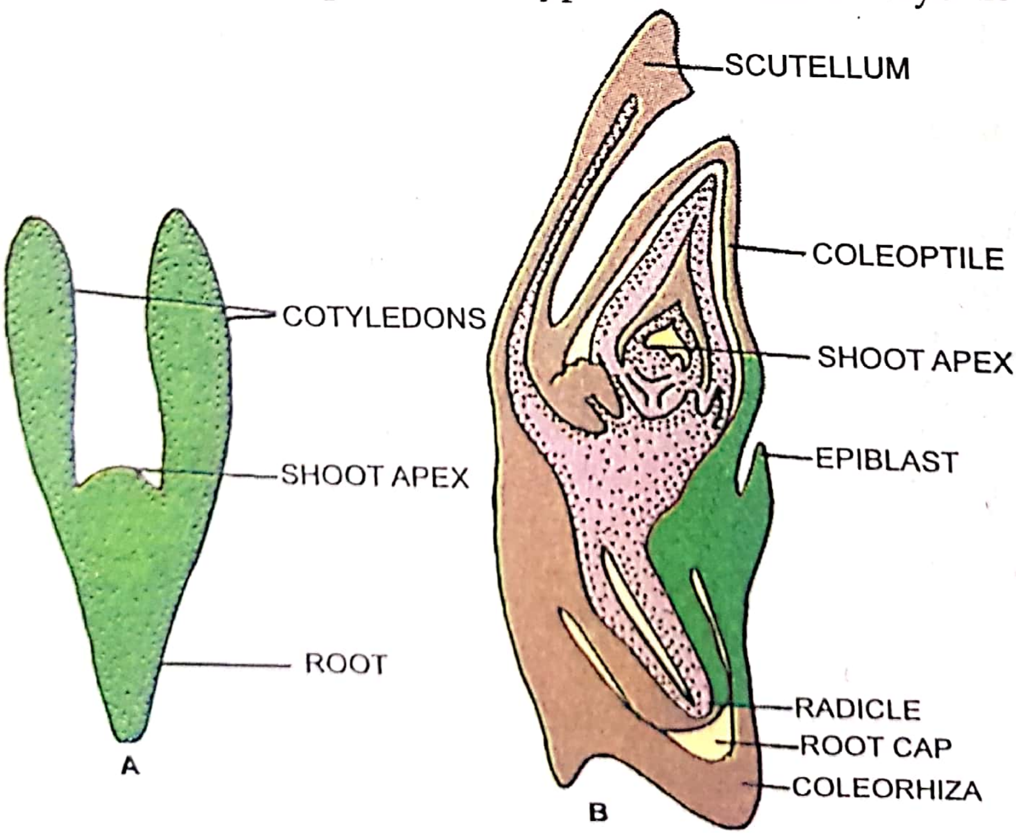

Fig. 2.34. **A.** A typical dicot embryo; **B.** L. S. embryo of a grass.

HOME TASK

1. Explain the process of development of ovules & female gametophyte.

2. Give a brief description of any four types of ovules.

3. Discuss the different types of endosperm development.

4. Draw a neat labelled diagram of L.S of anatropous ovule.

5. Draw a labelled diagram of the L.S of the pistil showing stages of pollen germination up to the fulfilment of the task of pollen tube.