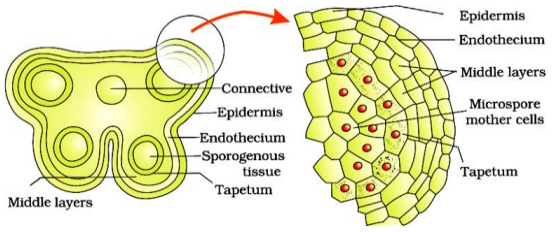
2. SEXUAL REPRODUCTION IN FLOWERING PLANTS

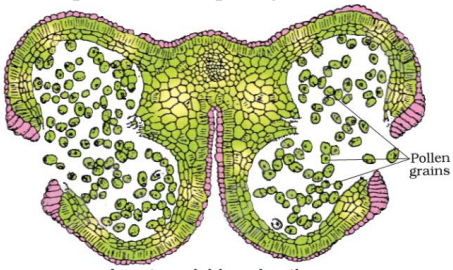
PRE-FERTILISATION: STRUCTURES & EVENTS

Transverse section of anther:



Structure of a microsporangium:

- A microsporangium has 4 wall layers: **epidermis, endothecium, middle layers & tapetum** (innermost layer).
- The outer 3 layers give protection and help in dehiscence of anther to release the pollen.
- The **tapetum** nourishes the developing pollen grains. Cells of the tapetum contain dense cytoplasm and generally have more than one nucleus.
- In young anther, each microsporangium has **sporogenous tissue** at centre. It consists of compactly arranged homogenous diploid cells (sporogenous cells).



A mature dehisced anther

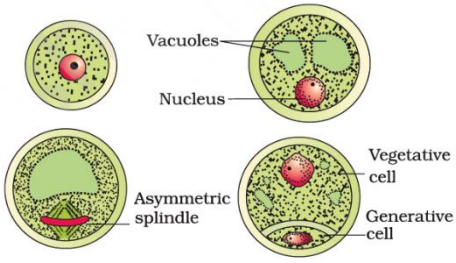
Pollen grain (male gametophyte):

A pollen grain has a two-layered wall: **exine** and **intine.**

- **Exine:** Hard outer layer. Made up of **sporopollenin** (highly resistant organic material). It can withstand high temperature and strong acids and alkali. Enzymes cannot degrade sporopollenin.
  Exine has apertures called **germ pores** where sporopollenin is absent.
- **Intine:** Inner wall. It is a thin and continuous layer made up of **cellulose** and **pectin.**

A matured pollen grain contains 2 cells:

- **Vegetative cell:** It is bigger, has abundant food reserve and a large irregularly shaped nucleus.
- **Generative cell:** It is small and floats in the cytoplasm of the vegetative cell.

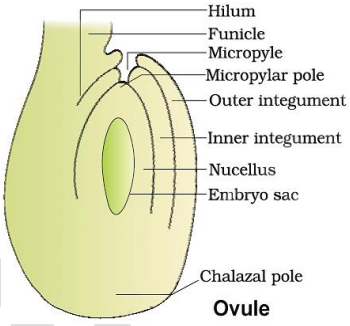


Stages of a microspore maturing into a pollen grain

- Over 60% angiosperms shed their pollen grains at 2-celled stage. In others, generative cell divides mitotically to give 2 male gametes. Thus pollen grains are shed at 3-celled stage.

Structure of Megasporangium (Ovule):

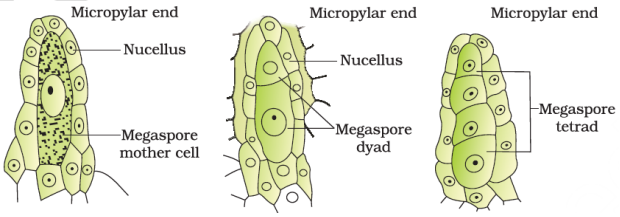
- Ovule is attached to the placenta by a stalk **(funicle)**.
- Junction b/w body of ovule and funicle is called **hilum.**
- Each ovule has 1 or 2 protective envelopes (**integuments)** except at the tip where a small opening (**micropyle)** is present.
- Opposite the micropylar end is the **chalaza**.
- Enclosed within the integuments, there is a mass of cells called **nucellus**. Its cells contain reserve food materials.
- Inside the nucellus is **embryo sac (female gametophyte)**.



Ovule

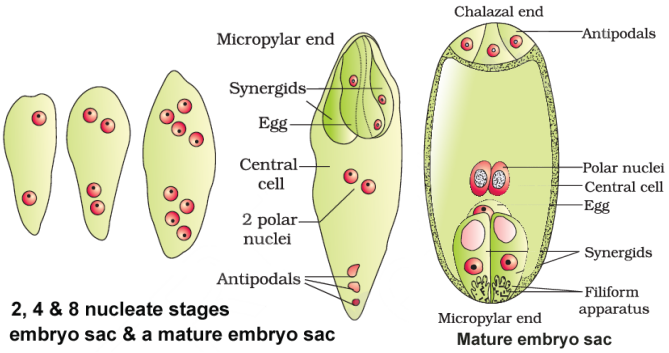
Megasporogenesis:

- It is the formation of megaspores from **megaspore mother cell (MMC).**
- Ovules generally differentiate a single MMC in micropylar region of the nucellus. It is a large cell containing dense cytoplasm and a prominent nucleus.
- MMC undergoes meiosis to produce 4 **megaspores**.



Formation of Female gametophyte (embryo sac):

- In majority of flowering plants, one megaspore is functional while the other three degenerates.
- The **functional megaspore** develops into the **female gametophyte.** The embryo sac formation from a single megaspore is called **monosporic development.**
- Nucleus of the functional megaspore divides mitotically to form two nuclei. They move to the opposite poles, forming **2-nucleate** embryo sac.
- The nuclei again divide two times forming **4-nucleate** and **8-nucleate** stages of the embryo sac.



2, 4 & 8 nucleate stages embryo sac & a mature embryo sac

Mature embryo sac

- After the 8-nucleate stage, cell walls are laid down leading to the organization of the typical **female gametophyte.**

- 6 of the 8 nuclei are surrounded by cell walls and organized into cells. Remaining 2 nuclei (polar nuclei) are situated below the egg apparatus in the large **central cell.**

Distribution of cells within the embryo sac:

A typical mature embryo sac is **8-nucleate** and **7-celled**.

- 3 cells (2 **synergids** + one **egg cell)** are grouped at the **micropylar end** and form **egg apparatus.**
  Synergids have special cellular thickenings at the **micropylar tip** called **filiform apparatus.** It helps to guide the pollen tubes into the synergid.
- 3 cells **(antipodals)** at the **chalazal end.**
- A large **central cell** with two **polar nuclei.**

POLLINATION

It is the transfer of pollen grains from the anther to the stigma of a pistil.

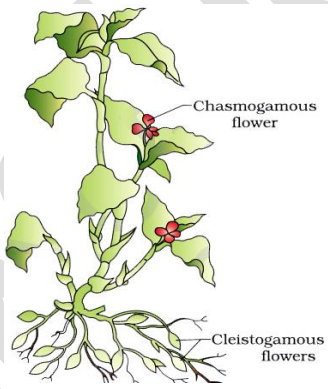
Based on the source of pollen, pollination is 3 types:

a. Autogamy (self-pollination): It is the transfer of pollen grains from the anther to stigma of the **same flower.**

In flowers with exposed anthers & stigma, complete autogamy is rare. Autogamy in such flowers requires synchrony in pollen release and stigma receptivity. Also, anthers & stigma should be close to each other.

Plants like *Viola* (common pansy), *Oxalis* & *Commelina* produce 2 types of flowers:

- **Chasmogamous flowers:** They are similar to flowers of other species with exposed anthers and stigma.
- **Cleistogamous flowers:** They do not open at all. Anthers & stigma lie close to each other. They are autogamous. When anthers dehisce in the flower buds, pollen grains come in contact with stigma for pollination. Cleistogamous flowers produce assured seed-set even in the absence of pollinators.
  Cleistogamy leads to inbreeding depression.



b. Geitonogamy: It is the transfer of pollen grains from the anther to the stigma of **another flower of the same plant.** It is functionally cross-pollination involving a pollinating agent. But it is genetically similar to autogamy since the pollen grains come from the same plant.

c. Xenogamy: It is the transfer of pollen grains from anther to the stigma of a **different plant.** It brings genetically different pollen grains to the stigma.

Agents of Pollination

1. Abiotic agents (wind & water)

Pollination by wind (anemophily):

- More common abiotic agent.
- Wind pollinated flowers often have a single ovule in each ovary and numerous flowers packed into an inflorescence.
- E.g. Corncob – the tassels are the stigma and style which wave in the wind to trap pollen grains. Wind-pollination is quite common in grasses.
- **Ways for effective pollination:**
  - The flowers produce enormous amount of pollen.
  - Pollen grains are light and non-sticky.
  - They often possess well-exposed stamens (for easy dispersion of pollens into wind currents).
  - Large, feathery stigma to trap air-borne pollen grains.

Pollination by water (hydrophily):

- It is quite rare. It is limited to about 30 genera, mostly monocotyledons. E.g. *Vallisneria* & *Hydrilla* (fresh water), *Zostera* (marine sea-grasses) etc.
- But in lower plants, water is a regular mode of transport for the male gametes. Distribution of some bryophytes & pteridophytes is limited because they need water for the transport of male gametes and fertilisation.
- In *Vallisneria*, the female flower reaches the surface of water by the long stalk and the male flowers or pollen grains are released on to the surface of water. They are carried by water currents and reach the female flowers.
- In sea grasses, female flowers remain submerged in water. Pollen grains are long and ribbon like. They are carried inside the water and reach the stigma.
- The pollen grains of most of the water-pollinated species have a mucilaginous covering to protect from wetting.

2. Biotic agents (animals)

- Majority of flowering plants use animals as pollinating agents. E.g. Bees, butterflies, flies, beetles, wasps, ants, moths, birds, bats, primates, arboreal (tree-dwelling) rodents, reptiles (gecko lizard & garden lizard) etc.
- Pollination by insects **(Entomophily),** particularly bees is more common.
- **Features of insect-pollinated flowers:**
  - Large, colourful, fragrant and rich in nectar. Nectar & pollen grains are the floral rewards for pollination.
  - Small flowers form inflorescence to make them visible.
  - The flowers pollinated by flies and beetles secrete foul odours to attract these animals.
  - The pollen grains are generally sticky.
- Some plants provide safe places as floral reward to lay eggs. E.g. *Amorphophallus* (It has the tallest flower of 6 feet).
- Many insects consume pollen or nectar without bringing about pollination. They are called **pollen/nectar robbers.**

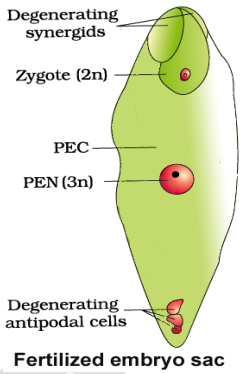
Artificial hybridisation

It is a crop improvement programme in which desired pollen grains are used for pollination. The steps are:

- **Emasculation:** Removal of anthers from the bisexual flower bud of female parent before the anther dehisces.
- **Bagging:** Here, emasculated flowers are covered with a bag to prevent unwanted pollen.
- **Pollination:** When stigma attains receptivity, pollen grains collected from male parent are dusted on the stigma.
- **Rebagging** the flowers. It is allowed to develop the fruits.

DOUBLE FERTILISATION

- After entering the synergid, the pollen tube releases 2 male gametes into the cytoplasm of the synergid. One male gamete moves towards the egg cell and fuses with its nucleus **(syngamy)** to form **zygote** (diploid).
- The other male gamete moves towards the two polar nuclei located in the central cell and fuses with them to produce a triploid **primary endosperm nucleus (PEN).** As it involves fusion of 3 haploid nuclei, it is called **triple fusion.**
- Since 2 types of fusions (syngamy & triple fusion) take place in an embryo sac, it is called **double fertilisation.** It is an event unique to flowering plants.
- The central cell after triple fusion becomes the **primary endosperm cell (PEC)** and develops into the **endosperm** while the zygote develops into an **embryo.**

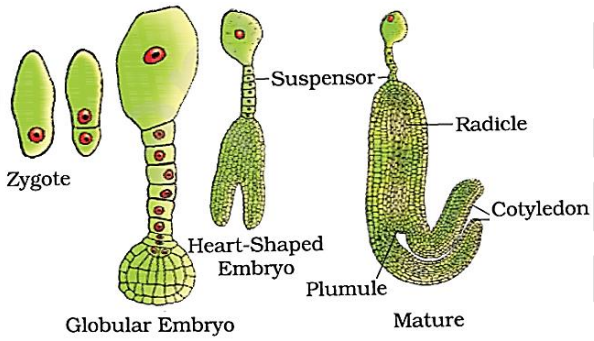


Fertilized embryo sac

POST- FERTILISATION: STRUCTURES & EVENTS

Embryo development

- Embryo develops at the micropylar end of the embryo sac where the zygote is situated.
- Most zygotes divide only after the formation of some endosperm. This provides nutrition to developing embryo.
- In monocots & dicots, seeds differ greatly but **embryogeny** (early embryonic developments) is similar.
- **Zygote → Pro-embryo → Globular → Heart-shaped → Mature embryo.**



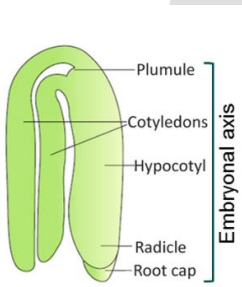
Stages in embryo development in a dicot

Dicotyledonous embryo

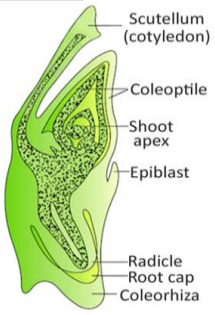
- It has an **embryonal axis** and 2 **cotyledons.**
- Portion of embryonal axis above the level of cotyledons is the **epicotyl,** which terminates with **plumule (stem tip).**
- The cylindrical portion below the level of cotyledons is **hypocotyl** that terminates with the **radicle (root tip).** The root tip is covered with a **root cap.**

Monocotyledonous embryo

- They possess only **one cotyledon.**
- Cotyledon of the grass family is called **scutellum.**
- It is situated lateral to the embryonal axis. At its lower end, the embryonal axis has the radicle and root cap enclosed in **coleorrhiza** (an undifferentiated sheath).
- Portion of embryonal axis above the level of attachment of scutellum is the epicotyl. It has a shoot apex and a few leaf primordia enclosed in **coleoptile** (a hollow foliar structure).



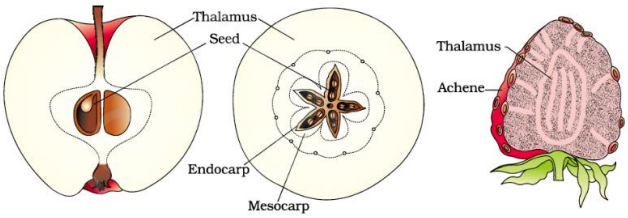
A typical dicot embryo



LS of grass embryo (monocot)

Fruit from Ovary

- The ovary develops into a fruit.
- The wall of ovary develops into **pericarp** (wall of fruit).
- Fruits are 2 types:
  - **True fruits:** In this, fruit develops **only from the ovary.** Other floral parts degenerate & fall off. E.g. most plants.



False fruits of apple and strawberry

  - **False fruits:** In this, the **thalamus** also contributes to fruit formation. E.g. apple, strawberry, cashew etc.
- In some species, fruits develop without fertilisation. Such fruits are called **parthenocarpic fruits.** E.g. Banana.
- Parthenocarpy can be induced through the application of growth hormones. Such fruits are seedless.

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