BIOLOGY

SEXUAL REPRODUCTION IN FLOWERING PLANTS

PARTS OF A TYPICAL FLOWER, MICROSPOROGENESIS

NOTES

Key Takeaways

- Parts of a typical flower
- Structure of a stamen
    - Internal structure of an anther
    - Structure of a microsporangium
- Microsporogenesis

Prerequisites

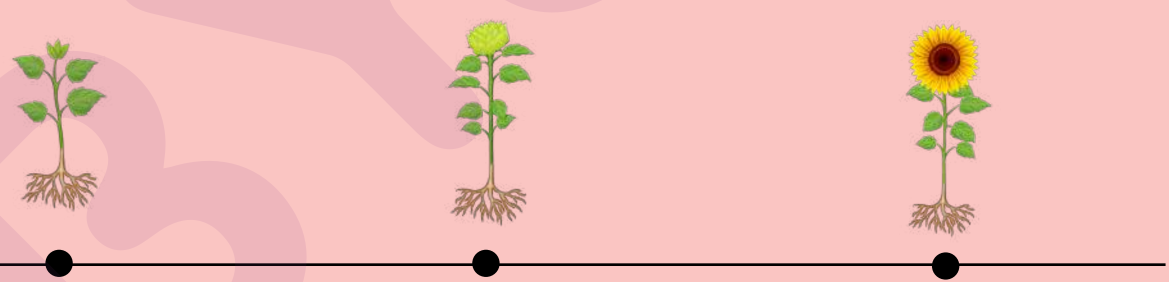
Kingdom Plantae

- Algae
- Bryophytes
- Pteridophytes
- Gymnosperms
- Angiosperms

- **Flowering plants** belong to angiosperms.
- Angiosperms bear **seeds enclosed in fruits**, which is their characteristic feature.

Sexual Reproduction in Flowering Plants

Several changes occur in angiospermic plants before a flower blooms.



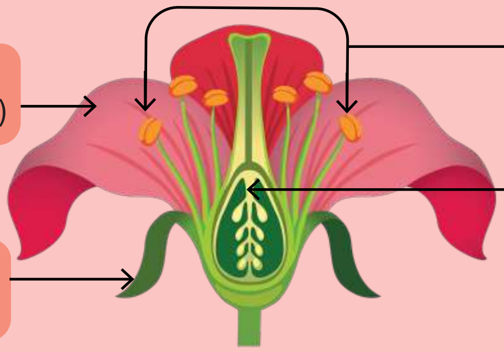
1) **Formation of floral primordium**
It is the tissue that develops to form flowers.

2) **Formation of buds**
Inflorescence bears the floral buds.

3) **Formation of flowers**
The buds of the inflorescence blossom into flowers.

- Flowers play a very important role in sexual reproduction of flowering plants.

Parts of a Typical Flower



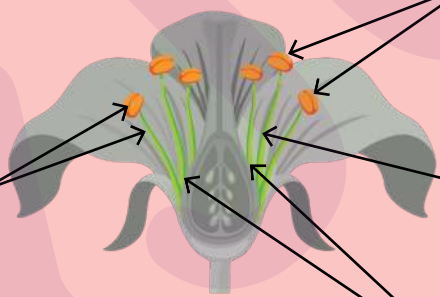
Stamen

Stamen

- The stamen is a long slender structure that forms the male reproductive organ in flowers.
- **The anther** and **the filament** together form the stamen.
- The number and the length of stamens are variable in the flowers of different species.

Examples:

Anthurium: 4 stamens
Hibiscus: Several stamens
Lily: 6 stamens
Jasmine: 2 stamens

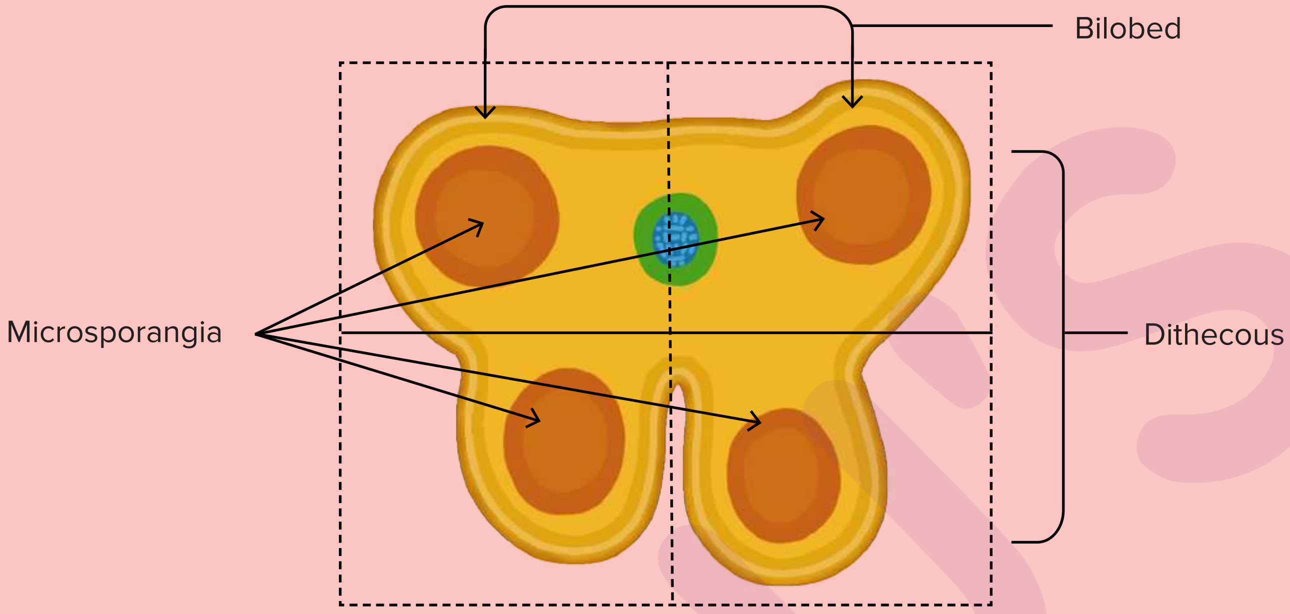


Anther
It is the lobed terminal structure that produces and bears the **pollen grains.**

Filament
It is the long and slender stalk that **connects the anther to the thalamus** or the petal.

The proximal end is attached to the thalamus or the petal.

Internal structure of an anther

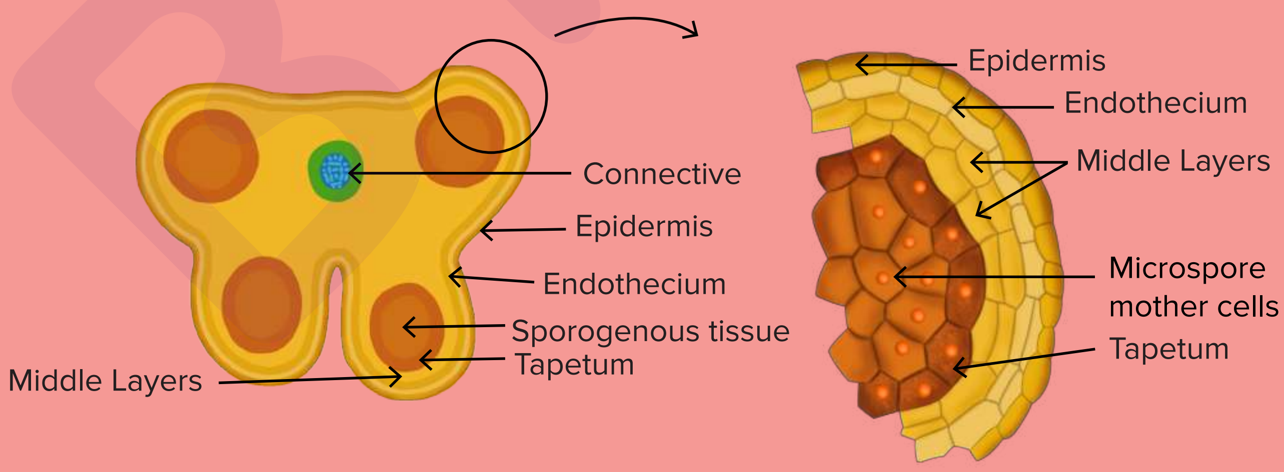


Transverse section of a young anther

- A typical angiospermic anther has two lobes, i.e., it is **bilobed.**
- Each lobe has two chamber-like structures known as the theca, i.e., they are **dithecous.**
- A longitudinal groove runs lengthwise that separates the theca.
- Each theca consists of a **microsporangium** at the corner.

Structure of a microsporangium

- Each microsporangium is covered by four wall layers.

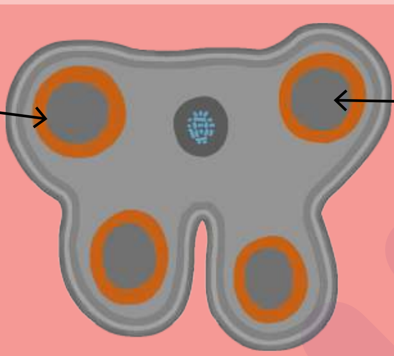


Enlarged view of one microsporangium

- Layers surrounding microsporangium (from exterior to interior)
  Epidermis → Endothecium → Middle layers → Tapetum
- The epidermis, endothecium, and middle layers are **protective** in nature.
- The **innermost** layer is known as tapetum.

Tapetum

- It helps in the **nourishment** of the pollen grains.
- Cells of the tapetum have a dense cytoplasm and contain more than one nucleus.

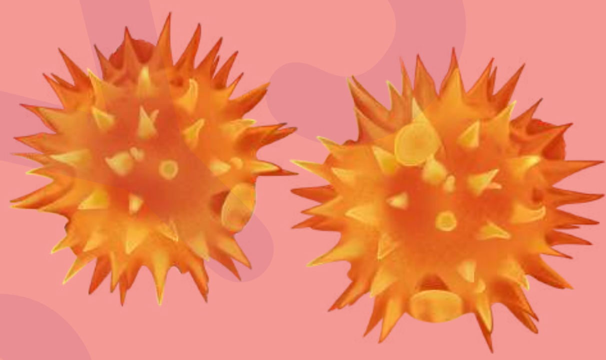


Sporogenous tissue

- The tissue present in the microsporangium that undergoes **meiosis** to produce gametes is known as the sporogenous tissue.

Pollen grains

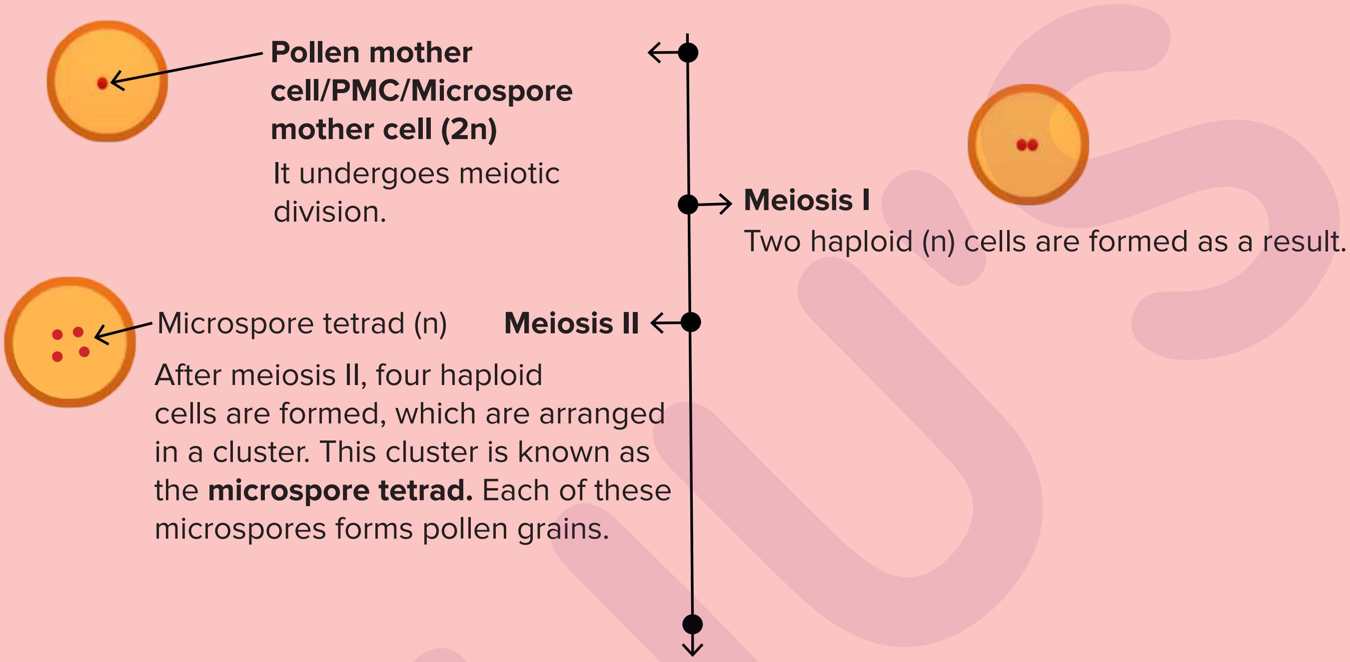
- Pollen grains are the **male gametophytes** seen in angiosperms, i.e., they are the structures that bear the male gametes.
- The precursor to pollen grains are the **microspores.**



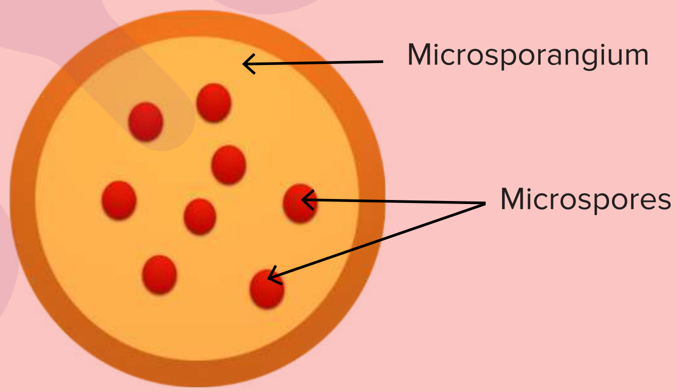
Microspores (Magnified)

Microsporogenesis

- It is the process of formation of **microspores** from microspore mother cell.
- The process of microsporogenesis takes place in **microsporangia** of the anther.
- One of the cells of the sporogenous tissue differentiates and acts as the **pollen mother cell.**

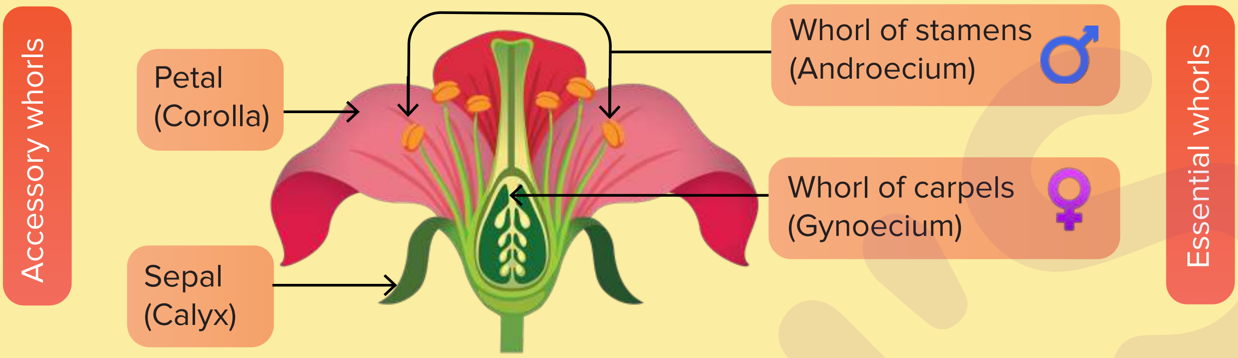


- Each of the pollen mother cells undergoes similar meiotic divisions to yield microspore tetrads.
- Upon maturation and dehydration of the anthers, the microspores dissociate from each other and develop into **pollen grains.**
- Hence, each microsporangium contains several thousands of microspores or pollen grains.

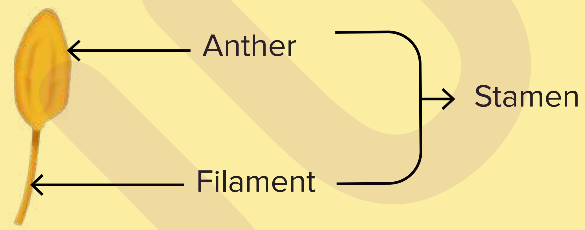


Summary Sheet

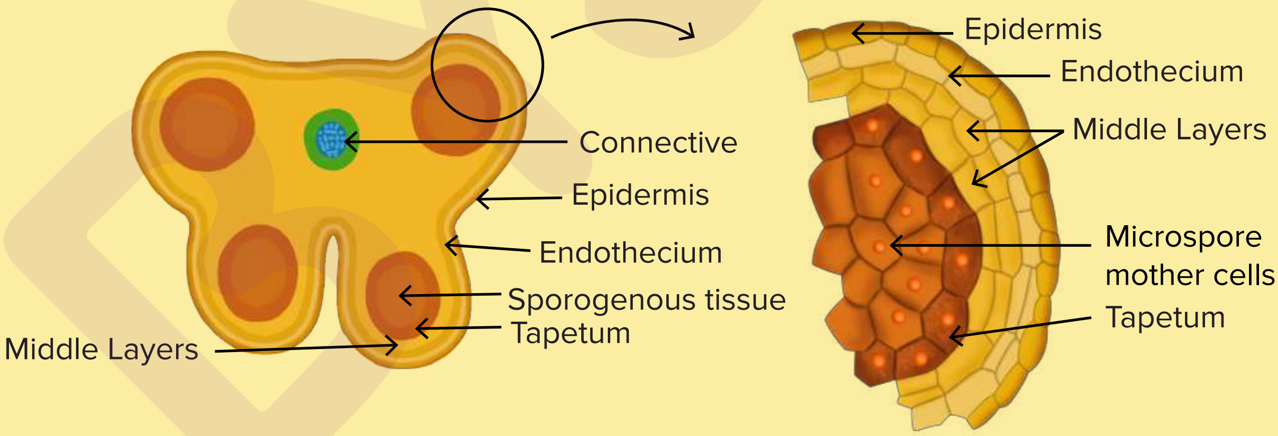
Parts of a flower



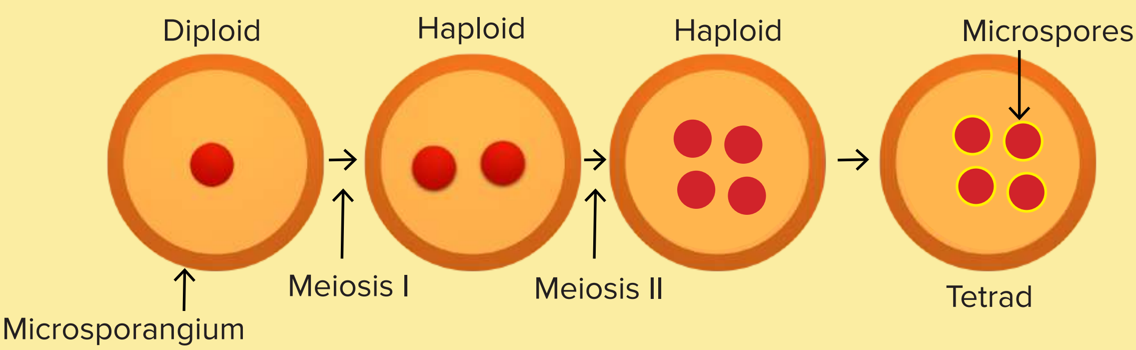
Structure of a stamen



Structure of a microsporangium



Microsporogenesis



SEXUAL REPRODUCTION IN FLOWERING PLANTS

MICROGAMETOGENESIS, STRUCTURE OF A MATURE POLLEN GRAIN, DEHISCENCE, POLLEN ALLERGY, POLLEN VIABILITY

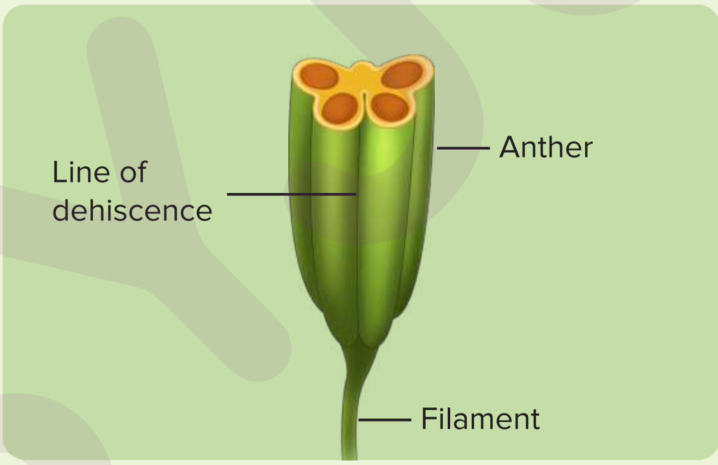
NOTES

Key Takeaways

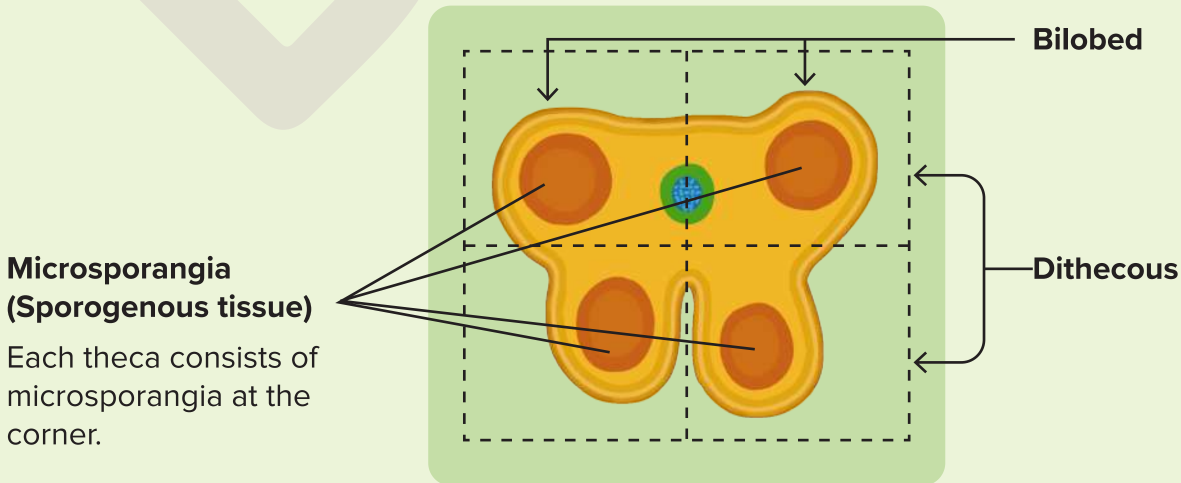
- Microgametogenesis
- Vegetative cell and generative cell
- Structure of a mature pollen grain
  - ➜ Sporopollenin
- Dehiscence
- Pollen allergy
- Pollen viability

Prerequisites

- Structure of a stamen

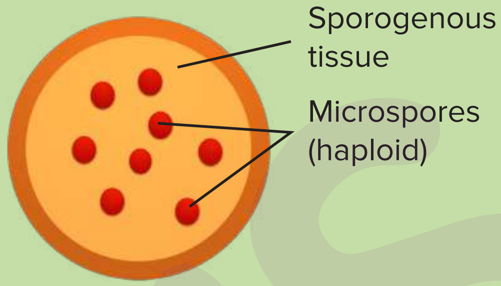


- Structure of an anther (transverse section)

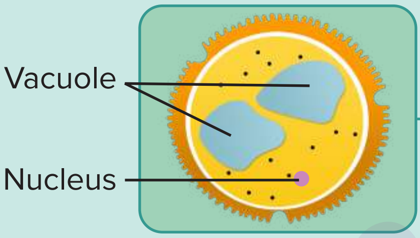


Microsporogenesis

- It is the process of formation of microspores from the microspore mother cell via **meiotic division.**
- The process of microsporogenesis takes place in the microsporangia of an anther.

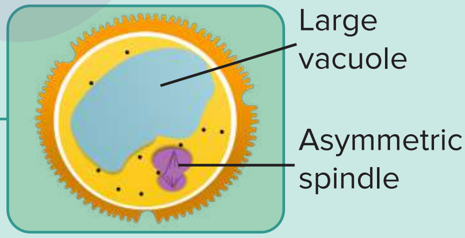


Microgametogenesis

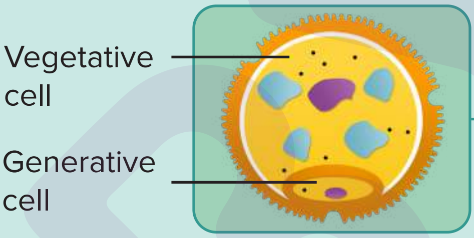


Microspore expands and a single large vacuole is formed.

1st mitosis



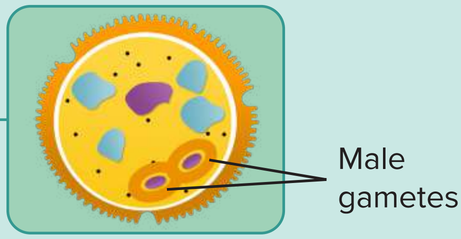
The nucleus divides asymmetrically and the spindle holds the chromosomes.



2-celled stage

- Consequently, one large cell **(vegetative cell)** and a small cell **(generative cell)** are formed.
  - ➜ This is the **two-celled stage** of the pollen grain.
- Slowly, the generative cell detaches from the wall of the pollen grain.

2nd mitosis

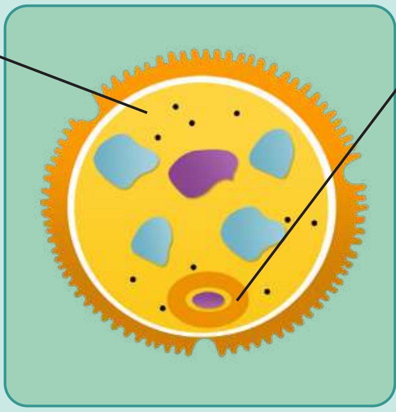


- The generative cell divides mitotically to form the **two male gametes**.
- This is the completely matured **three-celled pollen grain**.

Vegetative Cell and Generative Cell

Vegetative cell

- **Large** in size
- Stores **abundant** food reserve
- Has **irregularly** shaped nucleus



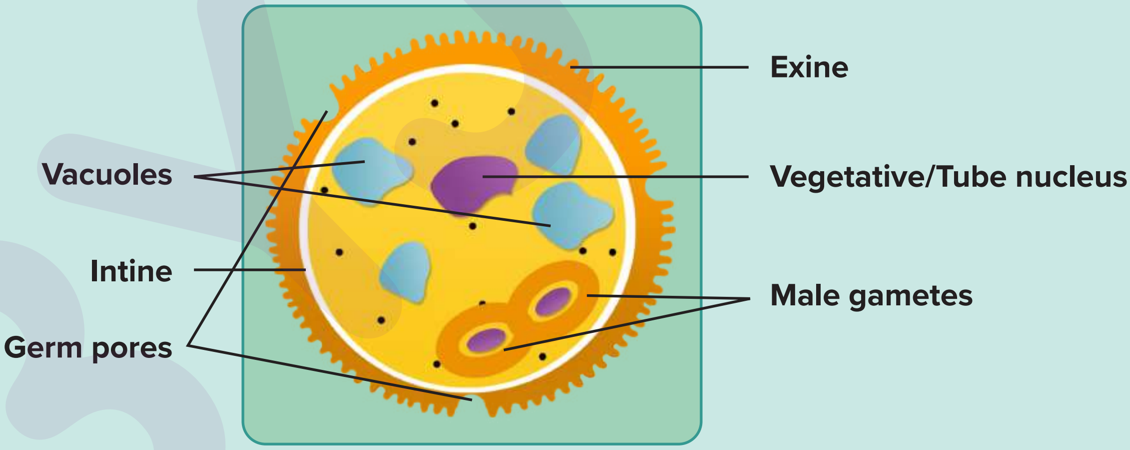
Two-celled stage of pollen grain

Generative cell

- **Small** in size
- Floats in the cytoplasm of vegetative cell
- **Spindle**-shaped
- Has **cell wall**
- Has **dense** cytoplasm and nucleus

Structure of a Mature Pollen Grain

- Pollen grains are usually **spherical** measuring about **25-50 micrometers** in diameter.
- They have a prominent **double layered wall** consisting of exine and intine.
- It consists of **two male gametes** and a **vegetative cell** with a nucleus each.



Exine

- It constitutes the **outer hard layer.**
- Exine is made of **sporopollenin**, which is the **most resistant organic material** known.
- It has apertures called **germ pores**, where the sporopollenin is absent.

Vacuoles

- The single large vacuole of the immature pollen grain breaks down into multiple small vacuoles after the **first mitosis.**

Vegetative/Tube nucleus

- It later helps in the formation of a pollen tube through a germ pore.

Intine

- It is the **inner wall** of the pollen grain.
- It is a continuous layer.
- It is made up of **cellulose** and **pectin.**

Male gametes

- They are formed from the mitosis of the generative cell.
- One of them later **fuses with the egg** cell to form the zygote.
- The other gamete fuses with the polar nuclei to form the primary endosperm nucleus.

Germ pores

- It is a **pore in the exine** through which the pollen tube germinates.

Sporopollenin

- A lot of plant fossils are of pollen.
- This is due to the presence of sporopollenin in pollen grains.
- It is one of the **most resistant organic materials** on this planet.
- It forms the major component of exine.
- It can **withstand high temperature.**
- It can **withstand strong acids** and **alkalis.**
- It protects pollen grain from external damage.

Dehiscence

It is the process by which the pollen grains are released from the anther.

- Pollen grains are present inside pollen sacs, which are nothing but microsporangia.
  - ➜ Pollen sacs are in turn present inside the anther.
- For dehiscence, pollen **loses water**.
- A strip between the pollen sacs disintegrates, resulting in the release of pollen grains.
- This powdery deposit of pollen grains accumulates on the anther.
- It is then picked up by a different agent.
- Around 60 percent of angiosperms shed pollen grains at the **two-celled stage**.
  Example: **Lily plant**

- In remaining species, the pollen grains are shed at the three-celled stage.
  Example: **Wheat plant**

Pollen Allergy

Pollen grains of several species can cause the following:

- **Severe allergies**
- Bronchial afflictions, which can lead to **chronic respiratory disorders like:**
  - **Asthma**
  - **Bronchitis**

- ***Parthenium* (carrot grass)** is an example of a plant whose pollen can cause several allergies.
- It came to India as a contaminant with imported wheat.

Pollen Viability

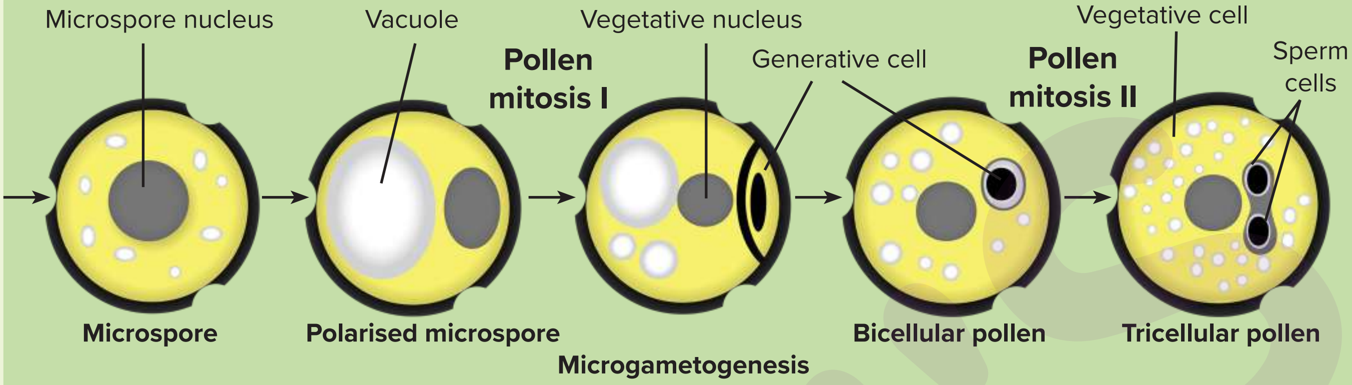
Pollen viability refers to the ability of pollen to live, mature, germinate on the stigma, and transfer the male gametes to the embryo sac.

- The quality of pollen is determined by its viability.
- Pollen viability differs amongst species.
- Examples:
  - It is 30 minutes for rice and wheat.
  - It is a few months for the members of Rosaceae, Leguminosae, and Solanaceae.
- Pollen grains can be **stored at -196 degree Celsius** in liquid nitrogen**.**
- This method of storing pollen is known as **cryopreservation**. It is also used in the case of humans and higher animals to store the gametes for later use.

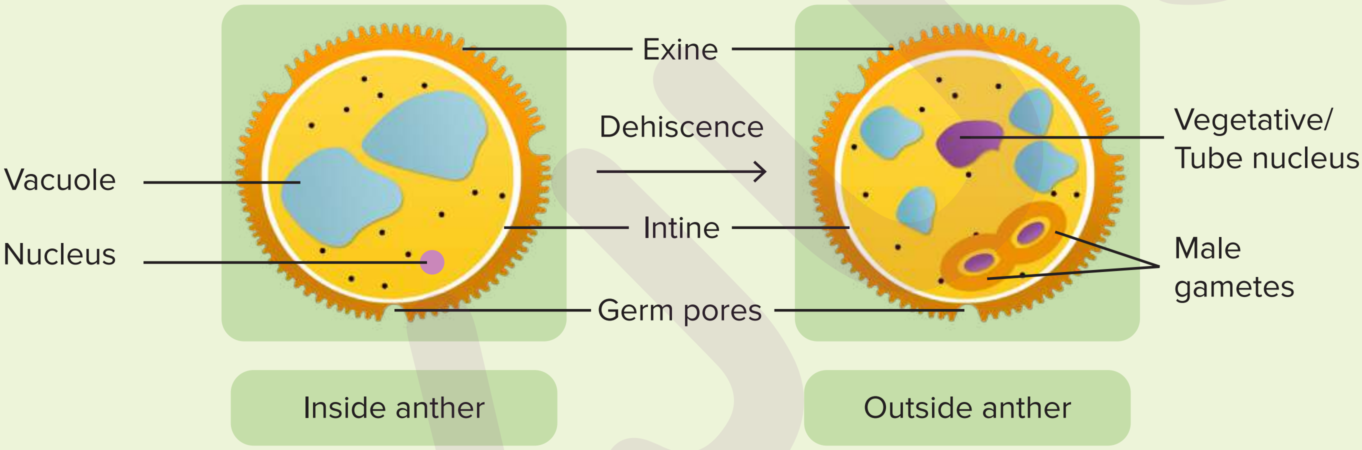
Did you know?

- Pollen grain tablets/syrups have become popular as food supplements.
- They are rich in nutrients.
- It has been claimed that pollen consumption improves the performance of athletes and race horses.

Summary Sheet



Development of sperm cells in the pollen grains



- **Dehiscence** is the process by which the **pollen grains are released** from the anther.
- Polles can cause several **allergies** and chronic **respiratory disorders** like asthma.
- Pollen viability refers to the ability of pollen to live, mature, germinate on the stigma, and transfer the male gametes to the embryo sac.

SEXUAL REPRODUCTION IN FLOWERING PLANTS

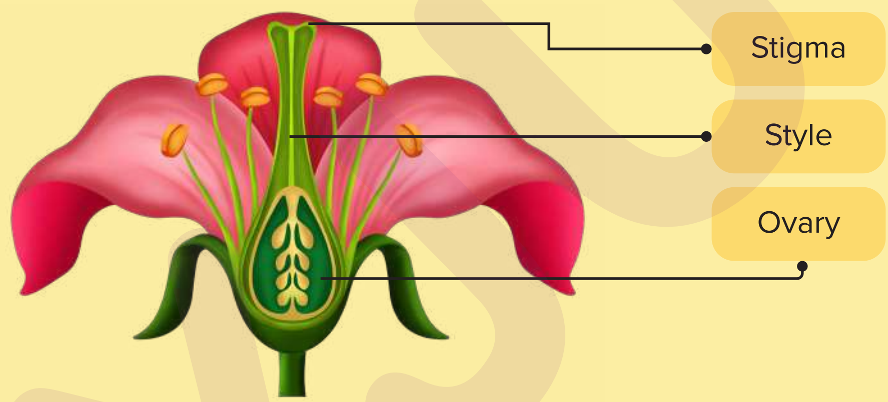
STRUCTURE OF OVARY AND OVULE, FEMALE GAMETOPHYTE

Key Takeaways

- Structure of an ovary
- Structure of an ovule
- Female gametophyte
  - » Megasporogenesis
  - » Megagametogenesis (Monosporic development)
  - » Structure of female gametophyte

Prerequisites

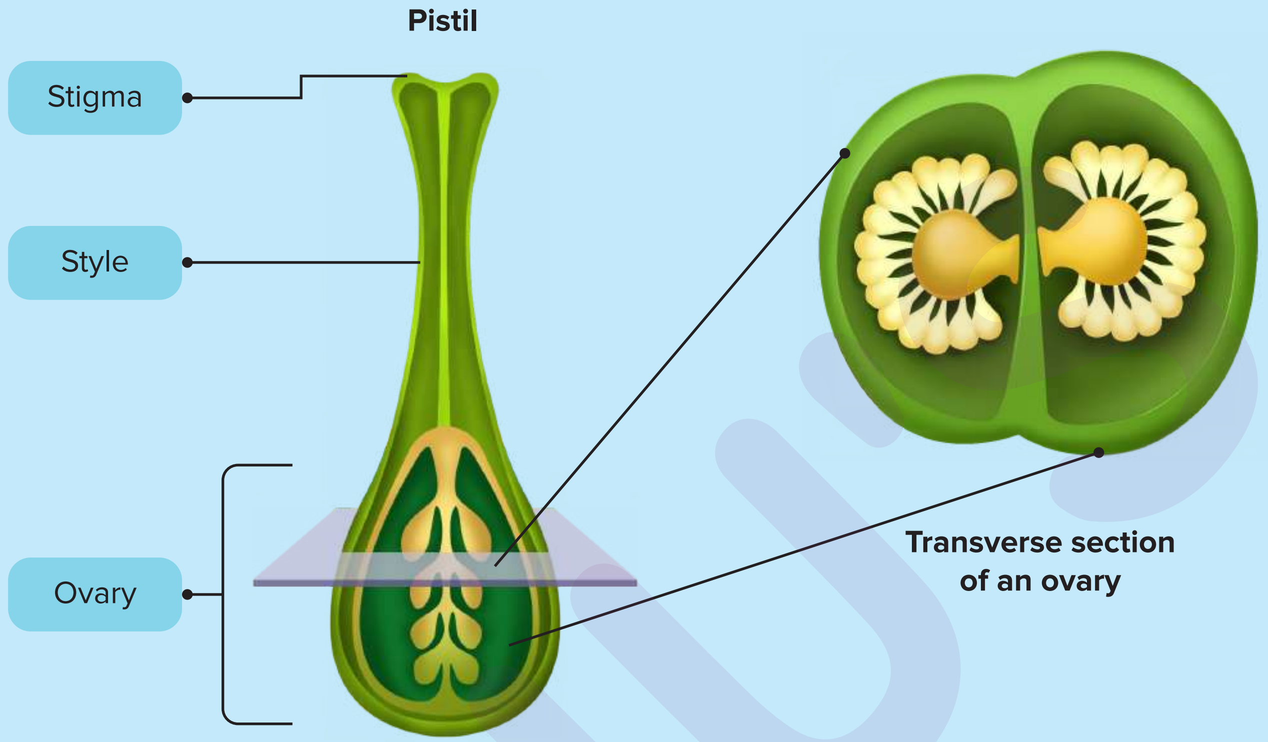
Carpel: Female reproductive organ



Gynoecium

- Monocarpellary
  - Single free carpel
  - Ex: **Mango**
- Multicarpellary
  - Apocarpous
    - Multiple free carpels
    - Ex: ***Michelia***
  - Syncarpous
    - Multiple carpels fused
    - Ex: ***Papaver***

Structure of an Ovary

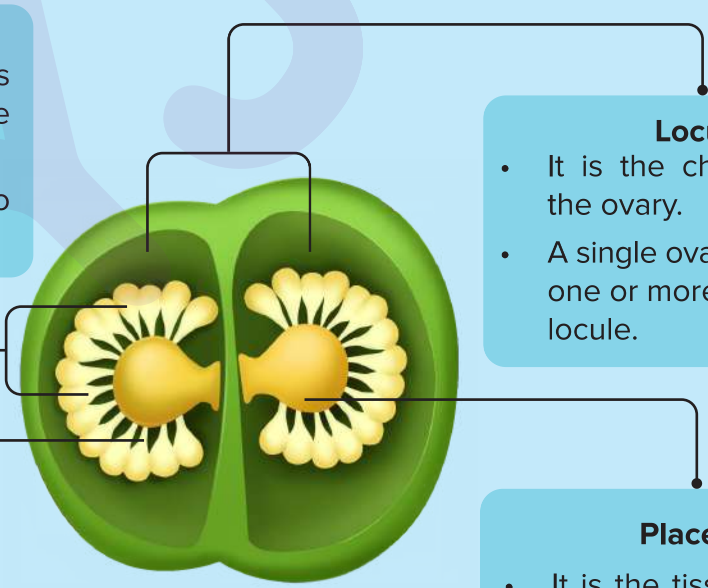


Ovules

- Ovules are the structures that later develop into the seeds of angiosperms.
- They contain the embryo sac.

Locule

- It is the chamber inside the ovary.
- A single ovary can have one or more than one locule.



Funicle

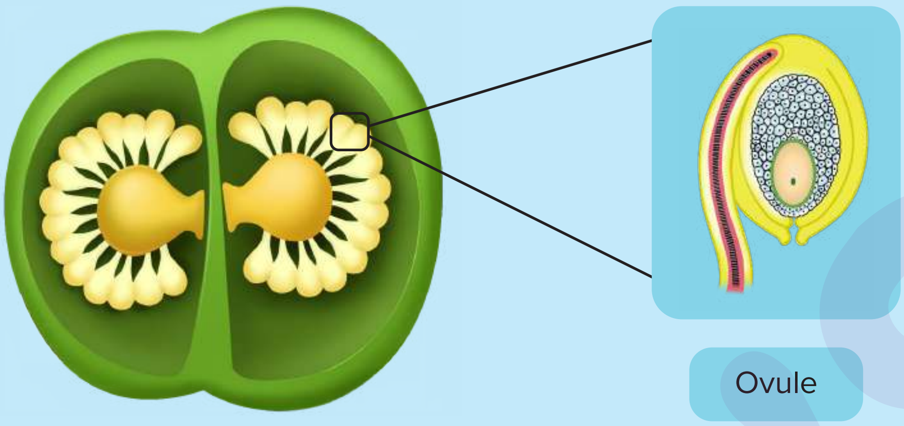
- It is a thin stalk that attaches the ovule to the placenta.

Transverse section of an ovary

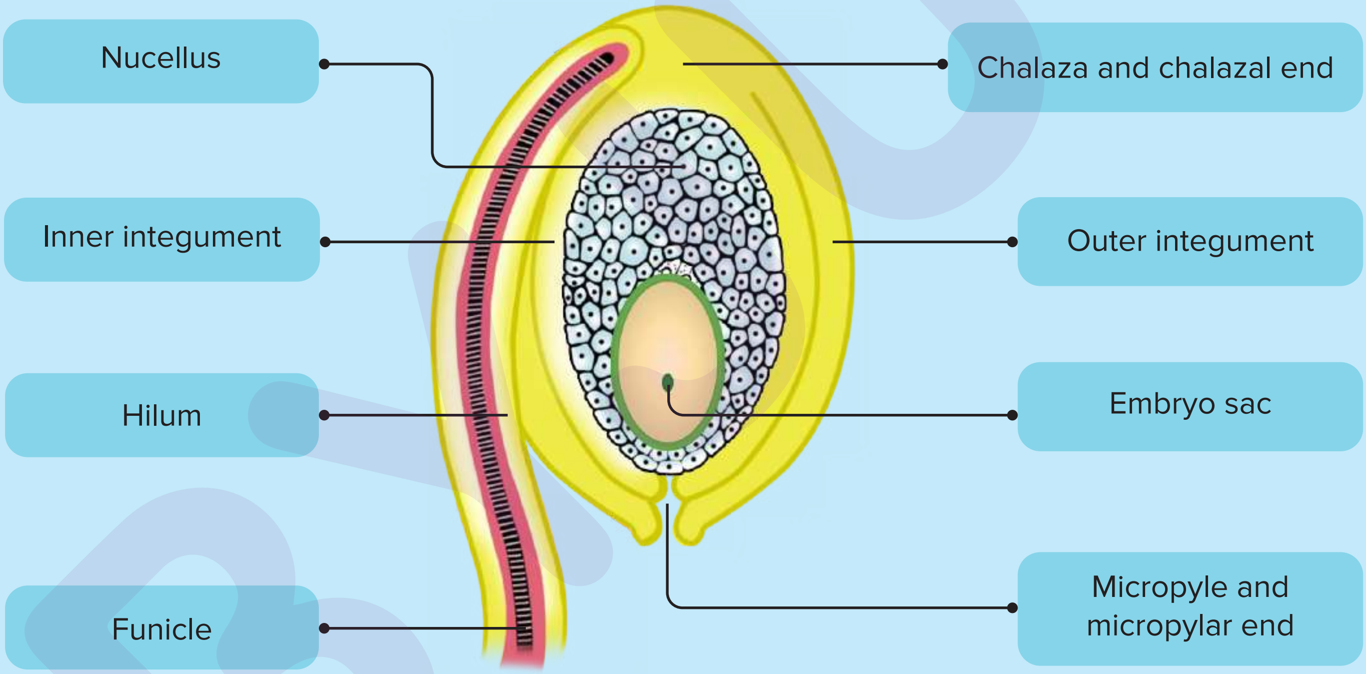
Placenta

- It is the tissue to which the ovules are attached.

Structure of an Ovule



Ovule is a structure present inside the ovary that contains the female gamete and develops into the seed of the future fruit.

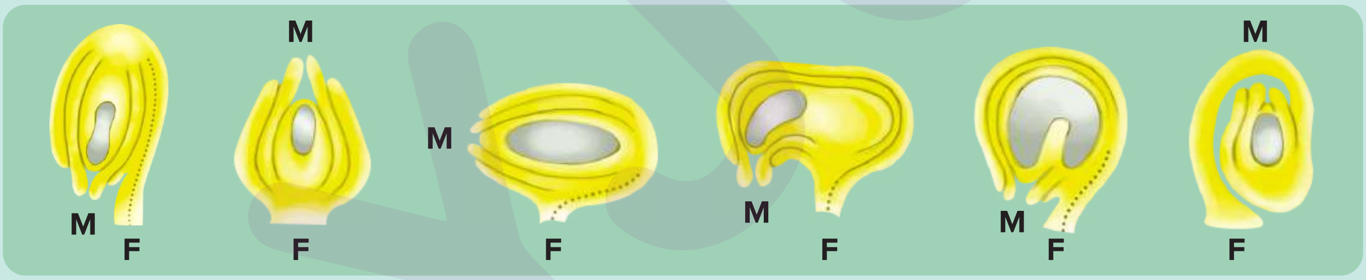


- **Chalaza and chalazal end**
    - It is the region **opposite** to the **micropylar end**.
- **Nucellus**
    - Nucellus is the **cell mass** made of parenchymal cells.
    - It is **enveloped** by the layers of integuments.
    - Nucellar cells have an abundant **food reserve** that helps during the embryonic development.
- **Inner integument**
    - It is the protective layer of the ovule present **beneath the outer integument**.
- **Outer integument**
    - It is the **outer protective covering** of the ovule.

- **Hilum**
  - It is the point of **attachment** of the funicle with the ovule.
- **Embryo sac**
  - It is present in the **innermost region** of the ovule.
  - It is covered by nucellus.
  - It is also known as the **female gametophyte**.
  - Female gametophyte is the structure having the female gametes.
- **Funicle**
  - It is the structure through which the **ovule is attached to the placenta**.
- **Micropyle and micropylar end**
  - Micropyle is the tip of the nucellus that is **not covered by integuments**.
  - It is the small opening through which the **pollen tube penetrates** the ovule.
  - The region of ovule near the micropyle is known as the **micropylar end**.

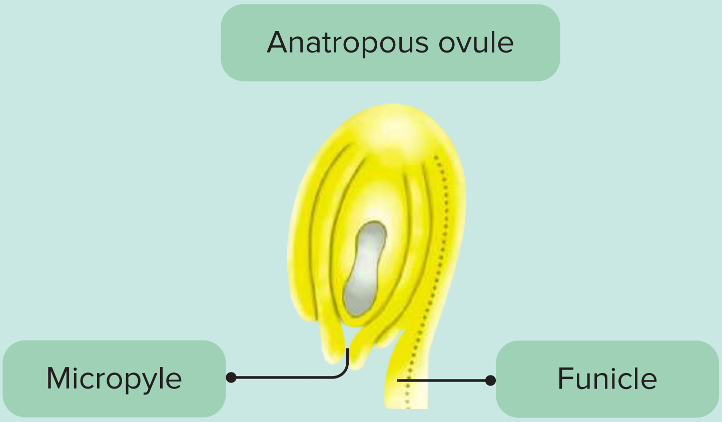
Did you know?

Ovules can be of different shapes and sizes. Here, **F stands for funicle**, while **M stands for micropyle.**



Anatropous ovule

- It is found in 80% of angiosperms.
- When ovule is rotated by 180°, micropyle comes closer to funicle.

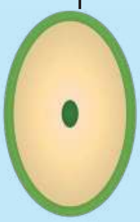


Female Gametophyte

Megasporogenesis

It is the process of formation of megaspores from megaspore mother cell (MMC).

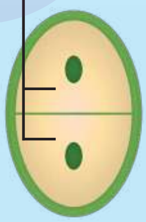
Megasporogenesis



Megaspore mother cell/MMC (2n)

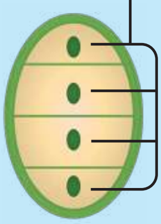
- At the micropylar end, one of the cells from the nucellus **differentiates** to form a megaspore mother cell (MMC).
- It contains dense cytoplasm and a prominent nucleus.

Meiosis I
↓
Megaspore dyad (n)



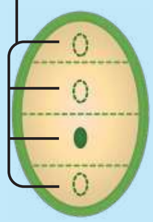
MMC undergoes the first meiotic division to give rise to megaspore dyad. (haploid).

Meiosis II
↓
Megaspore tetrad (n)



After meiosis I, MMC undergoes meiosis II. This results in the formation of megaspore tetrad (four megaspores), which are haploid.

Megaspore tetrad (n)
↓
Degeneration



Generally, only one out of the four megaspores remains functional, while the other **three cells degenerate**.

Functional megaspore (n)

The single haploid megaspore known as **functional megaspore** undergoes further development to form the female gametophyte.

Megagametogenesis (Monosporic development)

- It is the process of maturation of **megaspore into a female gametophyte**.
- It occurs from a **single functional megaspore** and hence is known as **monosporic development**.

Megagametogenesis

Functional megaspore (n)

The haploid functional megaspore undergoes mitosis.

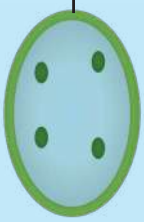
1st mitosis ↓

Two-nucleate stage (n)

- The nucleus of the megaspore divides mitotically to form **two nuclei**.
- These nuclei move towards the **opposite poles**.

2nd mitosis ↓

Four-nucleate stage (n)



The binucleate embryo sac undergoes a second mitosis to form a **four nucleate embryo sac**.

3rd mitosis ↓

Eight-nucleate stage (n)

Finally, the nuclei undergoes a third mitosis to give an **eight-nucleate embryo sac**. Till this stage, mitosis is strictly **free nuclear**, because the nuclear division is not followed by the cell wall formation.

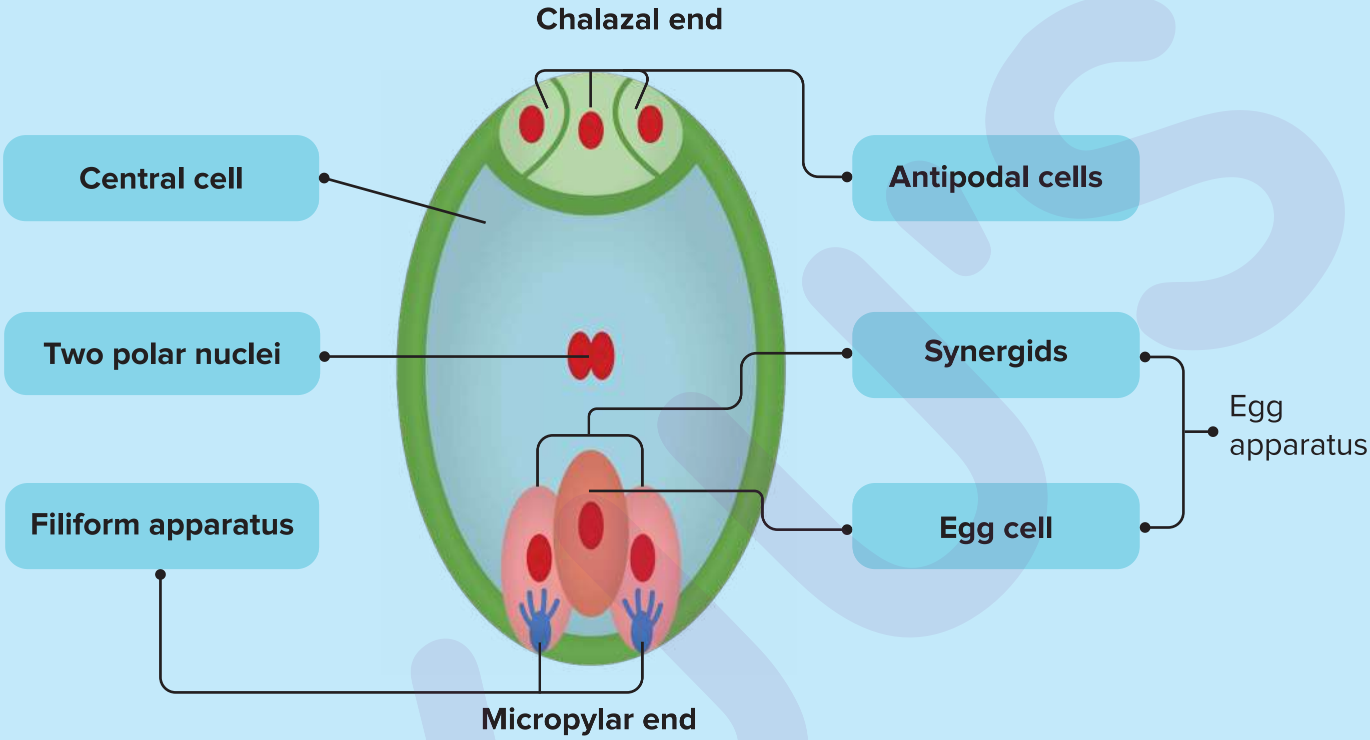
Cytokinesis ↓

Female gametophyte

- After the eight-nucleate stage, **six** of the eight nuclei are **surrounded by cell walls** and organised into cells.
- The remaining two nuclei, known as **polar nuclei**, are situated in the large central cell.

Structure of female gametophyte

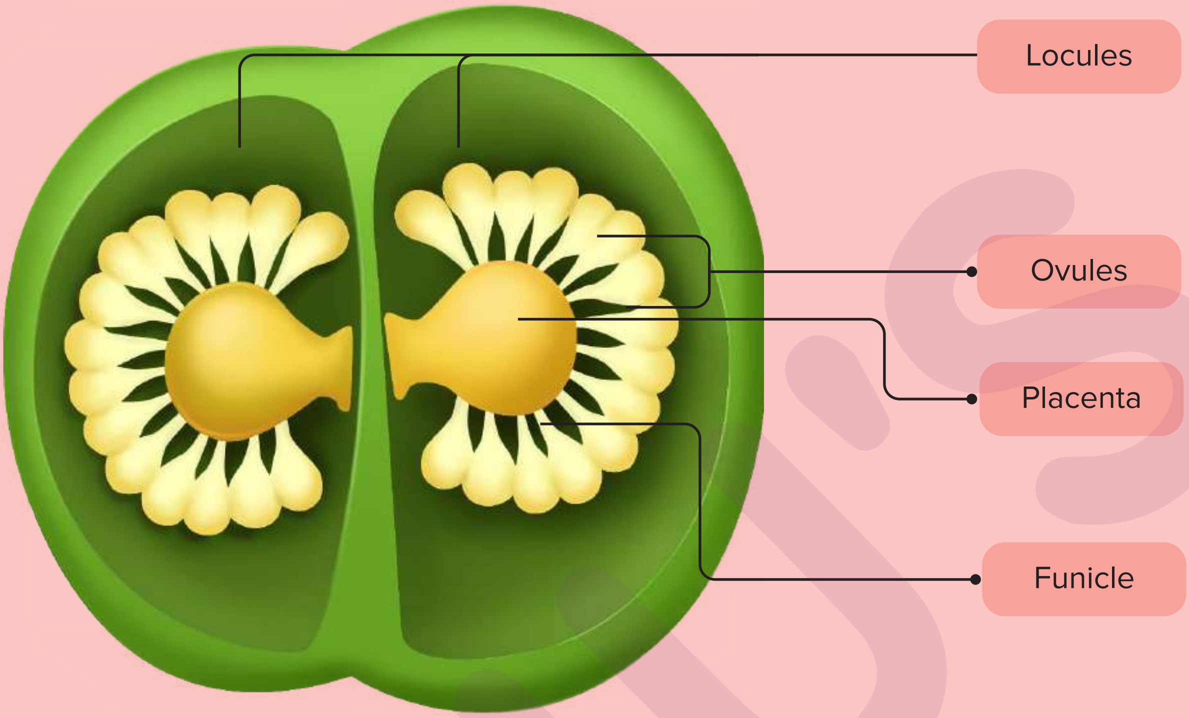
- It is a **seven celled, eight nucleate** structure that contains the female gamete, i.e., the egg cell.



- **Antipodal cells**
  - **Three** antipodal cells are formed towards the chalazal end.
- **Egg cell**
  - The egg cell is the **female gamete**.
  - It fuses with the male gamete to form the zygote, which later develops into an embryo.
- **Synergids**
  - Synergids are present beside the egg cell.
  - Synergids and egg cells are grouped together at the **micropylar end**.
  - These constitute the **egg apparatus**.
- **Central cell**
  - Six of the eight nuclei are surrounded by cell walls and organised into cells.
  - The remaining two nuclei, known as polar nuclei, are present in the large central cell.
- **Polar nuclei**
  - These later fuse with the male gamete and undergo **triple fusion** to form an endosperm.
- **Filiform apparatus**
  - They are the **cellular thickenings** present at the micropylar tip of the synergids.
  - They play an important role in **guiding the pollen tube** into the embryo sac.

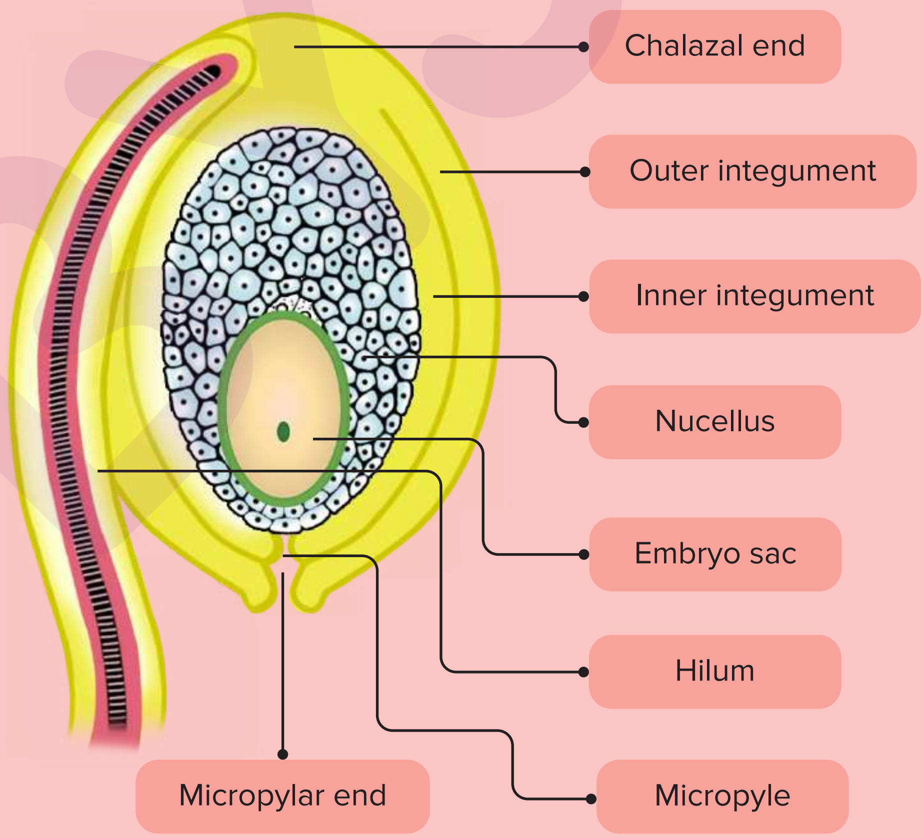
Summary Sheet

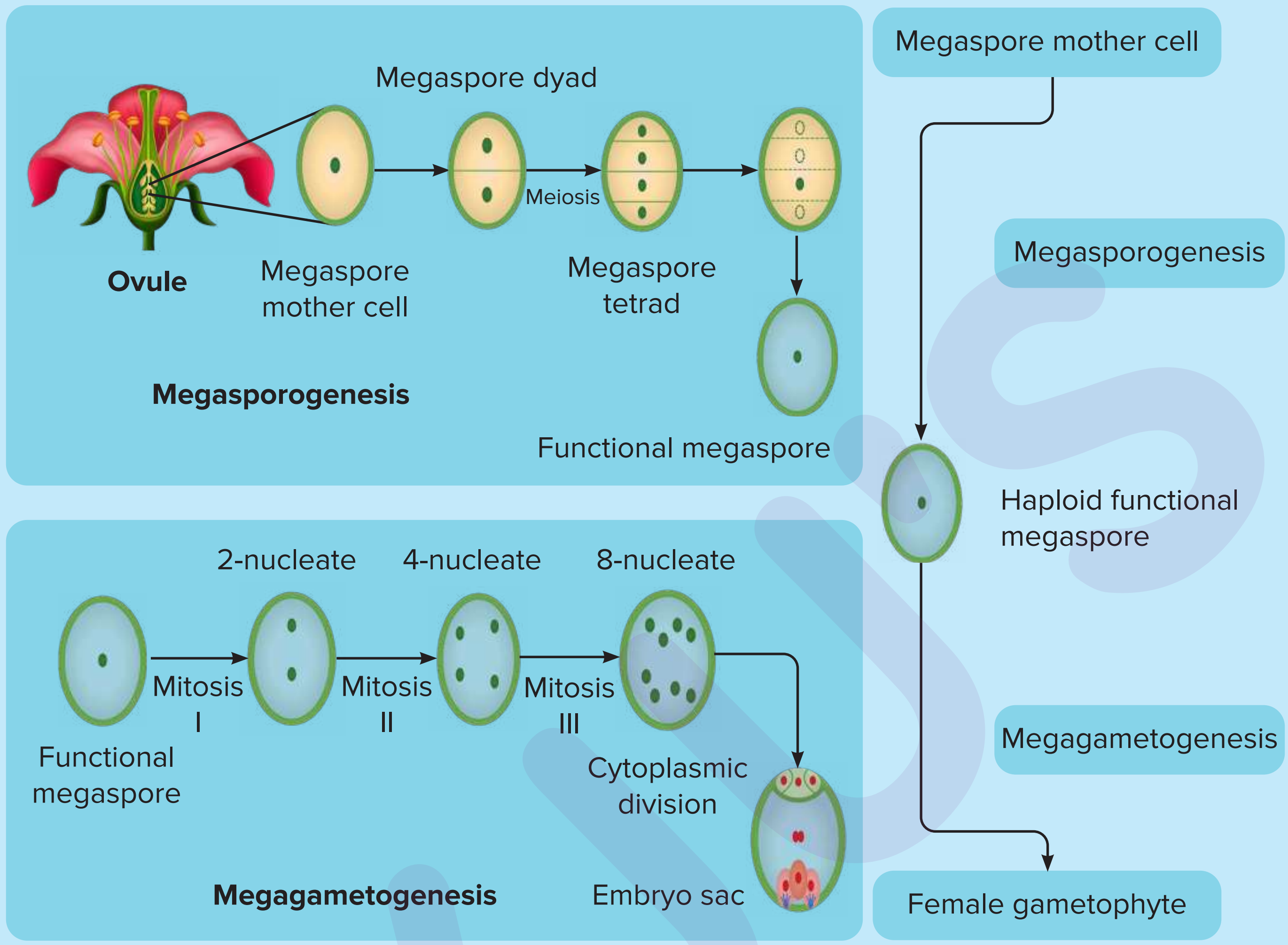
Ovary



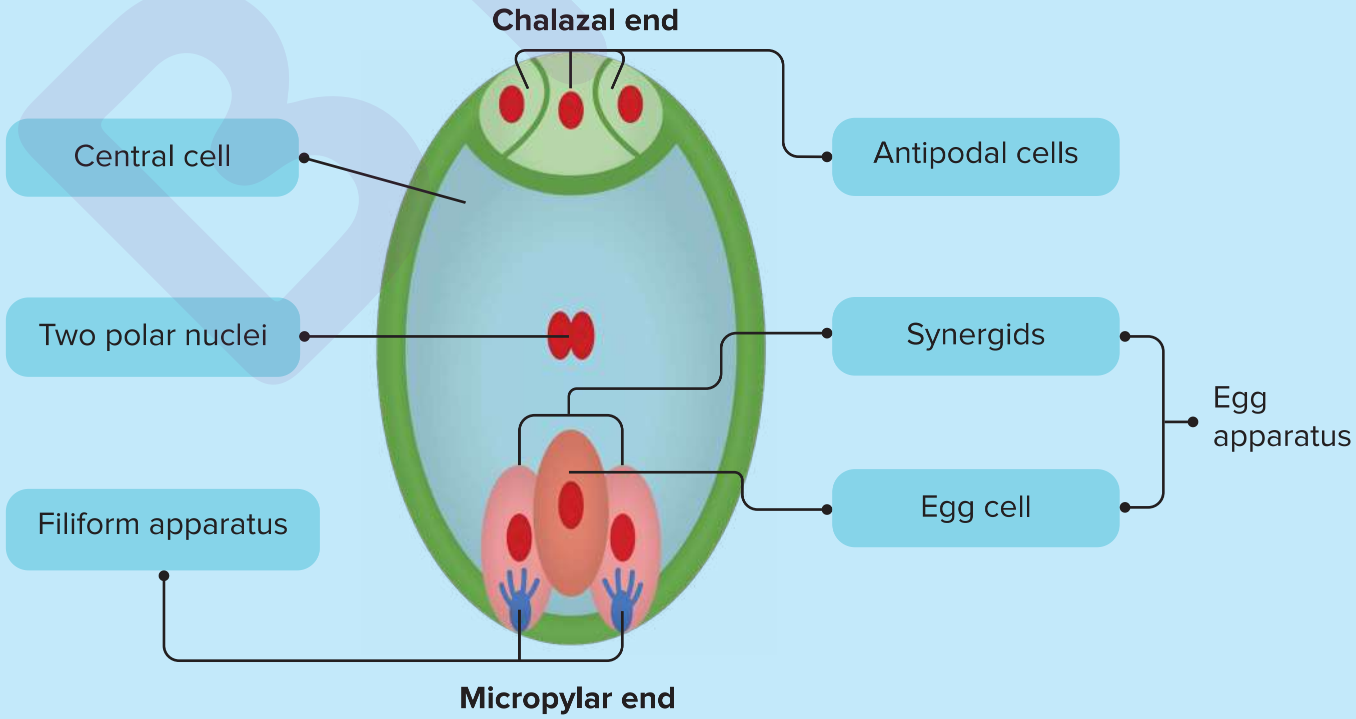
Transverse section of an ovary

Ovule





Mature embryo sac (female gametophyte)



BIOLOGY

SEXUAL REPRODUCTION IN FLOWERING PLANTS

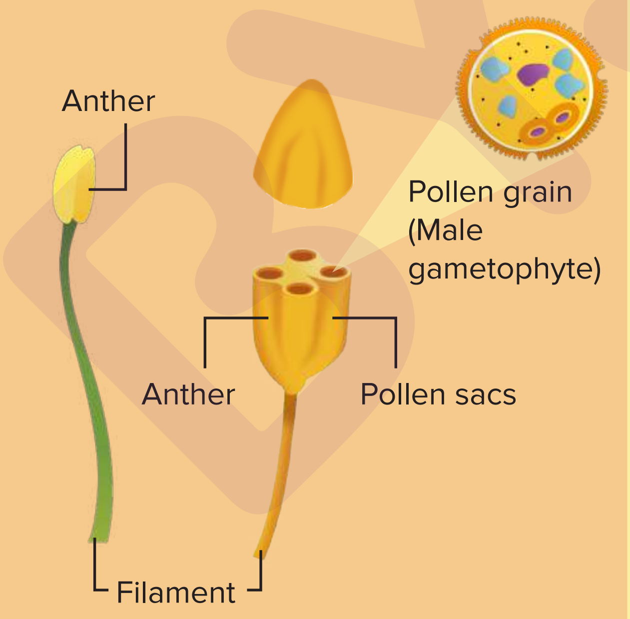
TYPES OF POLLINATION, AGENTS OF CROSS-POLLINATION

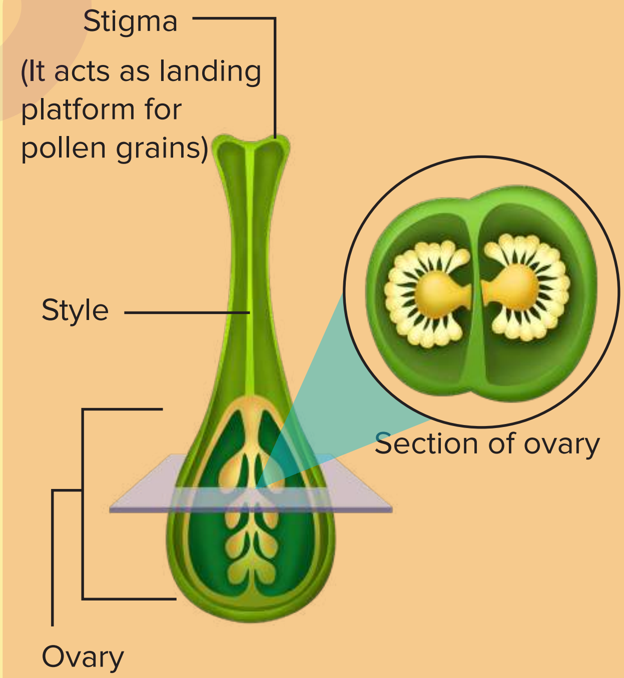
NOTES

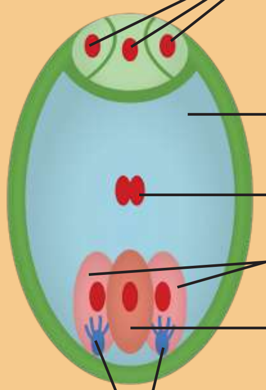
Key Takeaways

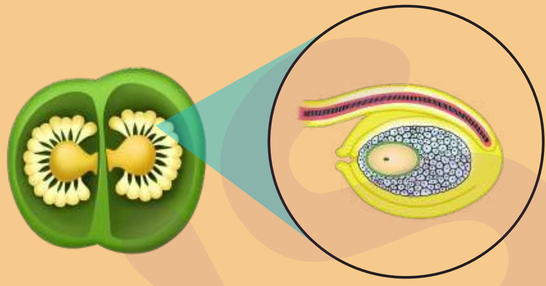
- Pollination
- Types of pollinations
- Self pollination
  - Advantages of self-pollination
  - Disadvantages of self-pollination
- Cross pollination
  - Agents of cross-pollination
  - Advantages of cross pollination
  - Disadvantages of cross pollination

Prerequisites









Pollination

Pollination is the transfer of pollen grains (shed from the anther) to the stigma of a pistil.

Types of Pollinations

Types of pollinations
(Depending upon the source of pollen)

Self-pollination
It is the transfer of pollen from anther to stigma of a genetically similar flower.

Cross-pollination
It is the transfer of pollen from anther of one flower to stigma of a genetically different flower.

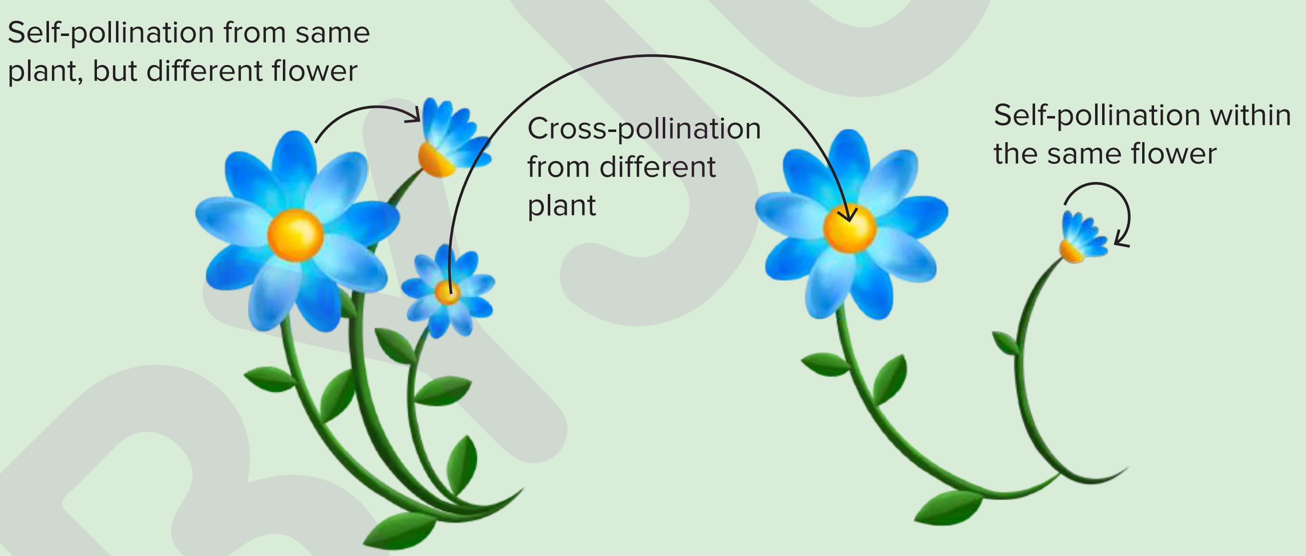
→ **Xenogamy**

Autogamy

Geitonogamy

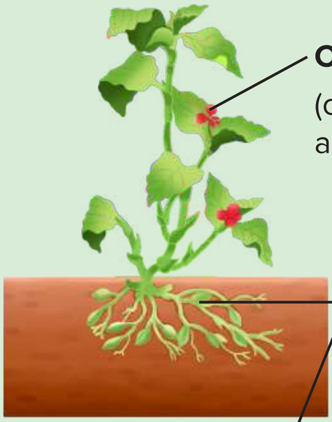
- Auto = Self, Gamos = Marriage
- Autogamy is the transfer of pollen grains from the anther to the stigma of the **same flower**.
- It requires **synchrony** in **pollen release** and **stigma receptivity**.
- The anthers and the stigma should **lie close** to each other so that self-pollination occurs.

- Geiton = Neighbour, Gamos = Marriage
- Geitonogamy is the transfer of pollen grains from the anther to the stigma of another flower of the **same plant**.
- Even though geitonogamy is functionally cross-pollination, **genetically, it is similar to autogamy**.



Autogamy

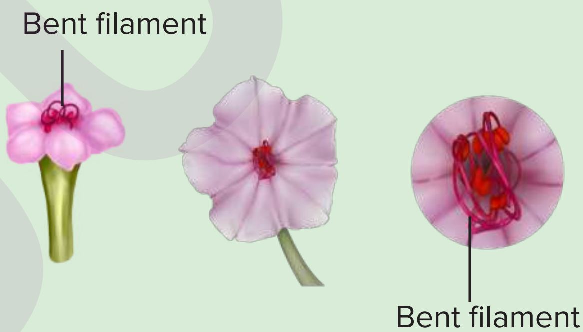
- A complete autogamy is very **rare** in flowers that have stamens and stigma exposed, i.e., in an **open flower**. For this reason, some plants produce two types of flowers; chasmogamous and cleistogamous flowers.



Chasmogamous flower
(open; exposed anther and stigma)

Anthers and stigma are brought together by various mechanisms.
Examples: *Catharanthus*, *Mirabilis*

Style grows such that the stigma is placed towards anthers in *Catharanthus*.



Filaments curve over stigma in *Mirabilis jalapa*.

Cleistogamous flower
(closed; flower does not open at all)

Anthers and stigma lie close to each other within the closed flower.
No pollinators are required.
Examples: ***Viola* (common pansy)**, ***Oxalis***, and ***Commelina***

Open flower of *Viola*

Closed flower of *Viola*

Did you know?

Sunflower has a fail safe mechanism for pollination.

- When cross pollination fails in sunflowers, the stigma curls to pick up its own pollen. This is a fail safe mechanism of self-pollination.

Sunflower

Pollination in cleistogamous flowers

Anthers dehisce in the flower buds

↓

Pollen grains come in contact with the stigma

↓

Assured production of seed-set

- Thus, cleistogamous flowers are invariably autogamous as there is no chance of cross-pollen landing on the stigma.

Advantages of self-pollination

- It maintains the parental characters/purity of the race.
- It is useful in maintaining pure lines for hybridisation experiments.
- The plants do not have to produce large quantities of pollen grains.
- The flowers do not have to develop characteristics to attract pollinators.
- Seed production is assured.
- It eliminates undesirable recessive characters.

Disadvantages of self-pollination

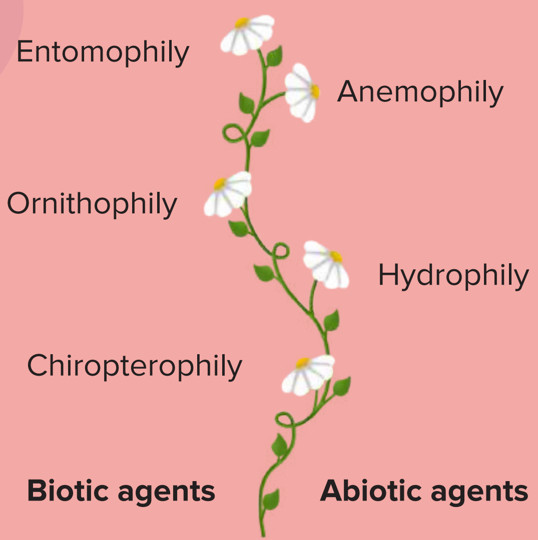
- There will be no introduction of new characters.
- There can be decreased immunity to disease.
- It might lead to decreased adaptability to change in environment.
- There will be a decrease in variability.

Cross-pollination

Xenogamy	• Xenos = Strange, Gamos = Marriage • Xenogamy is the transfer of pollen grains from the anther of one plant to the stigma of a different plant. • It needs help from external agents. • It brings genetically different pollen grains to the stigma.

Agents of Cross-Pollination

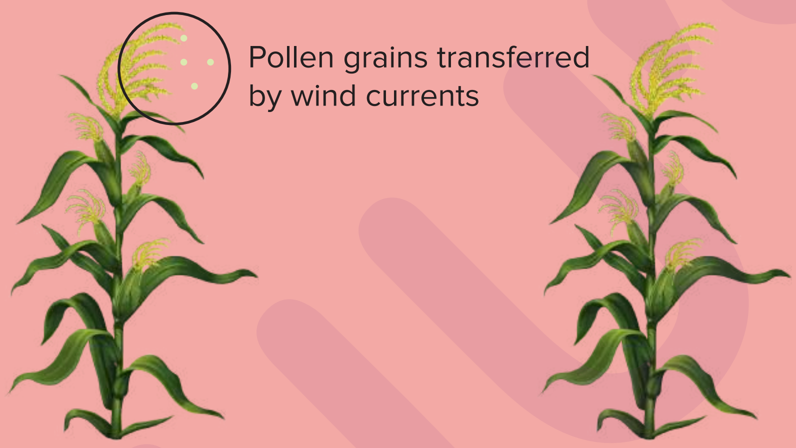
Both abiotic and biotic agents help in cross-pollination.



Abiotic agents

Anemophily

- Anemos = **wind** and philein = to love.
- Pollination by wind is more **common** amongst abiotic pollinations.
- The transfer of pollen grains from the anther to the stigma occurs with wind as an agent.
- Examples: Coconut palm, date palm, grasses, etc.



Transfer of pollen grains by wind

- **Characteristics of anemophilous flowers**

1. Small and inconspicuous flowers
2. Colourless, odourless, nectarless flowers (as there is no need to attract animals)
3. Numerous flowers packed into an inflorescence
4. Light and dry pollens
5. Dusty and non-sticky pollen grains

Coconut palm flower

Orchard grass flower

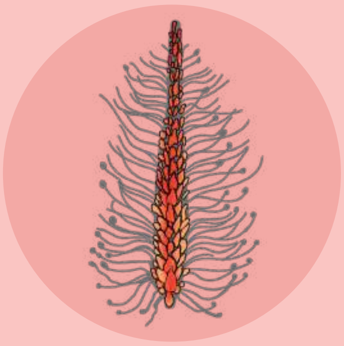
Light and dry pollens

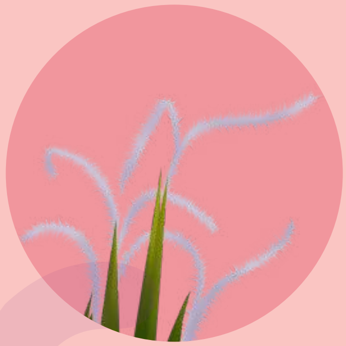
Dusty and non-sticky pollens

6. Well-exposed stamens (so that the pollen is easily dispersed by wind currents)

7. Feathery stigma to easily trap air-borne pollen grains

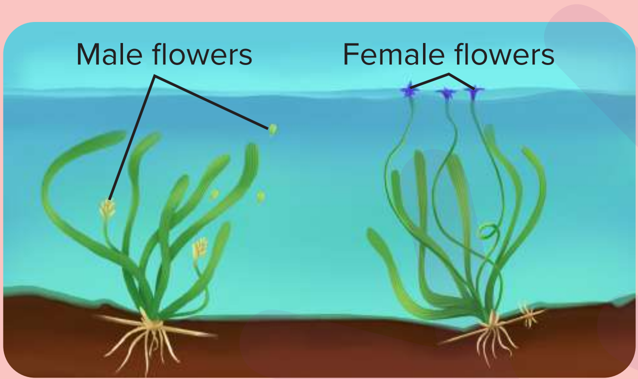
8. Uniovulated pistil (single ovule in each ovary)


Well-exposed stamen


Feathery stigma

Hydrophily

- ***Hydro*** – water; **philein** – to love
- Pollination by water is quite **rare in flowering plants** and is limited to about 30 genera, mostly monocotyledons.



Pollination in *Vallisneria*

- In ***Vallisneria***, the female flower reaches the surface of water by the long stalk and the male flowers or pollen grains are released into the water. They float on the water surface.
- They are carried passively by water currents, some of them eventually reach the female flowers and the stigma.

Sea grasses

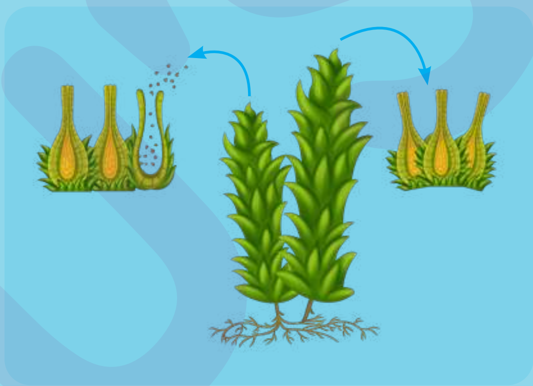
- In another group of water-pollinated plants such as sea grasses, female flowers remain submerged in the water and the pollen grains are released inside the water.

Note

- Not all aquatic plants use water for pollination.
- In a majority of aquatic plants, such as water hyacinth and water lily, the flowers emerge above the level of water and are pollinated by insects or wind alike most of the land plants.

Did you know?

- The limited distribution of lower plant groups is due to the need of water.
- Water is a regular mode of transport for the male gametes among the lower plant groups such as algae, bryophytes, and pteridophytes.
- The distribution of some bryophytes and pteridophytes is limited because of the need for water for the transport of male gametes and fertilisation.



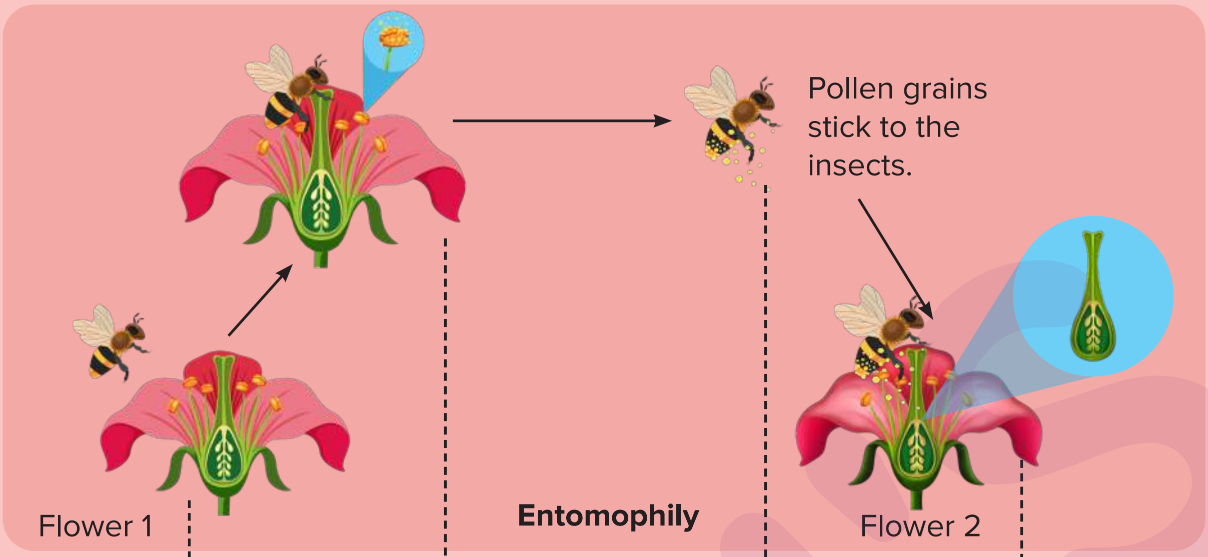
Transfer of gametes in lower plant groups such as algae, bryophytes, and pteridophytes

Biotic agents

- **Majority** of flowering plants use various animals as biotic agents for pollination.
- Bees, butterflies, beetles, flies, wasps, ants, moths, birds, and bats are the common agents.
- Larger animals such as lemurs, rodents, garden lizards, and gecko lizards are also known to be pollinators.

Entomophily

- Entomon – **insect**; philein – to love
- It is the **most common** method.
- Pollination occurs by **insects**, **moths**, **butterflies**, **wasps**, **bees**, **beetles**, **etc**.
- Plants provide **nectar**, **edible pollen grains**, **or shelter**.



When an insect lands on a flower, it comes in contact with the anther and stigma of the flower.

When it lands on another flower, the pollen comes in contact with the stigma of that flower.

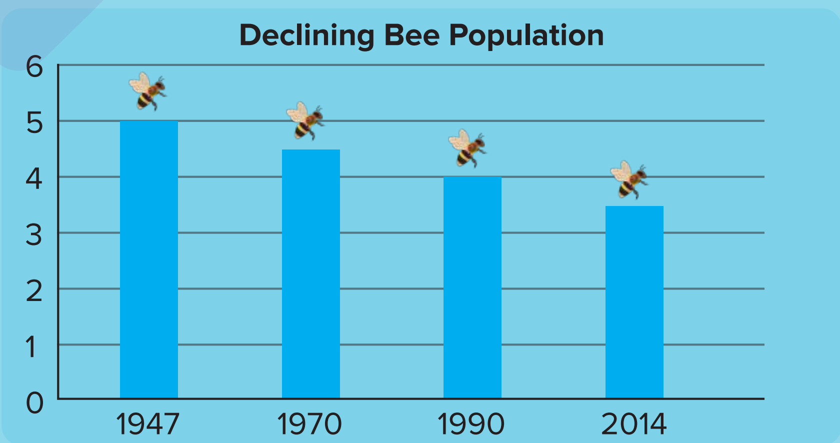
The body of the insect gets coated with pollens.

To sustain the visits from pollinators, the flowers provide edible pollen, nectar, or shelter.

Did you know?

Nearly **80% of the flowers** are pollinated by **bees**. Bees have **pollen baskets** in which they carry pollen.

Through the years, the population of bees has been declining drastically. Without bees, humans can only survive for about four years.



- **Characteristics of entomophilous flowers**

1. Showy flowers and brightly coloured

2. Small flowers clustered into an inflorescence to make them conspicuous

Lily

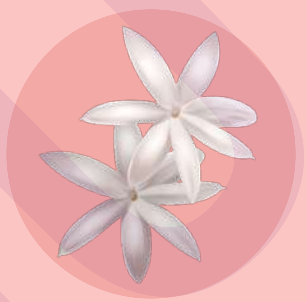
Sunflower

3. Presence of landing platform and/or honey/nectar guides

4. Produce odour: pleasant/foul

Landing platform in *Viola*

Nectar guides in *Mimulus*



Pleasant odour in jasmine

Foul odour in *Rafflesia* attracts flies and beetles

5. Provide nectar and edible pollens to the agents.

6. Closely placed stamens and nectar gland, so that when pollinators come to drink the nectar, the pollens stick to their body.

Nectar glands in *Magnolia*

Edible pollens in *Magnolia*

Inserted stamens in *Petunia*

7. Sticky stigma to adhere to the pollens

8. Spiny and heavy pollens surrounded by pollen kit (a yellow, oily, sticky substance)

Sticky stigma in Lilies

Pollen grains

9. In some species, floral rewards are in providing safe places to lay eggs. An example is *Amorphophallus* (the foul-smelling Corpse flower)

Amorphophallus

- *Amorphophallus* is the tallest flower (about 6 feet in height)

- The moth deposits its eggs in the locule of the ovary and the flower, in turn, gets pollinated by the moth.
- The larvae of the moth comes out of the eggs as the seeds start developing.

Ornithophily

- Ornis – **bird**; philein – to love
- Pollination by **birds**
- Few specialized bird species
  - Small size; long beak
  - Sun birds like hummingbirds
- Very few ornithophilous plants- *Bombax*, *Lobelia*, etc
- Other birds- crows, bulbul, parrots, etc


Sun bird


Hummingbird


Bombax


Lobelia

- **Characteristics of ornithophilous flowers**

1. The flowers secrete abundant **watery nectar** or have **edible parts** as rewards for the pollinators.

2. The **floral parts** are commonly **leathery** and are **brightly coloured**.

3. They have **funnel – shaped** or **tubular corollas**.

Chiropterophily

- Cheir – hand; pteros – wing; philein – to love
- Pollination by **bats**
- **Long distance** pollen transfer
- E.g. *Agave palmeri*, *Anthocephalus*, *Adansonia*, etc


Chiropterophily

Agave palmeri

Anthocephalus

Adansonia

- **Characteristics of chiropterophilous flowers**

1. Dull coloured
2. Large and stout
3. Strong fermenting/ fruity smell
4. Abundant pollen and nectar

Did you know?

Darwin's prediction: Pollination of the orchid by a moth with extremely long proboscis

- Darwin predicted that the orchid was pollinated by a moth with an extremely long proboscis.
- Twenty-one years after his death, in 1903, people realized that Darwin's mystery moth had already been described.
- *Xanthopan morganii* is a moth which has 6-inch (15 cm) proboscis, which is far longer than its body. It's proboscis is long enough to reach *Angraecum sesquipedale* flower's nectar.
- Darwin had predicted an otherwise improbable proboscis.

Advantages of cross pollination

- Cross-pollination introduces genetic recombination and thus variations in the progeny.
- Certain plants produce higher yields only when pollinated with the biotic agents. E.g. apple, grapes.
- It increases the adaptability and thus the organisms are favoured in the struggle for existence.
- Leads to the production of disease resistant plants.
- It produces new and useful varieties.
- Defective characters are eliminated or replaced by better characters due to cross-pollination.

Disadvantages of cross pollination

- Factor of chance
- Highly wasteful production of large number of pollens
- Bad characters might be introduced
- Good characters might be lost

Did you know?

- Many insects consume pollen or the nectar without bringing about pollination.
- Such floral visitors are referred to as **pollen/ nectar robbers**.
- Bumblebee bites open the base of a flower and uses its tongue to drink the nectar.

Bumblebee “nectar robbing” a flower

Summary Sheet

Types of pollinations
(Depending upon the source of pollen)

Self-pollination

It is the transfer of pollen from anther to stigma of genetically similar flower.

Cross-pollination

It is the transfer of pollen from anther of one flower to stigma of genetically different flower.

Autogamy

Autogamy is the transfer of pollen grains from the anther to the stigma of the **same flower**.

Geitonogamy

Geitonogamy is the transfer of pollen grains from the anther to the stigma of **another flower** within the **same plant**.

Xenogamy

Xenogamy is the transfer of pollen grains from anther to the stigma of a **different plant** of the same species.

Chasmogamous flowers - open flowers with exposed anther and stigma.

Cleistogamous flowers - closed flowers that do not open at all and produce assured set of seeds due to autogamy.

Agents of pollination

Abiotic

Anemophily

- Pollination by wind
- Pollen grains are light and non-sticky
- E.g. Coconut palm, date palm, grasses

Hydrophily

- Pollination by water
- Long, ribbon like pollen grains with mucilaginous covering
- E.g. *Vallisneria*, *Hydrilla*, marine sea grasses (*Zostera*)

Biotic

Entomophily

- Pollination by insects - moths, butterflies, wasps, bees, beetles, etc
- Plants provide nectar, edible pollen grains or shelter
- E.g. Lily, jasmine

Ornithophily

- Pollination by birds - sun birds, crow, hummingbirds
- E.g. *Bombax*, *Lobelia*, etc

Chiropterophily

- Pollination by bats
- Long-distance pollen transfer
- E.g. *Agave palmeri*, *Anthocephalus*, *Adansonia*, etc

BIOLOGY

SEXUAL REPRODUCTION IN FLOWERING PLANTS

OUTBREEDING DEVICES, ARTIFICIAL HYBRIDISATION, FERTILISATION

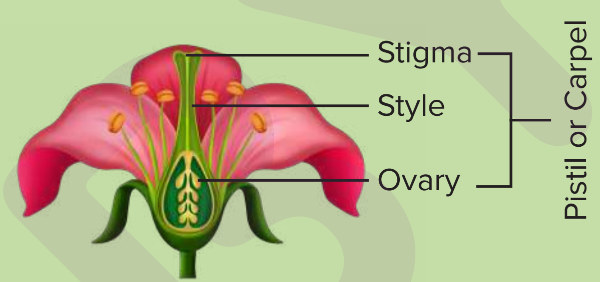
NOTES

Key Takeaways

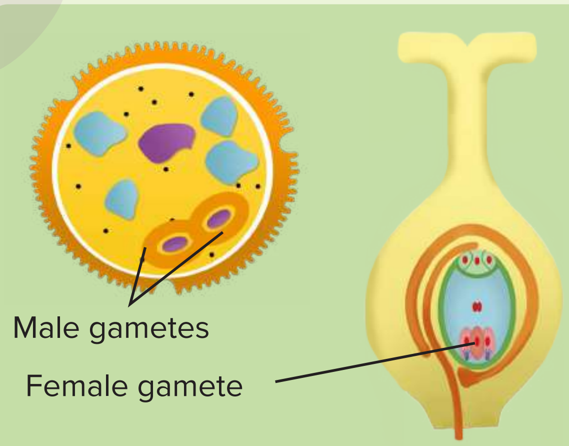
- Inbreeding depression
- Outbreeding devices
- Artificial hybridisation
  - Steps of artificial hybridisation
  - Benefits of artificial hybridisation
- Pollen-pistil interaction
  - Self-incompatibility
- Post-pollination events
  - Fertilisation
    - Double fertilisation
      - Syngamy
      - Triple fusion
- Types of fertilisation

Prerequisites

- **Female reproductive system**



- **Male and female gametes**



Types of pollination

- Self pollination from the same flower
- Self-pollination from the same plant but different flower
- Cross-pollination from the pollens of a different plant

Inbreeding Depression

- Majority of flowering plants produce **hermaphrodite flowers** and hence the chances of pollens coming in contact with the stigma of the same flower is high.
- In self-pollination, the undesirable characters from one generation get passed onto the next generation.
  - ➜ Propagation of these undesired characters can lead to the loss of population.
- Hence, continued self-pollination results in **inbreeding depression**.
  - ➜ **Inbreeding depression** is the **reduced biological fitness** in a given population (as a result of inbreeding or breeding of related individuals).
- Over the course of evolution, plants have developed **outbreeding devices** to overcome the disadvantages of inbreeding.
  - ➜ **Outbreeding** is the breeding between genetically different individuals.

Outbreeding Devices

Outbreeding devices

➜ These are the devices that discourage self-pollination and encourage cross-pollination.

Unisexuality

Monoecious plant

- Male and female reproductive parts are **not present on the same flower**.
- However, male and female flowers are present on the **same plant**.
- This **prevents autogamy** but not geitonogamy.
- Examples: Maize and castor plants

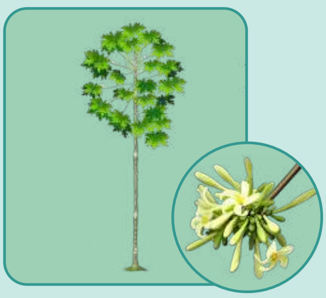
Maize

Castor

Dioecious plant

- A single plant has **only male flowers or only female flowers (dioecy).**
- This **prevents both** autogamy and geitonogamy.
- Example: Papaya plant

Papaya male plant



Papaya female plant

Dichogamy

- The pollen release does not occur at the time when the stigma is receptive (non-synchronous).
- Hence, **autogamy is avoided**.

Protandry

- The **anther matures before** the **stigma** of the same flower.
- Examples: *Salvia* and sunflower

Salvia

Sunflower

Anther matures first

Stigma matures later

Protogyny

- The **pistil matures before the anther** of the same flower.
- Example: *Mirabilis jalapa* and *Gloriosa*

Mirabilis jalapa

Gloriosa

Stigma matures first

Anther matures later

Heterostyly

- Both the **anther** and the **stigma** are present at **different locations,** thus **preventing autogamy**.
- Examples: Primrose, jasmine, and *Lythrum*

Primrose

Jasmine

Lythrum

Distyly

- There are two options for the arrangement of reproductive parts. They are as follows:
  - The style is long and the anthers are short.
  - The anthers are long and the style is short.

Distyly in flowers

Tristyly

- The length of the style and the anther can be long, short, or medium.
- Both the style and the anther will not have the same length.

Tristyly in flowers

Self incompatibility

- It is a **genetic phenomenon**.
- In this, the **pollen grains of a flower do not germinate** on the stigma (of the same flower or different flower) of the **same plant**.
- Consequently, pollen germination or pollen tube growth is eliminated, thus eliminating the chances of fertilisation.
- It **prevents both autogamy and geitonogamy**.
- Examples: Plants of tobacco, potato, and crucifers

Tobacco

Potato

Crucifers

Artificial Hybridisation

- **Artificial hybridisation** is the process by which the desired pollen grains are used for the pollination and the fertilisation of the female gamete.
  - This usually involves crossing-over between two different individual plants with **desirable characteristics.**
- Pollen grains from species that have the desired characteristics are carefully chosen.
  - Such pollen grains are referred to as **desired pollen grains.**
- The **offspring produced** by this process are referred to as **superior varieties.**

Individual 1
(With desirable traits)

Individual 2
(With desirable traits)

Artificial hybridisation

Hybrid

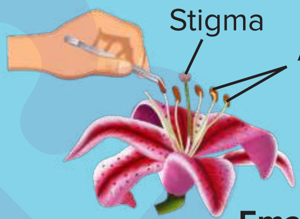
Steps of artificial hybridisation

Steps of artificial hybridisation

Bisexual flowers

Emasculation

- It is the **process of removing anthers** from bisexual flowers **without affecting** the **female reproductive part**.
- It is used in order to ensure that only the desired pollen grains are transferred to the stigma.
- Anthers from the flower bud are removed using a pair of forceps before the anther dehisces.



Emasculation

Unisexual flowers

Emasculation

- It is **not required** since the given flower only has either the male or the female reproductive parts.

Bagging (bisexual flowers)

Bagging (unisexual flowers)

- **Emasculated bisexual flowers or unisexual pistillate flowers are covered with a bag** of suitable size.
- Bag is generally made up of butter paper to prevent the contamination of the stigma with unwanted pollen.


Bagging

- When the stigma of the bagged flower attains receptivity, mature pollen grains collected from the anthers of the male parent are dusted on the stigma.

Rebagging

Rebagging

- Rebagging is the **covering of stigma after dusting the pollen grains**.
- The flowers are rebagged and the fruits are allowed to develop.

Rebagging

Benefits of artificial hybridisation

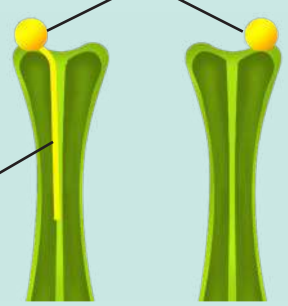
- This process can help in achieving the following objectives
    - Plants with high growth rate and yield
    - Disease-resistant plants
    - Plants that can sustain high temperatures

Pollen-Pistil Interaction

- It covers the sequential events from the **introduction of pollens on the stigma until the pollen tubes enter the ovules**.
- During this interaction, the pistil screens the pollen grains.
- The **pollens of the other incompatible species are inhibited** at the level of pollen germination or pollen tube growth in the style.

Pollen grains

Stigma → Compatible pollen → **Pollen tube formation**



Stigma → Incompatible pollen (✗) → **No pollen tube formation**

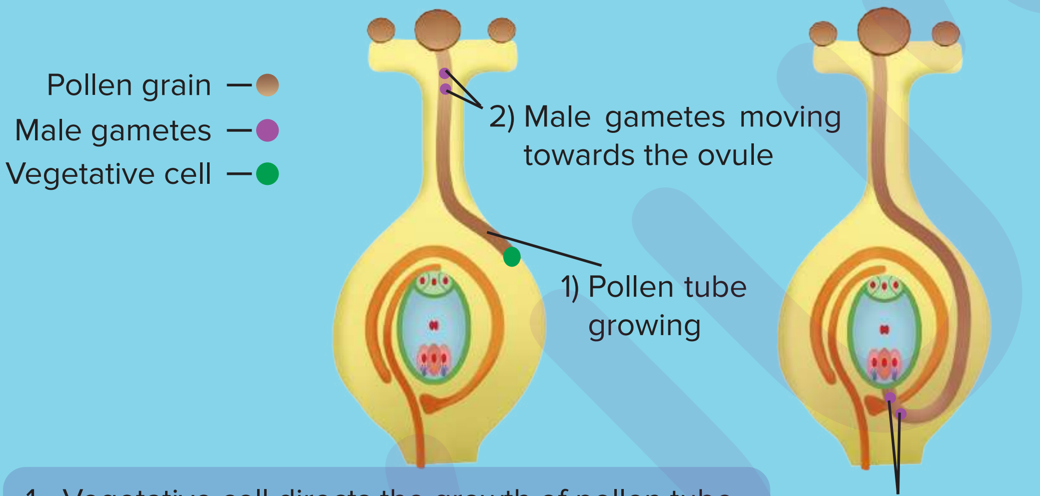
- The stigma of the pistil is the checkpoint.
- It checks for the compatibility of the pollen grains with the help of chemical interactions.
- If the **pollen grains are compatible,** the stigma allows the pollen grain to form the pollen tube.

- If the **pollen grain belongs to incompatible species,** then the stigma will not allow the formation of pollen tube.

Self-incompatibility

- It is the mechanism that prevents the pollen of one flower from fertilising the other flowers of the same plants.
- Self-incompatibility is often observed in plants belonging to families like **Solanaceae.**
- This prevents inbreeding.

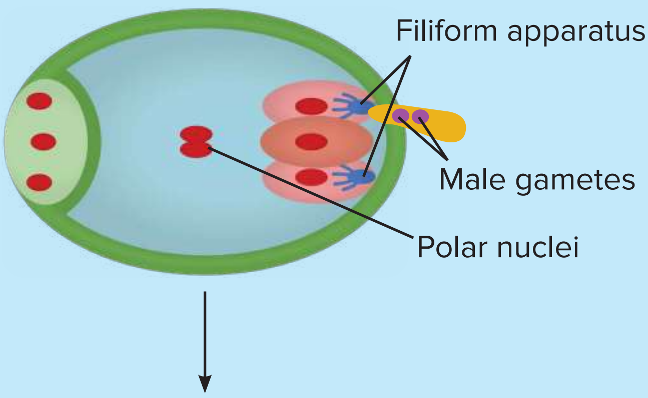
Post-Pollination Events



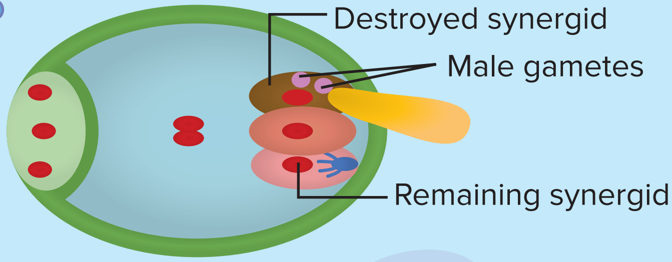
1. Vegetative cell directs the growth of pollen tube.
2. Male gametes travel towards the ovule via pollen tube.
3. Male gametes enter embryo sac through the micropylar end.

Fertilisation

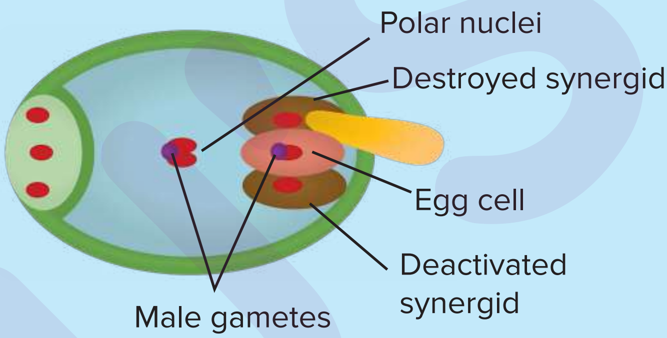
- It is the process of **fusion of male gamete with the female gamete**.
- It takes place in the embryo sac.
- The **filiform apparatus** present at the micropylar end of the synergids **guides** the **entry of the pollen tube**.
- The pollen tube bursts.
  - It opens into the embryo sac and releases the male gametes.
- The synergid cell into which the male gamete opens is destroyed, whereas the other one remains the same.



- The male gametes move to the **polar nuclei** and the **egg cell**.



- The synergid cell that remained unaffected gets deactivated.
- This **stops the growth of the pollen tube**.
- One of the male gametes fuses with the egg cell and the other fuses with the polar nuclei.



Double fertilisation

- In this phenomenon, two fertilisation events occurs:
  1. One of the male gametes **fertilises the egg cell**, resulting in the formation of a **zygote**.
  2. The other male gamete **fuses with the two polar nuclei**, resulting in the formation of an **endosperm**.

Syngamy

- The fusion of male and female gamete (egg cell) during double fertilisation is known as **syngamy**.
- This fusion results in formation of **zygote**.

1.

Male gamete (n) | **Female gamete (n)**

↓

Syngamy

↓

Zygote (2n)

Triple fusion

- The fusion of the male gamete with the two polar nuclei during double fertilisation is known as **triple fusion**.
- This fusion results in the formation of the **primary endosperm nucleus (PEN)**.

2.

Male gamete (n) | **Polar nucleus (n)** | **Polar nucleus (n)**

↓

Triple fusion

↓

Primary endosperm nucleus (PEN) (3n)

↓

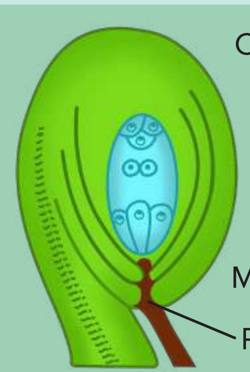
Endosperm (3n)

Types of Fertilisation

Fertilisation (based on pollen tube entry site)

Porogamy

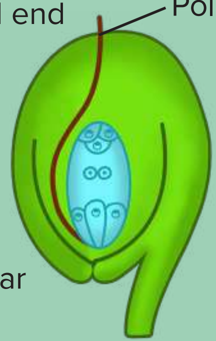
- It is the **most common** type of fertilisation carried out in all angiosperms or flowering plants.
- In this, **the pollen tube enters the ovule through the micropyle**.
- Example: Lily



Porogamy

Chalazogamy

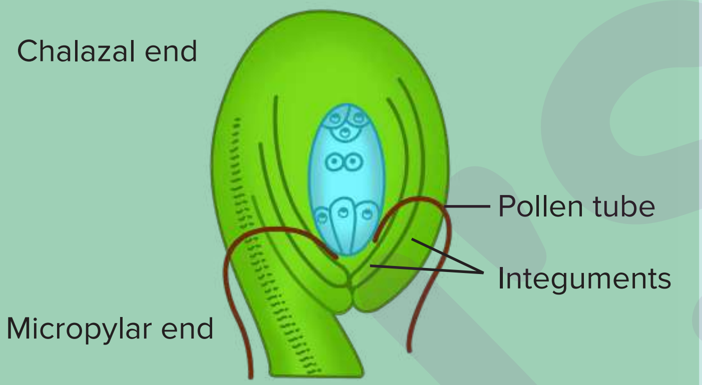
- In this, the **pollen tube penetrates the ovule through the tissue of chalaza**.
- Example: *Casuarina*



Chalazogamy

Mesogamy

- In this, the **pollen tube enters via integuments**.
- Example: *Cucurbita*



Mesogamy

Summary Sheet

Inbreeding depression

- Inbreeding depression is the reduced biological fitness in a given population as a result of inbreeding or breeding between related individuals.

Outbreeding devices: Devices that **discourage self-pollination** and **encourage cross-pollination** (between genetically unique individuals)

Unisexuality

Dioecious plant

- Male and female flowers are present on different plants
- Prevents autogamy and geitonogamy

Monoecious plant

- Male and female reproductive parts are not present on the same flower.
- However, male and female flowers are present on the same plant.
- Prevents autogamy but not geitonogamy

Dichogamy

Protandry

- Anthers mature before the stigma of the same flower
- Prevents autogamy

Protogyny

- Stigma matures before the anthers of the same flower
- Prevents autogamy

Self-incompatibility

- Pollen grains do not germinate on the stigma of the same flower or flowers of the same plant
- Prevents both autogamy and geitonogamy

Heterostyly

- Anther and stigma are placed at different heights
- Prevents autogamy

Artificial hybridisation

Individual 1 (With desirable traits) + **Individual 2** (With desirable traits)

↓

Artificial hybridisation

↓

Hybrid

Pollen-pistil interaction

Different/Self-incompatible species pollen grain

Same species (compatible) pollen grain

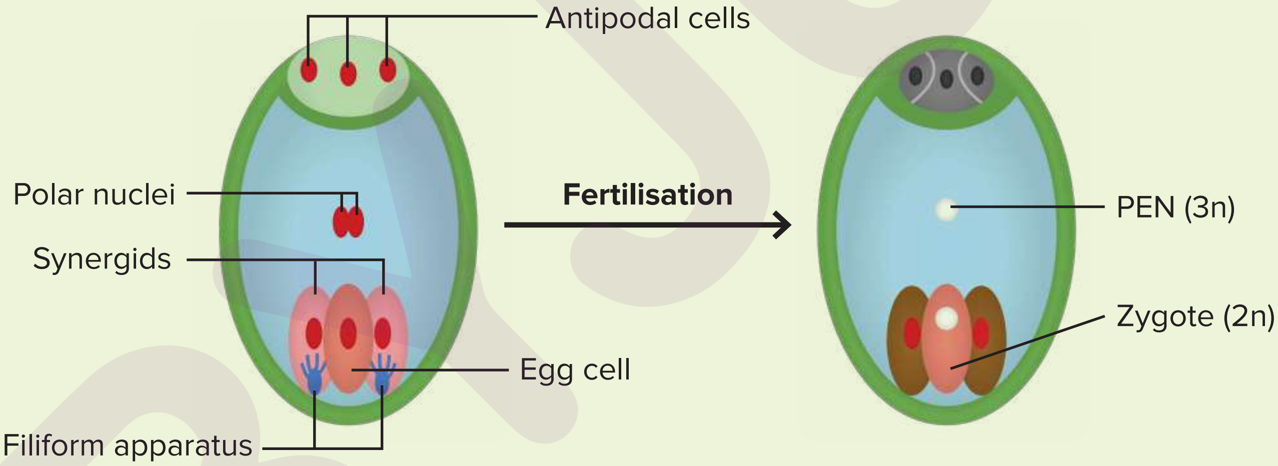
Pollen grain

Different/Self-incompatible species	Same species (compatible)
Stigma	**Stigma**
✗ ↓	↓
Pollen tube formation	**Pollen tube formation**

Double fertilisation

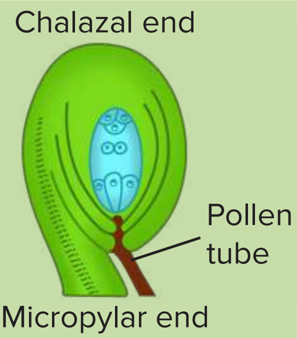
1 Egg cell	+	1 Male gamete	=	Zygote
2 Polar nuclei	+	1 Male gamete	=	Primary endosperm nucleus (PEN)

- **Changes in embryo sac**

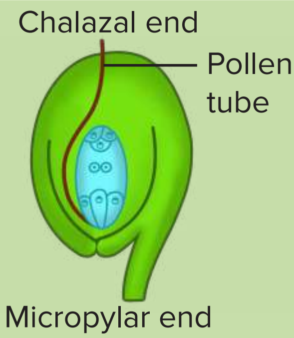


Fertilisation (based on pollen tube entry site)

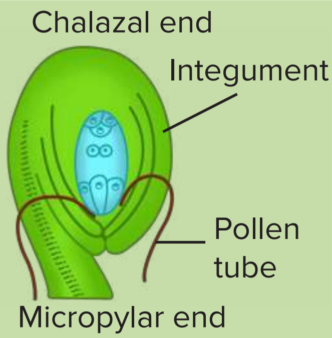
Porogamy



Chalazogamy



Mesogamy



BYJU'S Classes

B I O L O G Y

SEXUAL REPRODUCTION IN FLOWERING PLANTS

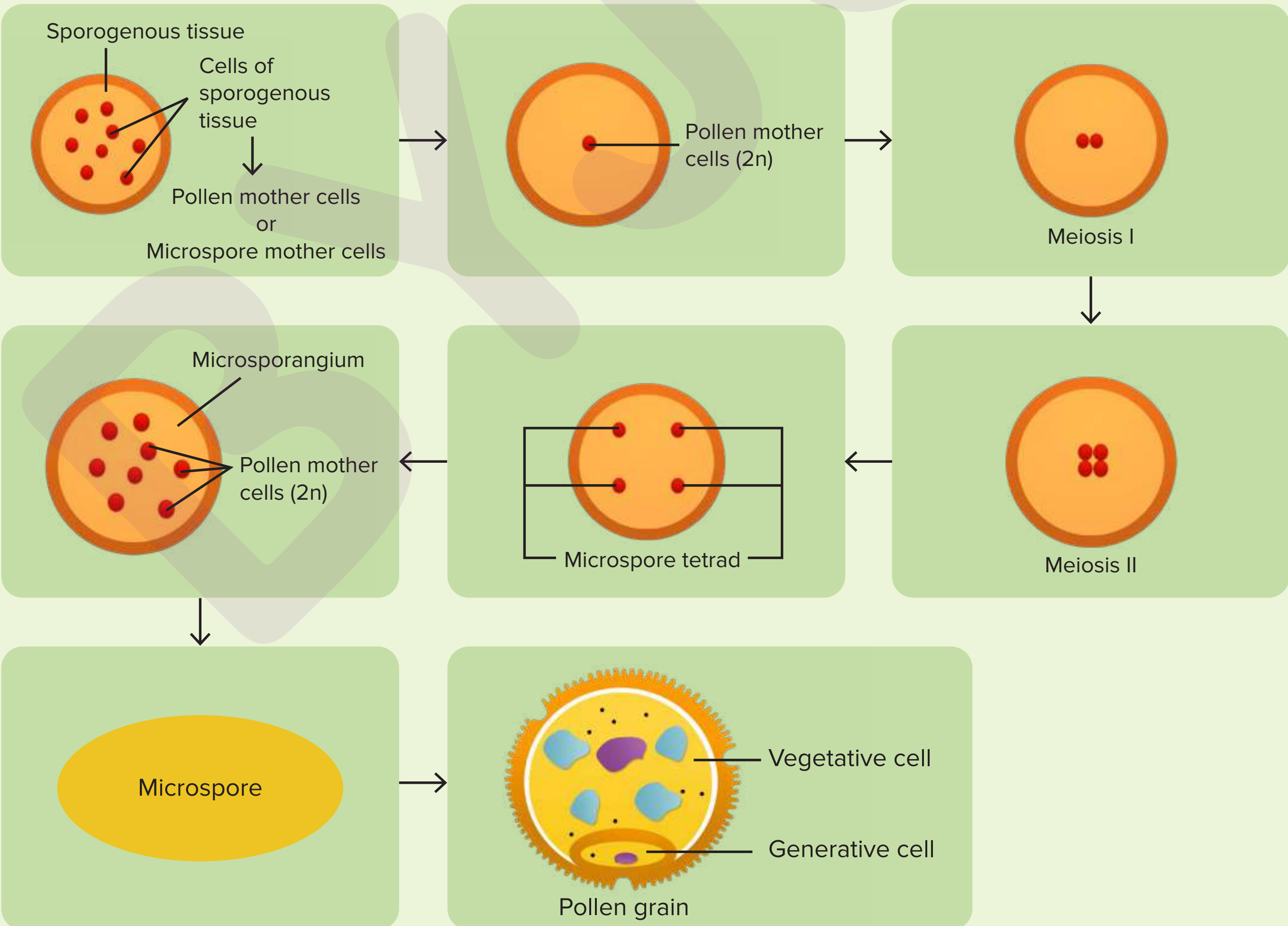
ENDOSPERM DEVELOPMENT, EMBRYO DEVELOPMENT

Key Takeaways

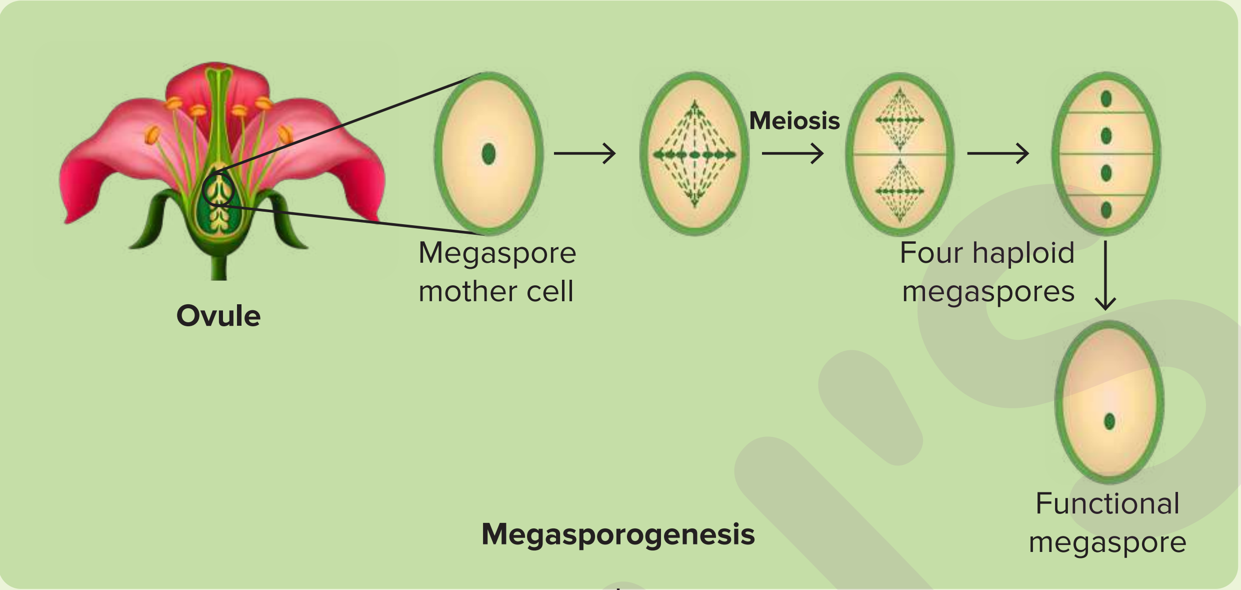
- Post-fertilisation events
  - Endosperm development
    - Types of endosperm development
  - Embryo development
    - Embryogenesis in dicots
    - Embryogenesis in monocots

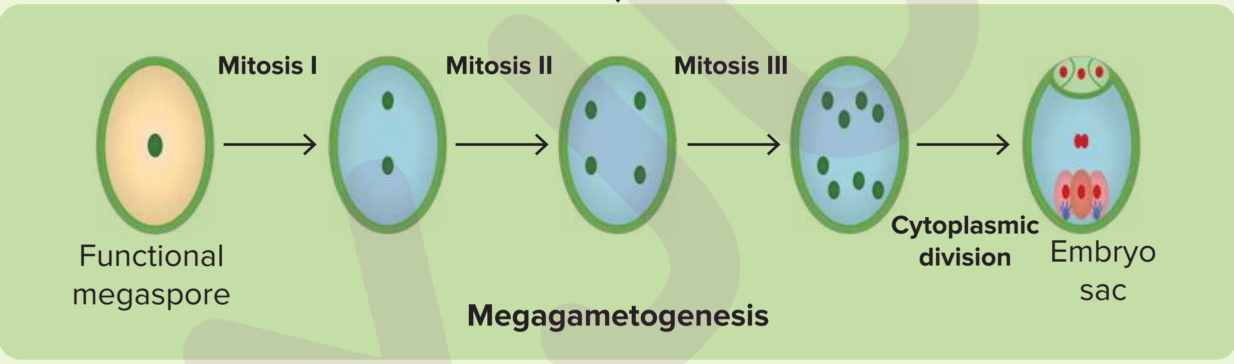
Prerequisites

A. Microsporogenesis

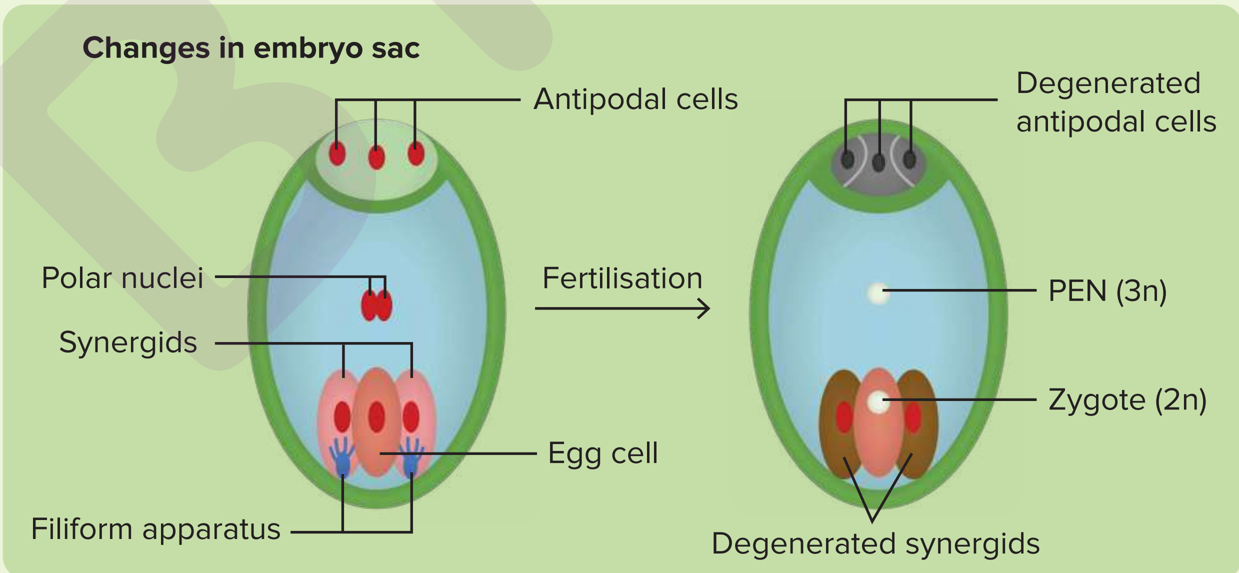


B. Megasporogenesis and megagametogenesis





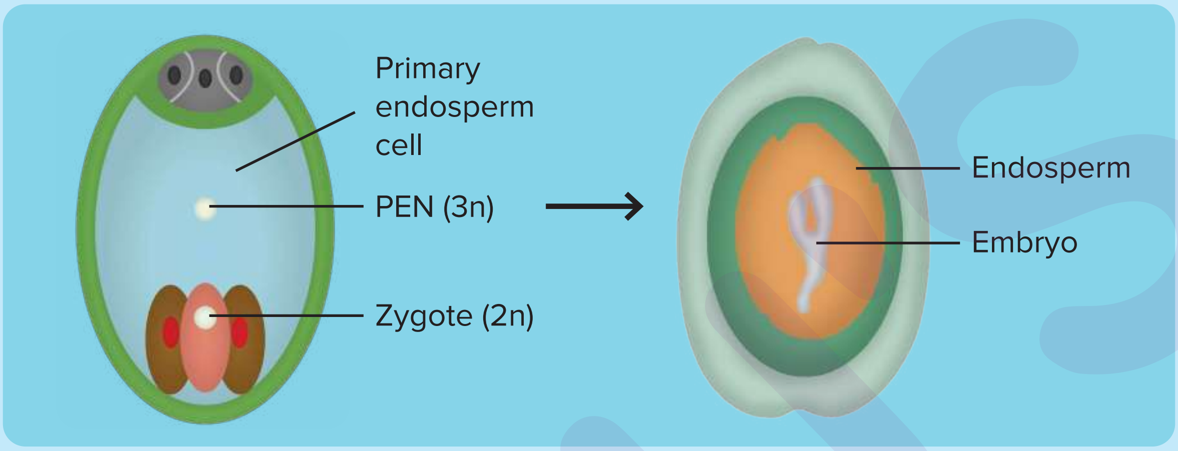
C. Double fertilisation



Post-Fertilisation Events

Endosperm development

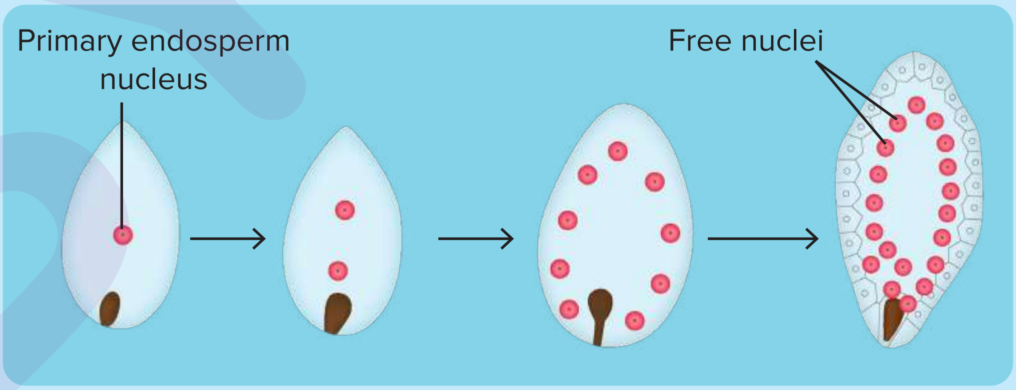
- The triploid primary endosperm cell divides repeatedly and forms a **triploid endosperm tissue.**



- Endosperm development precedes embryo development.
- The cells of triploid endosperm tissue are filled with reserve food materials and are used for the nutrition of the developing embryo.

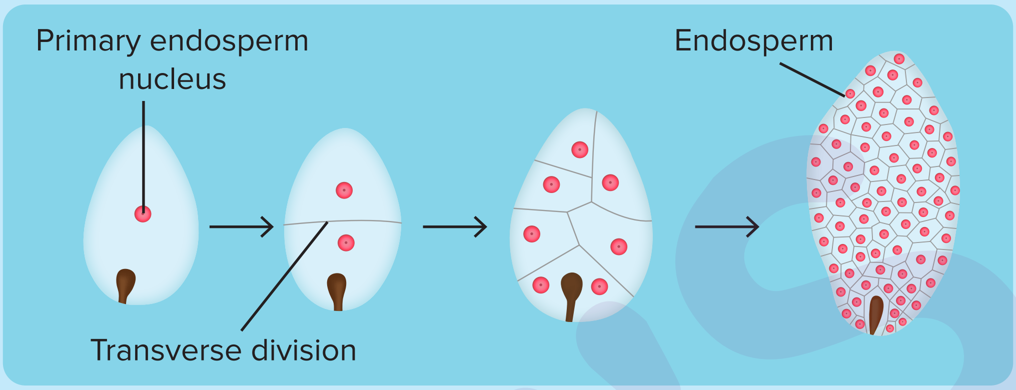
Types of seed based on endosperm development

Nuclear type



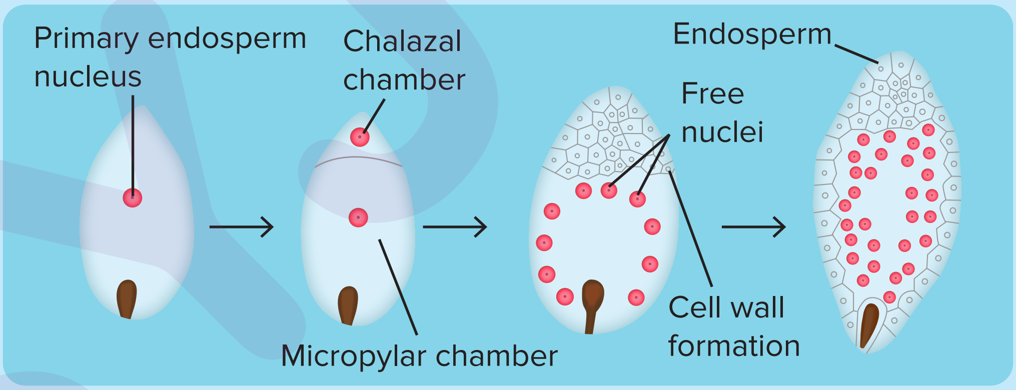
- PEN divides repeatedly (mitotic division) **without cytokinesis**.
- It results in the formation of a large number of free nuclei in the cell.
- A large central vacuole is formed and nuclei get arranged at the periphery.
- Cell wall is formed from the periphery towards the centre.
- **Examples:** Maize, rice, wheat, corn, sunflower

Cellular type



- The division of PEN (karyokinesis) is followed by cytokinesis and two cells are formed due to **transverse division**.
- It leads to the formation of the cellular endosperm.
- It is **not very common**.
- **Examples:** *Petunia*, balsam, *Datura*

Helobial type



- The first division results in a **large micropylar cell** and a **small chalazal cell** (similar to cellular endosperm).
- The chalazal cell **divides like cellular endosperm**, i.e., nuclear divisions are immediately followed by cytokinesis.
- The micropylar cell **divides** in the **free nuclear fashion**.
- Hence, helobial type of endosperm is a combination of both nuclear and cellular endosperms.
- It is common in monocotyledons.
- **Example:** *Eremurus*

Types of seeds based on endosperm utilisation

Endospermic seeds

Endosperm persists in the mature seed and is used up during seed germination.

Example: Coconut

Non-endospermic seeds

Endosperm is completely consumed by the developing embryo before seed maturation.

Examples: Peas and groundnut

Did you know?

Coconut

Plant tissue culture in coconut water

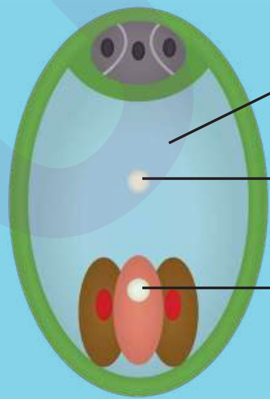
- In coconut, the formation of cell wall is incomplete, resulting in the formation of the **outer multicellular solid endosperm (white kernel)** and the **inner multinucleated (having free nuclei) liquid endosperm (coconut water)**. So, coconut is an exception.
- Coconut water has the ability to stimulate cell division and morphogenesis.
- Hence, coconut water is used in plant tissue culture to support plant growth in vitro.

What came first, the seed or the plant?

Neither of them came first. Although seeds are considered to be the first stage of a new plant's life, the foundation has more to do with what is inside that seed: **embryo**.

Embryo development

- **Embryo develops** at the **micropylar end** of the embryo sac where the zygote is situated.
- Most zygotes divide only after a certain amount of endosperm is formed.
- This is an adaptation to provide assured nutrition to the developing embryo.
- Embryogenesis/Embryo development varies depending on the type of seed.



Zygote → Embryo
Embryogeny

There are two types of seeds based on number of cotyledons

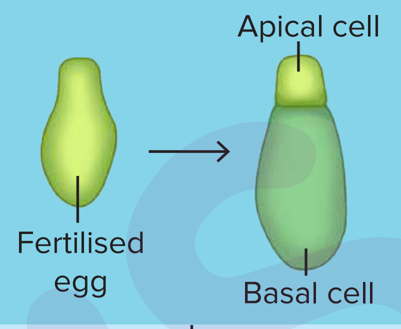
Monocots
One cotyledon

Dicots
Two cotyledons

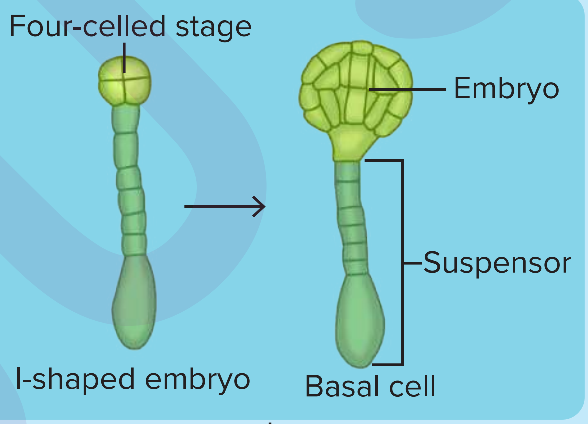
- Cotyledons are the first leaves to appear from a germinating seed.
- Development of both types of seeds is similar in the early stages but differ in the later stages.

Embryogenesis in dicots

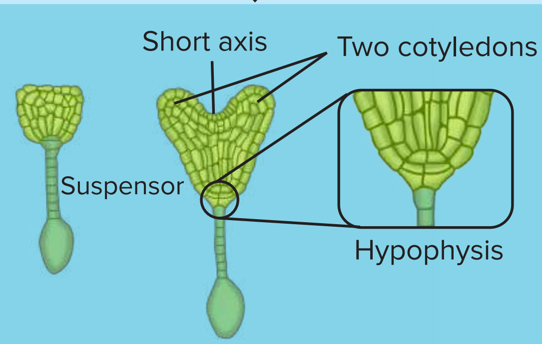
- The zygote divides transversely to form two cells:
  - → **Terminal cell (Apical cell)**
  - → **Basal cell**
- The terminal cell gives rise to the embryo, while the basal cell contributes to the formation of suspensor.



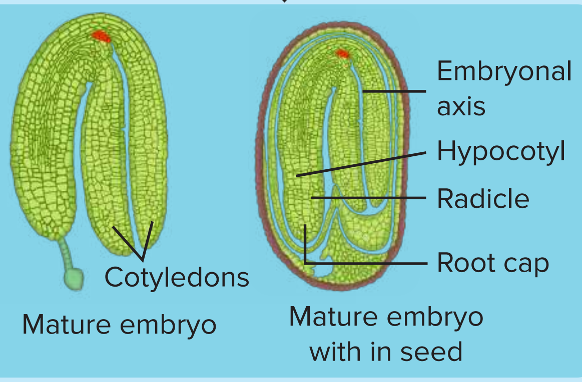
- The terminal cell divides by vertical division, forming a four-celled stage, **I-shaped** embryo.
- Each of the four cells divide transversely to from the **octant stage** (eight-celled) or the globular stage.
- At the same time, the basal cell divides transversely to form a six to ten celled filament known as **suspensor**.
- The suspensor attains its maximum development by the time embryo attains the globular stage.



- Due to uneven growth, the embryo becomes **triangular** and then **heart-shaped,** which possesses a short axis and two primordia of cotyledons.
- The part of the embryo attached to the tip of the suspensor is known as the **hypophysis,** which gives rise to the embryonic root and root cap.

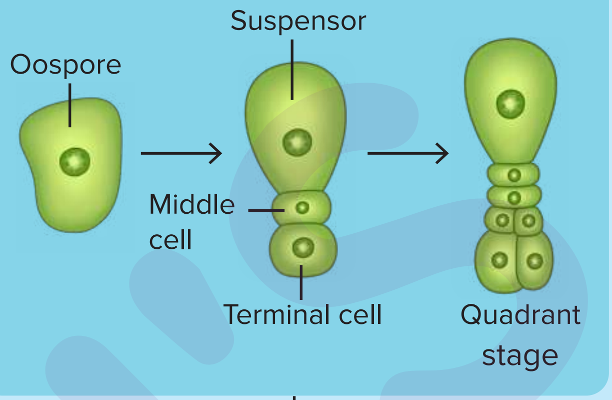


- The portion of embryonal axis above the level of cotyledons is the **epicotyl,** which terminates with the **plumule** or stem tip.
- The cylindrical portion below the level of cotyledons is **hypocotyl** that terminates at its lower end in the **radicle** or root tip.
- The root tip is covered with a root cap.

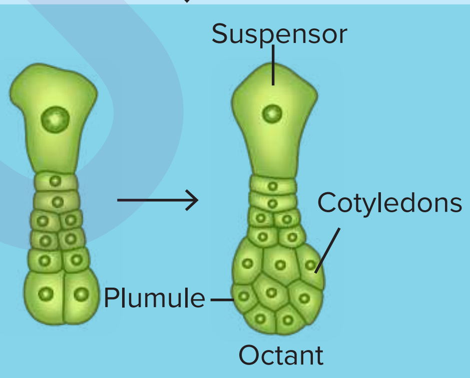


Embryogenesis in monocots

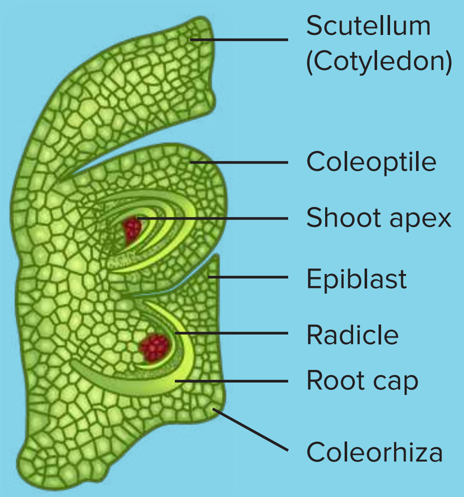
- Zygote divides transversely, forming the **terminal cell** and the **basal cell.**
- The basal cell, which is larger and lies towards the micropylar end, does not divide again but becomes transformed directly into a large vesicular cell.
- The terminal cell divides transversely, forming two cells.
- This series of division leads to the **quadrant stage.**



- The quadrants divide transversely, forming **octants** arranged in two tiers of four cells each.



- The embryos of monocotyledons possess only one cotyledon.
- The **single cotyledon** of a monocot is referred to as the **scutellum**, which is situated towards one side (lateral) of the embryonal axis.
- At the lower end of the embryonal axis, the radicle and root cap are enclosed in an undifferentiated sheath known as **coleorhiza**.
- The portion of the embryonal axis above the level of attachment of scutellum is the **epicotyl**.
- The epicotyl has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure, the **coleoptile**.

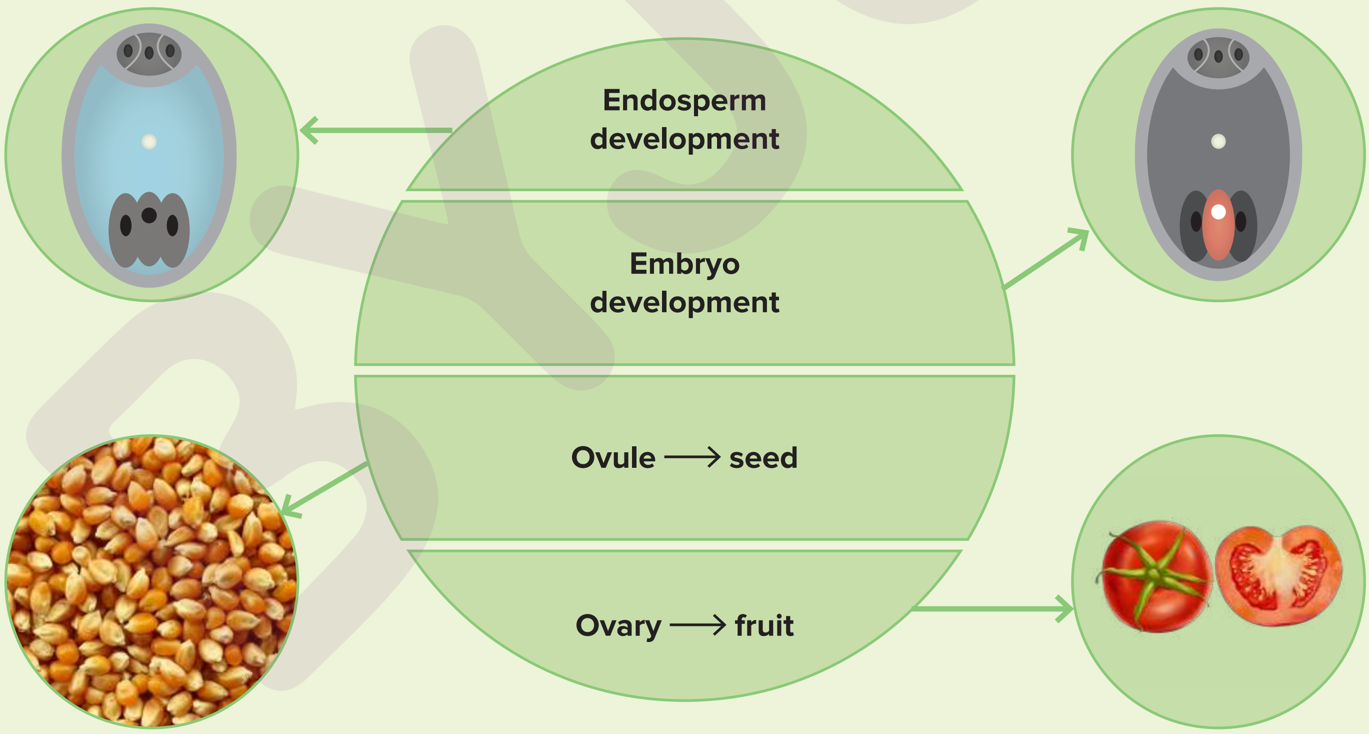


Difference between dicot and monocot embryos

Monocot embryo	Dicot embryo
There is a single cotyledon.	There are two cotyledons.
Protective sheath known as coleorhiza is present on radicle.	Coleorhiza sheath is absent.
Plumule envelope known as coleoptile is present.	Coleoptile envelope is absent.

Summary Sheet

- **Post-fertilisation events**



- **Endosperm**
  - It is the main source of nutrition for embryo in the seed.
  - It develops prior to the embryo.

Types of endosperm development

Nuclear type

- PEN divides repeatedly without cytokinesis
- Examples: Maize, rice, wheat, cotton, sunflower

Cellular type

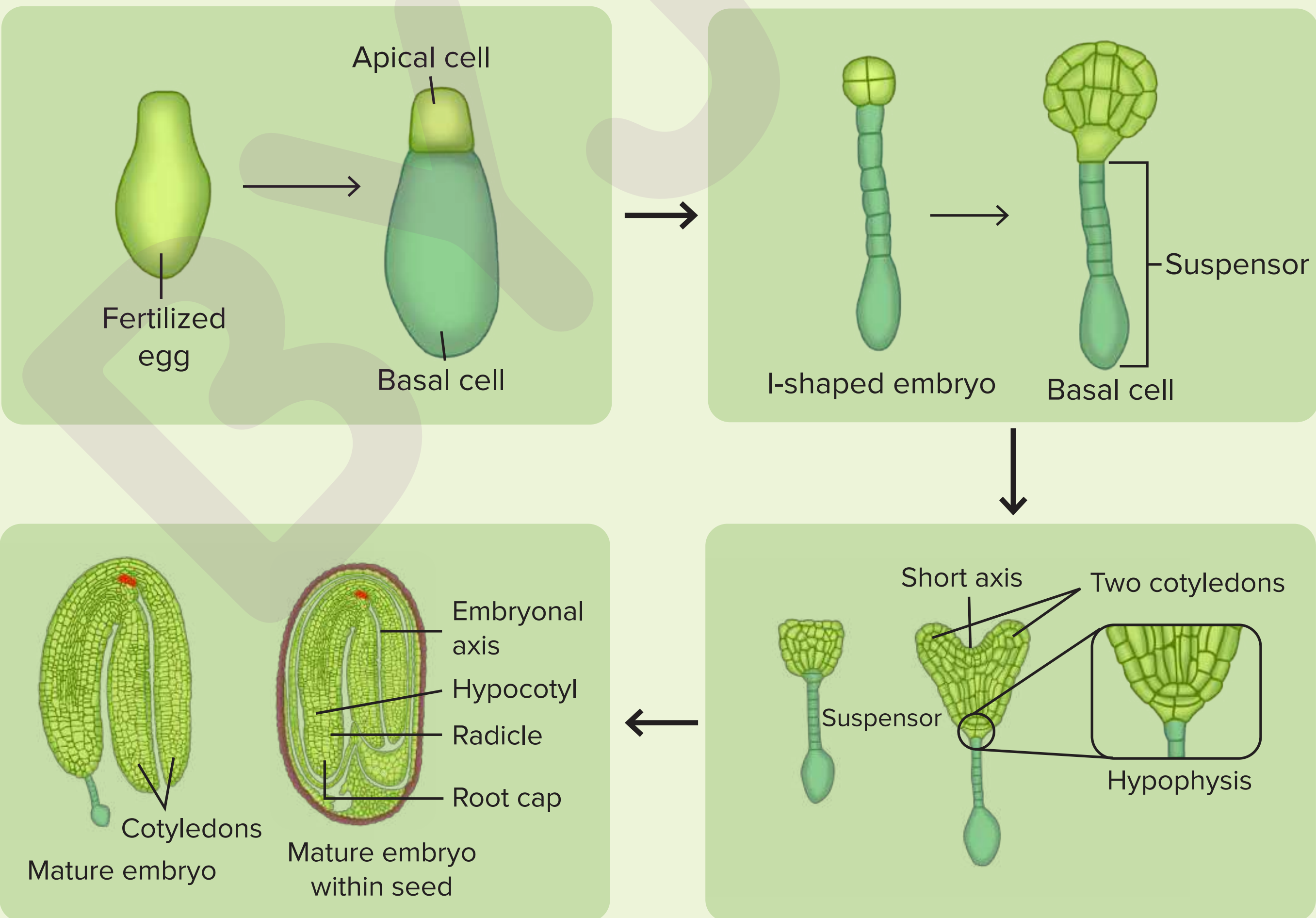
- PEN division is followed by cytokinesis.
- Examples: *Petunia*, balsam, *Datura*

Helobial type

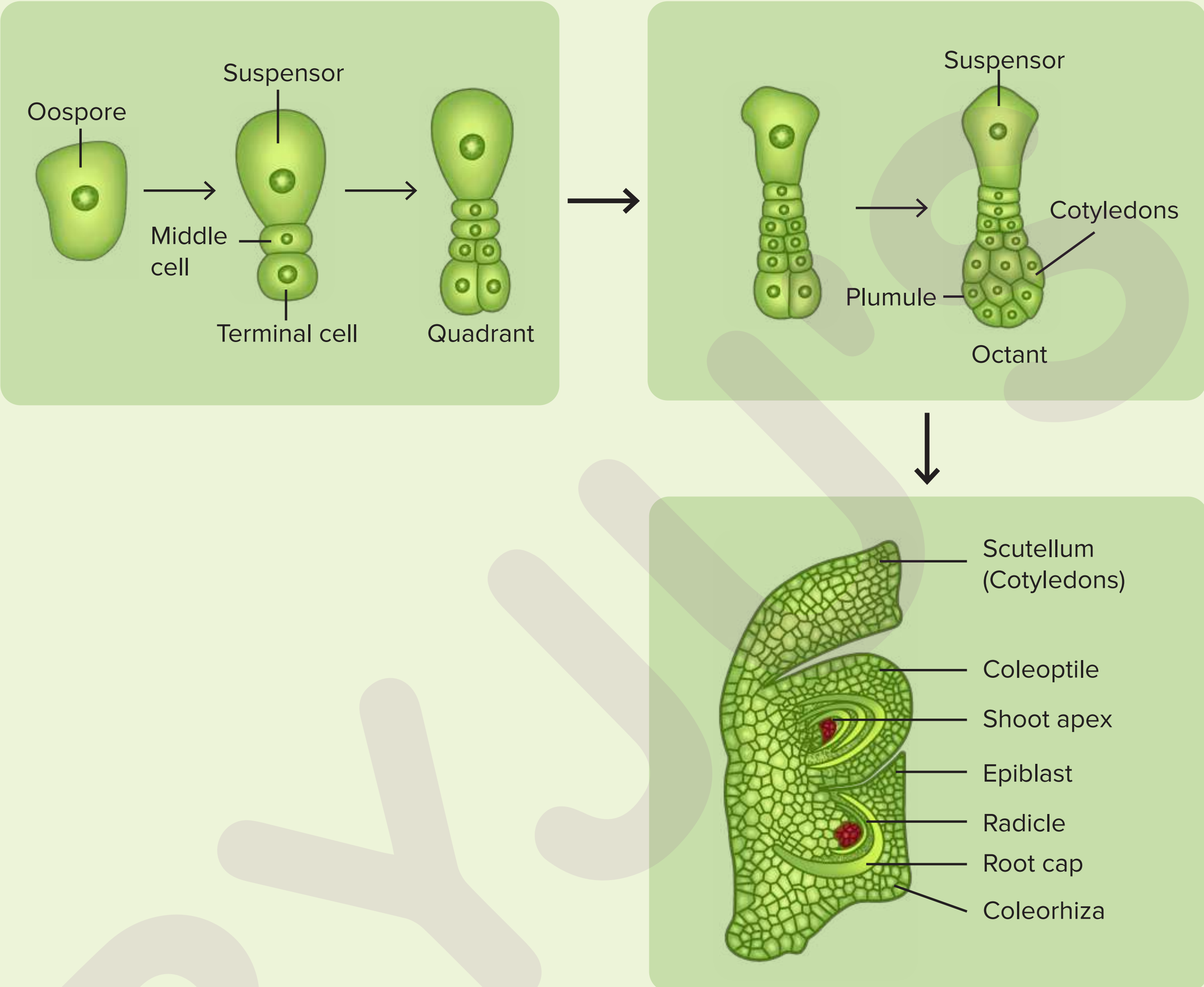
- The first division results in a large micropylar cell and a small chalazal cell.
- Example: *Eremurus*

- **Embryo development**
  - It develops at the micropylar end of the embryo sac.
  - Most zygotes divide only after a certain amount of endosperm has formed.
  - The endosperm provides nutrition for development of the embryo.

Embryogenesis in dicots



Embryogenesis in monocots



B I O L O G Y

SEXUAL REPRODUCTION IN FLOWERING PLANTS

SEEDS, FRUITS, SEED DORMANCY, SEED DISPERSAL

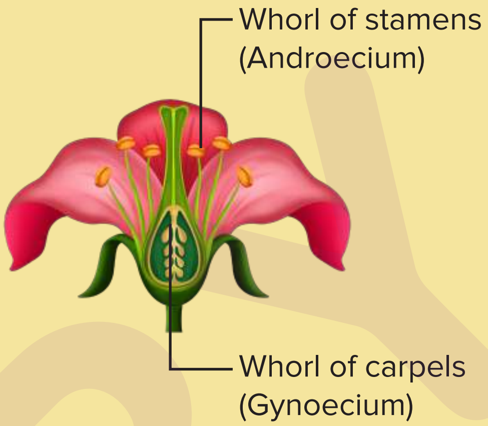
NOTES

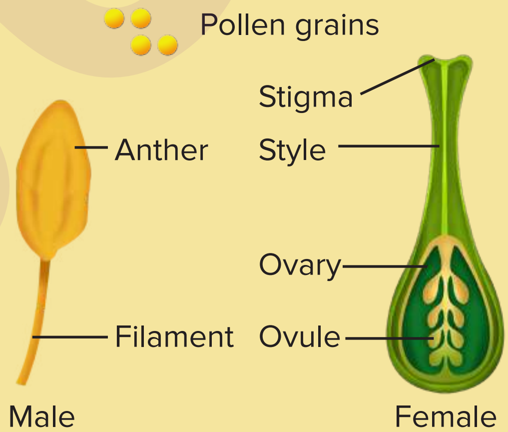
Key Takeaways

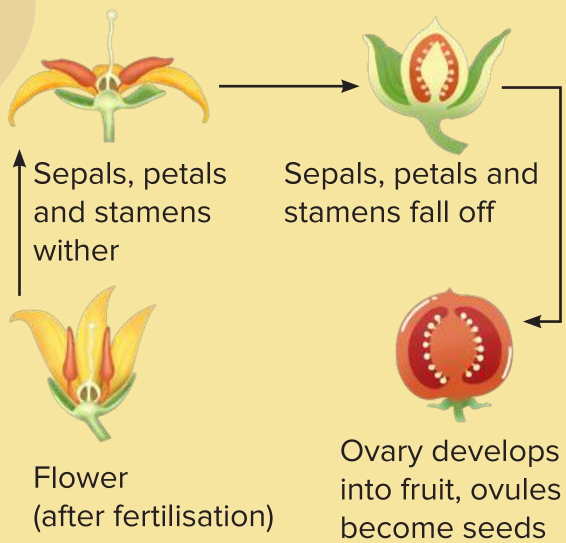
- Seed and fruit
- Importance of seed dispersal
- Seed dormancy
- Agents of seed dispersal

Prerequisites

Sexual reproduction



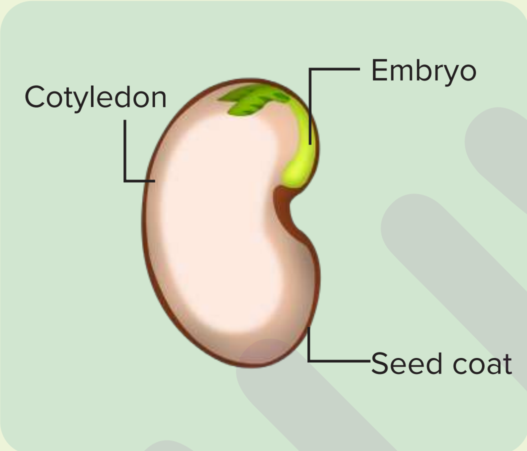




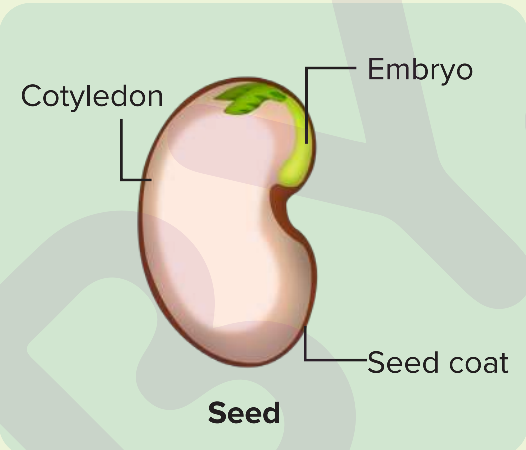
Seed and Fruit

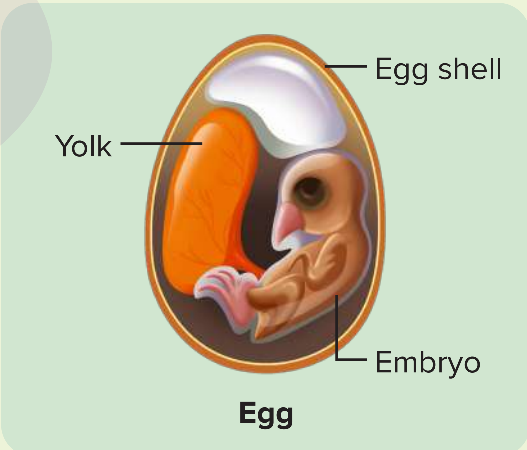
Seed

- A seed consists of an **embryo** enclosed in a protective outer covering.
- It is also known as the **fertilised ovule**.



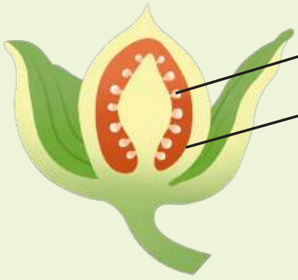
Comparison between seed and egg



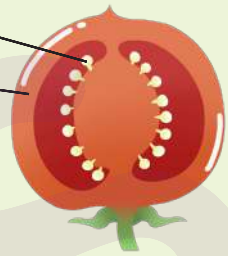


- **Embryo:** Develops from a zygote
- **Cotyledon/Yolk:** Food reserve, provides nutrition to the growing embryo
- **Seed coat/Egg shell:** Protects the developing embryo

Fruit



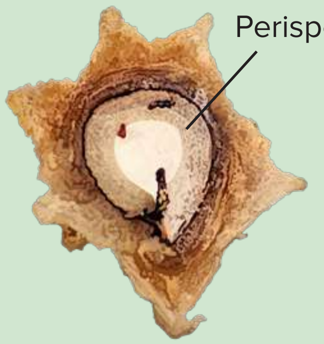
Ovary →	**Fruit**
Ovule →	**Seed**
Ovary wall →	**Pericarp**
Outermost layer →	Epicarp
Middle layer →	Mesocarp
Innermost layer →	Endocarp

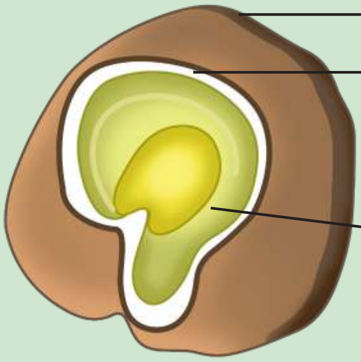


Parts of a fruit

The fruit wall (pericarp) is differentiated into three layers:

Characteristics of ovary	Characteristics of fruit
Ovules →	**Seeds**
Integument →	Seed coat
Micropyle →	Micropyle
Nucellus →	Disappears or persists





Beetroot

Pepper

- In some seeds, nucellar cells that surround the embryo persist.
- This nucellar tissue is a nutritive tissue. It is known as **perisperm**.
- The examples of seeds that contain the remnant nucellar tissue are
  - Beetroot
  - Pepper

Did you know?

- We can store seeds for a long duration after they have been harvested since the seeds are usually in a **dormant or inactive state**. This is because of the drying up and slow metabolism within it.

Fresh seed		**Dormant seed**
Wet (100% moisture by mass)	→	Dry (10–15% moisture by mass)
↓		↓
Normal metabolism		Slow metabolism

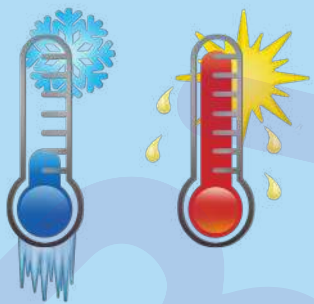
Seed Dormancy

- During certain unfavourable conditions (high temperature, dryness, etc.), the embryo becomes inactive, i.e., the **metabolic activities slow down**. This state is known as seed dormancy.
- The dormancy of seeds varies from species to species. However, there are some that can remain dormant for long periods.

Date palm (*Phoenix dactylifera*): **2,000 years**

Arctic lupine (*Lupinus arcticus*): **10,000 years**

Seed: Conditions for germination



Suitable temperature

Adequate moisture

Proper oxygen supply

- These conditions are important for photosynthesis and glucose formation.
- **Absence of seed dormancy:**
  - If there was no seed dormancy, then seeds would germinate soon after their formation.
  - As a result, they would have no shelf life.
  - The germinating plants would hence die if the conditions are not favourable at the time of germination.
  - Farmers would also not be able to store the seeds and sow them whenever required.

Importance of Seed Dispersal

- Seed dispersal is the process by which seeds are dispersed to different places through agents like wind, water, animals, and explosions.

- Once the fruit is formed it eventually ripens and then falls off the branch.
- If the baby plants were to grow right next to the parent, then it would be difficult for the baby plants to grow.
- Since the parent would have larger roots, the **baby plant would not have access to nutrients**.
- Majority of the water and nutrients would be taken up by the parent tree.
- The **young plant would not have the space** for the shoot or root to grow.
- The **larger tree** would also have a larger canopy, which would **block the sunlight from falling on the smaller plant**.

Hence, seed dispersal is essential for the baby plants to have enough resources for their growth and development.

Agents of Seed Dispersal

Wind

- Light seeds with wings or feathery structures get dispersed by wind.
- Example:

Dandelion

Swan plant

Water

- As the seeds of plants float on water, they get dispersed.
- Example:

Lotus

Coconut

Explosion

- Some seed-containing fruits burst on their own with some force, throwing the seeds at a distance.
- Example:

Exploding cucumber

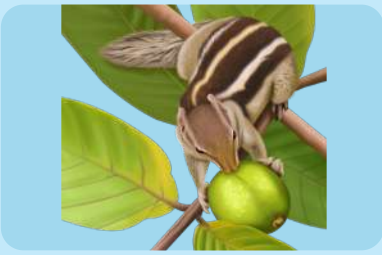
Pea

Animals

- Birds consume seeds that they cannot digest, but the acids and enzymes in their gut soften the seed coat, and they excrete the seeds. This makes seed germination easy.
- Apes eat fruits partially and throw the rest. This leads to the dispersal and germination of seeds.
- Example:

Cherries

Watermelon

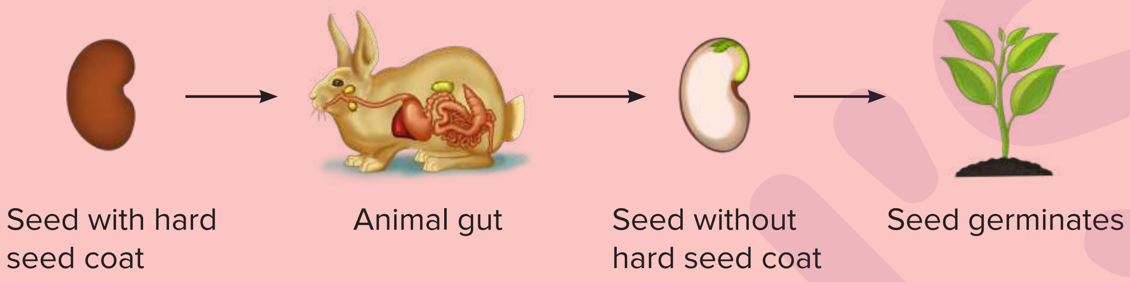


Guava

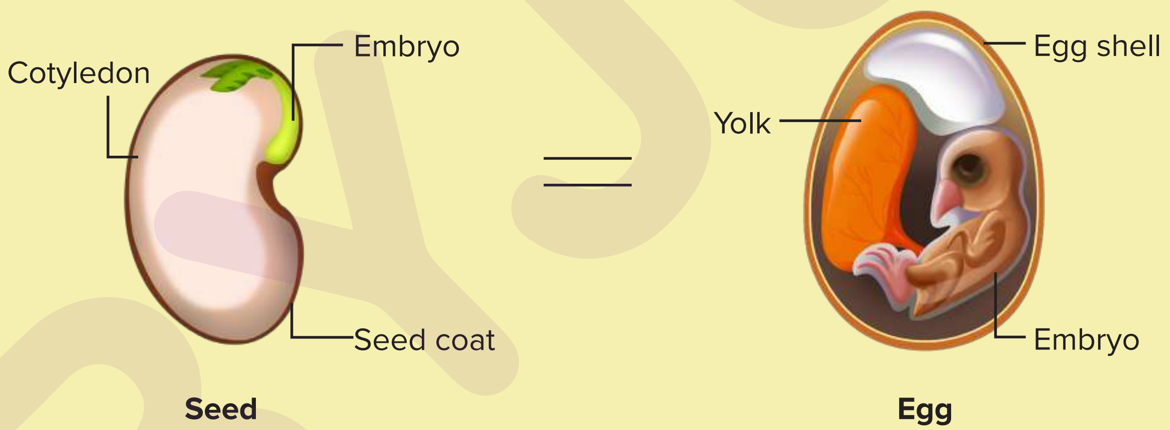
Did you know?

The hard seed coat of certain seeds prevents water and oxygen from reaching the seeds.

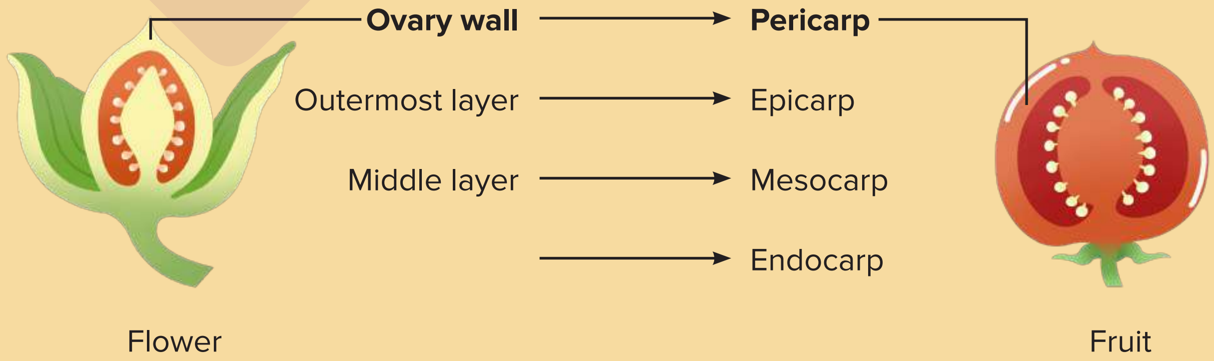
- When ingested, the acidic enzymes of animals weaken the hard seed coat.
- As they cannot digest the seed, they excrete it out.
- As a result, the seed coat becomes soft and starts germinating.



Summary Sheet



Comparison of ovary and fruit

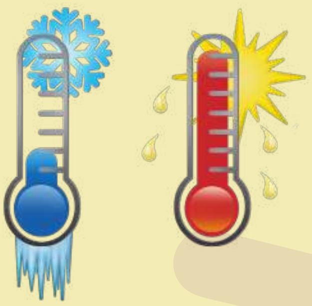


Characteristics of ovary	Characteristics of fruit
Ovules	**Seeds**
Integument	Seed coat
Micropyle	Micropyle
Nucellus	Disappears or persists (Perisperm)

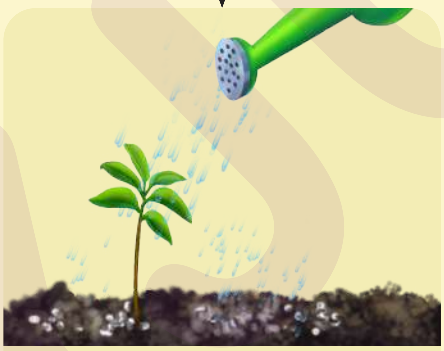
Seed dormancy

- During certain unfavourable conditions (high temperature, dryness, etc.), the embryo becomes inactive, i.e., the **metabolic activities slow down**. This state is known as seed dormancy.

Conditions for seed germination



Suitable temperature



Adequate moisture

Proper oxygen supply

Seed dispersal

It is the process by which seeds are dispersed to different places through agents like wind, water, animals, and explosions.

Agents of seed dispersal

Wind

Example: Swan plant

Water

Example: Coconut

Explosion

Example: Pea

Animals

Example: Cherries

BIOLOGY

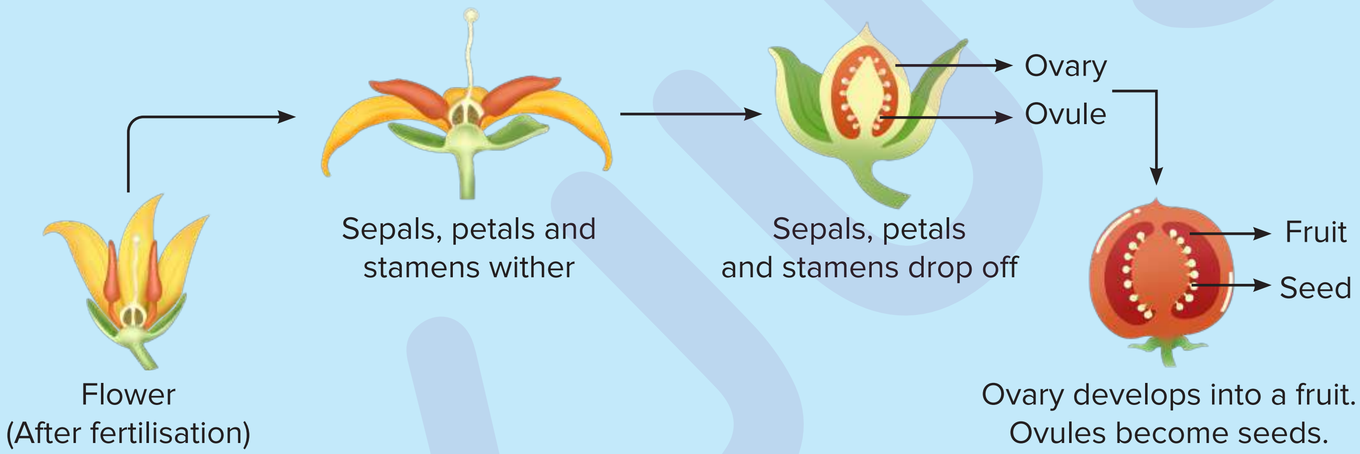
SEXUAL REPRODUCTION IN FLOWERING PLANTS

TYPES OF FRUITS AND SEEDS, APOMIXIS, POLYEMBRYONY, HYBRID SEEDS

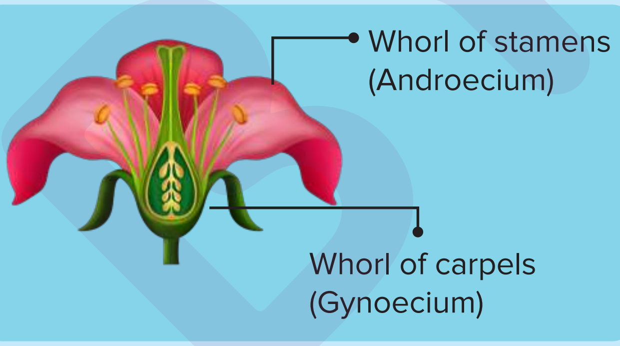
Key Takeaways

- Types of fruits
- Types of seeds
  - » Advantages of seeds in angiosperms
- Apomixis
  - » Types of apomixis
- Polyembryony
- Hybrid seeds

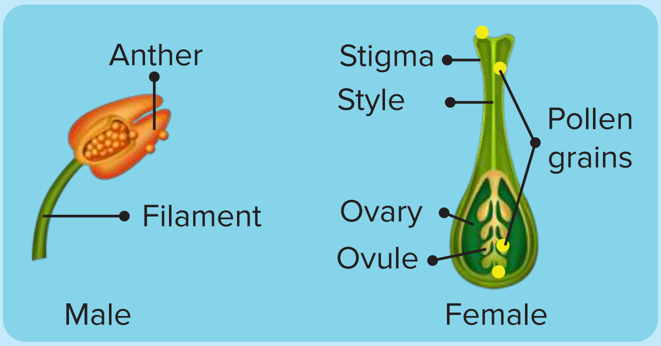
Prerequisites



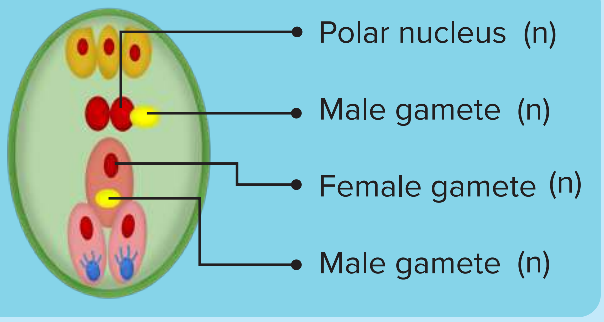
Transition of flower into fruit



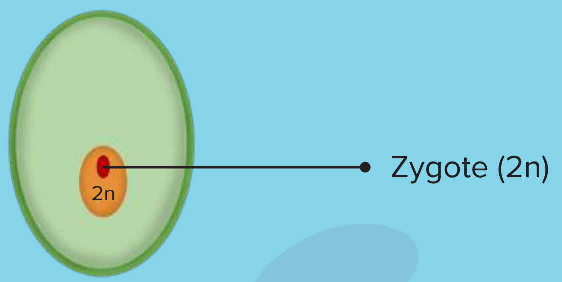
1. Flowers contain the sex organs of the plants: **androecium** and **gynoecium**



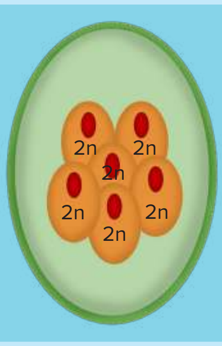
2. Anther produces male gametes (pollen grains), which are transferred to the ovary by the process of **pollination.**



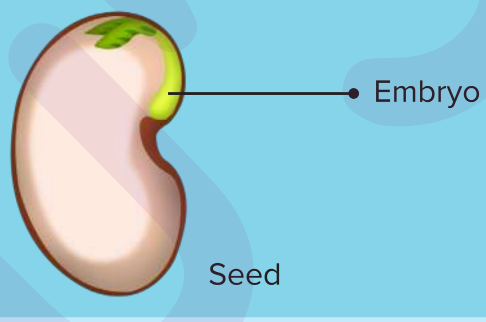
3. Male and female gametes fuse together and form zygote by the process of **fertilisation.**



4. This diploid zygote divides mitotically.



5. This division forms the embryo.



6. Embryo forms in the seed.

Types of Fruits

True fruit

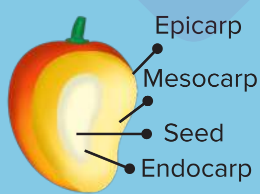
- True fruit usually develops from a mature ovary.
- Examples: Peas, grapes, mango, coconut

False fruit

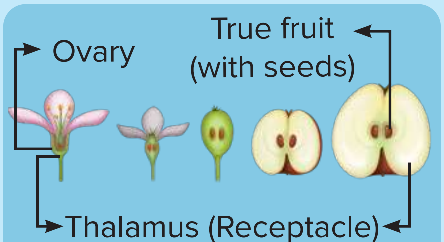
- False fruits develop from parts of the flower other than the ovary like the thalamus in case of apple.
- Examples: Apple, pear

Parthenocarpic fruit

- Fruits develop without fertilisation of the ovules.
- These are seedless fruits.
- Examples: Banana, watermelon (seedless), grapes (seedless)



Mango



Apple

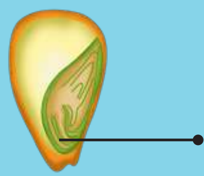
Watermelon

Types of Seeds

Seeds
(Based on types of cotyledons)

Monocotyledonous

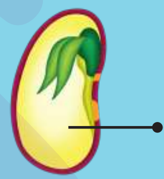
Seeds that have a single cotyledon



Examples: Maize, wheat

Dicotyledonous

Seeds that have two cotyledons

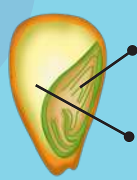


Examples: Beans, maple

Seeds
(Based on types of endosperm)

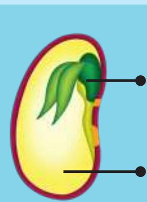
Albuminous

- Endosperm is **present.**
- Endosperm is not fully consumed during embryo development.
- Examples: Wheat, maize, barley, castor, sunflower



Non-albuminous

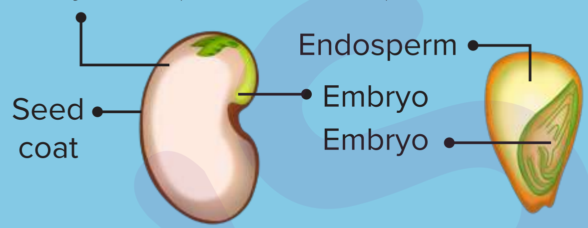
- Endosperm is **absent.**
- Endosperm is fully **consumed** during embryo development.
- Examples: Pea, groundnut



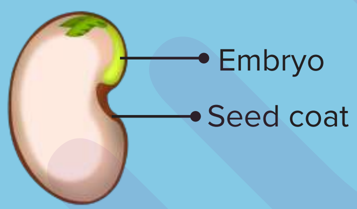
Advantages of seeds in angiosperms

Seed formation is dependable since pollination and fertilisation are **independent** of water, unlike lower plants.

They provide nourishment to the embryo.

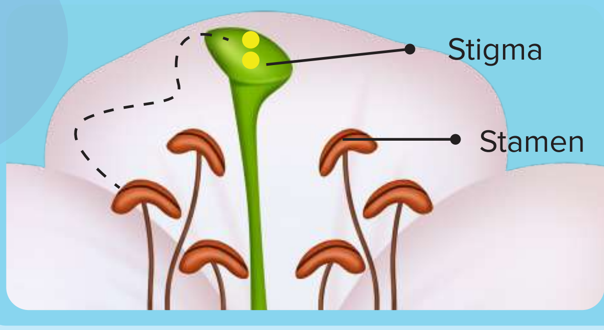


They provide protection to the embryo.



Seeds are dispersed by various agents.

Seeds are formed from sexual reproduction which leads to genetic variation.



Apomixis

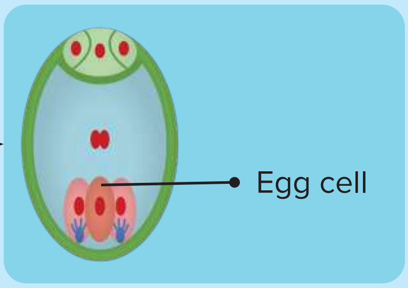
- It is the process of **production of seeds without fertilisation.**
- The term was coined by **Hans Karl Albert Winkler.**
- Apomixis = Apo (Without) + Mixis (Mingling)
- It is a type of **asexual reproduction** that **mimics sexual reproduction.**
- Examples: *Poa* (Meadow grasses), *Hieracium* (Hawkweed)

Poa (Meadow grasses)

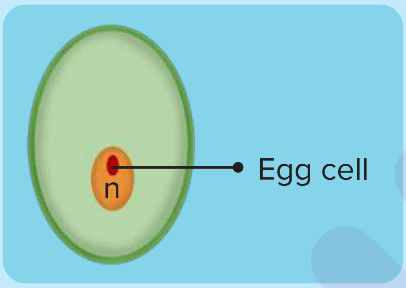
Hieracium (Hawkweed)

Apomixis

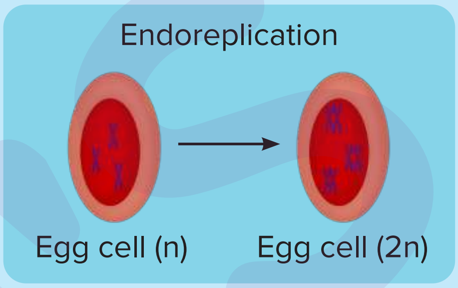
Type 1



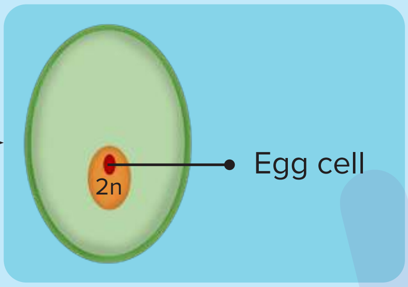
1. Egg cell of embryo sac (n)



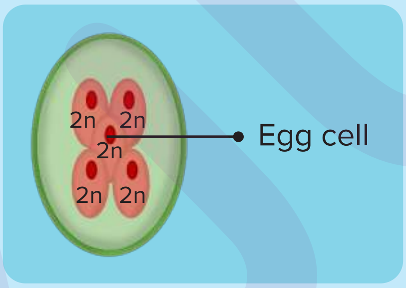
2. The egg cell that is haploid in nature undergoes **endoreplication.**



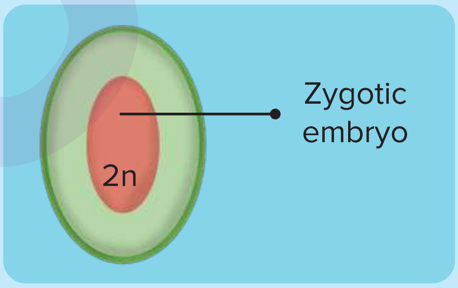
3. The egg cell replicates its genetic material without cytokinesis.



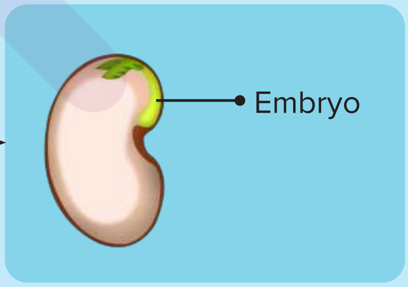
4. The egg cell becomes diploid (2n).



5. The diploid cell divides mitotically.

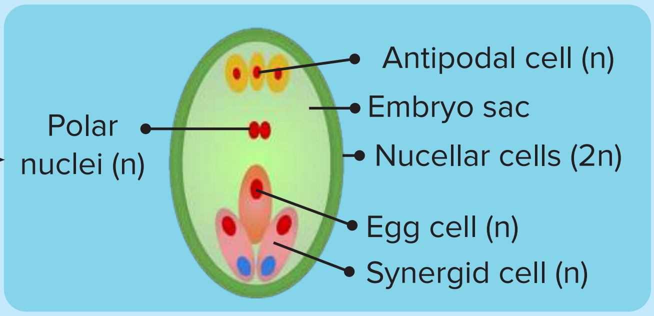


6. Multiple egg cells give rise to the zygotic embryo.

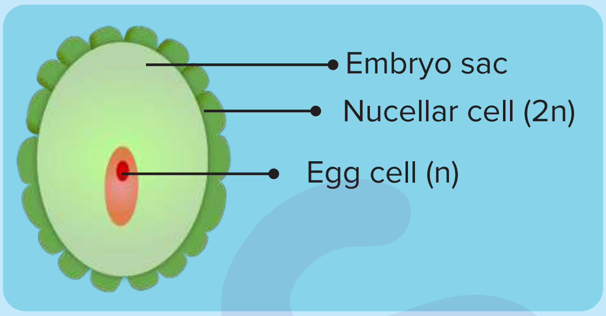


7. The embryo is formed.

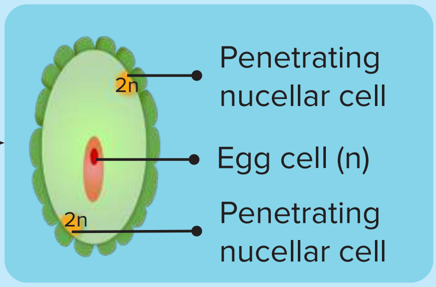
Type 2



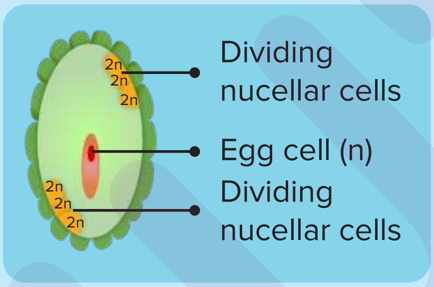
1. Female gametophyte



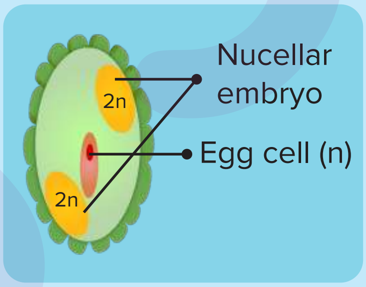
2. Nucellus cells are somatic diploid cells.



3. Nucellar cells penetrate into the embryo sac.



4. Some of the nucellar cells penetrate into the embryo sac and then start dividing inside.

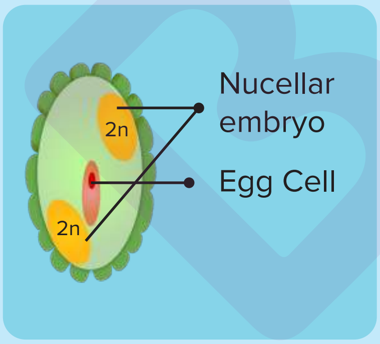


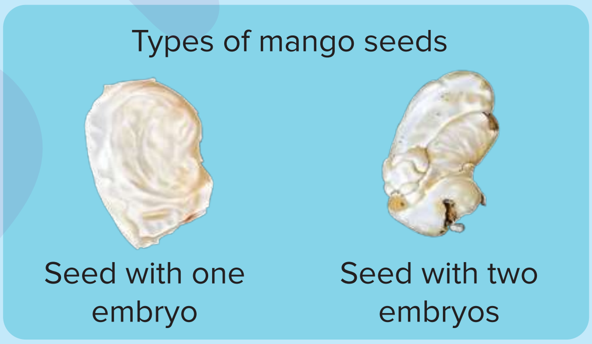
5. Thus, the nucellar embryo is formed.

Polyembryony

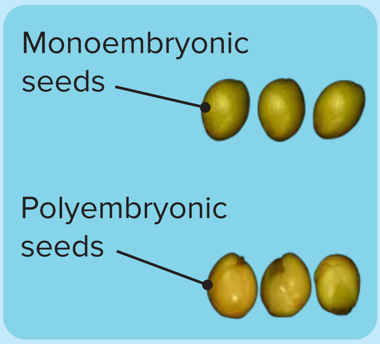
- The occurrence of **more than one embryo** is termed as polyembryony.

Examples:





Mango seeds



Orange seeds

Hybrid Seeds

- Hybrid seeds are produced by **cross-pollination.**
- They contain characteristics of diverse plant species.

- They show extensive growth and productivity.

Hybrid seeds can be produced by two methods

Method 1

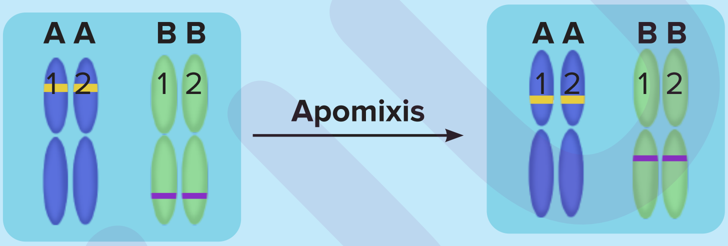
Create hybrid seeds every year

Method 2

Produce hybrid seeds by apomixis

Production of seeds through apomixis is better because:

- There is no occurrence of meiosis.
- There is no segregation of chromosomes in gametes.
- Hybrid nature of the seeds is maintained.



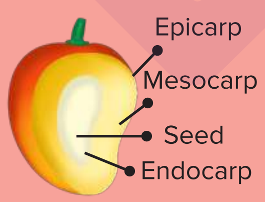
Hybrid parent (2n)

Hybrid zygote (2n)

Summary Sheet

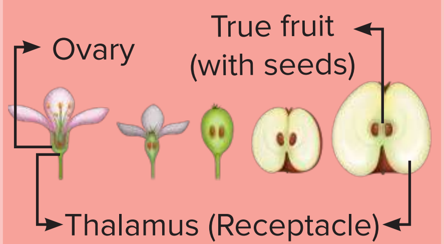
Types of fruits

True fruit



Mango

False fruit



Apple

Parthenocarpic fruit

Watermelon

Types of seeds

Seeds (Based on types of cotyledons)

Monocotyledonous

Seeds that have a single cotyledon

Examples: Maize, wheat

Dicotyledonous

Seeds that have two cotyledons

Examples: Beans, maple

Seeds (Based on types of endosperm)

Albuminous

- Endosperm is present.
- Endosperm is not fully consumed during embryo development.
- Examples: Wheat, maize, barley, castor, sunflower.

Non-albuminous

- Endosperm is absent.
- Endosperm is fully consumed during embryo development.
- Examples: Pea, groundnut.

Apomixis

- It is the process of production of seeds without fertilisation.

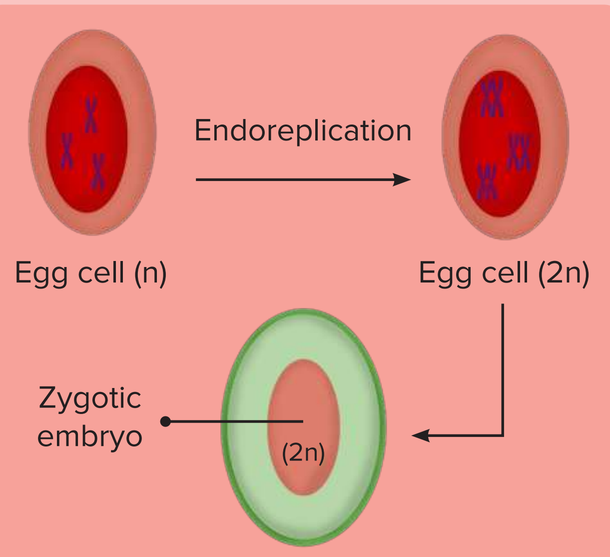
Apomixis

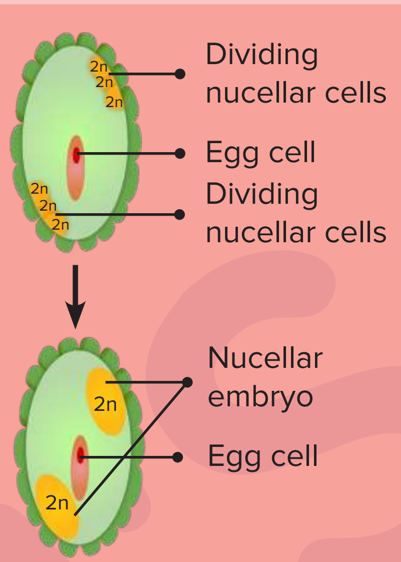
Type 1

The haploid egg cell undergoes endoreplication and forms diploid cells that divide mitotically to give the zygotic embryo.

Type 2

Diploid nucellar cells divide mitotically and form the zygotic nucellar embryo.





Polyembryony

- The occurrence of more than one embryo is termed as polyembryony.

Hybrid seeds

- Hybrid seeds are produced by cross-pollination.
- They contain characteristics of diverse plant species.
- They show extensive growth and productivity.
- The production of hybrid seeds using apomixis can sustain the hybrid characteristics.