SEXUAL REPRODUCTION IN FLOWERING PLANTS

1. Flower:

- A flower is a modified shoot for reproduction.
- Flowers bears reproductive organs where gametes are produced.
- Androecium represents the male reproductive organ and it consists of two part–

(1) Anther – Bilobed structure having two theca i.e, dithecous

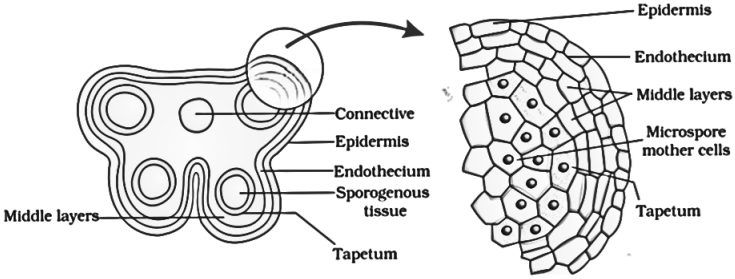
(2) Filament - It is a long slender stalk.

• Two microsporangia are present in each lobe of anther.

• After maturation two microsporangia of each lobe fused together, hence mature anther has two microsporangia.

2. Structure of Microsporangium

In a T.S of typical Microsporangium appears near circular, it is generally surrounded by four layers.



Microsporangia surrounded by four layers-

(i) Epidermis- outer single celled thick layer,

(ii) Endothecium - It helps in dehiscence of anther.

(iii) Middle layer - it stores food.

(iv) Tapetum – nourishes developing pollen grains, possess dense cytoplasm and multi nucleate

3. Microsporogenesis :

- As the anther develops, the cells of the sporogenous tissue undergo meiotic divisions to form microspore tetrads.
- PMC (Pollen Mother Cell) undergo meiosis to form four haploid microspore.
- Each spore of sporogenous tissue act as a PMC.
- As the anthers mature and dehydrate, the microspores dissociate from each other and develop into **pollen grains**.

Structure of Pollen Grains -

- Pollen grains are generally spherical measuring about 25-50 micrometers in diameter.
- Pollen grains are bilayered in structure. Its outer layer is exine and inner layer is intine.

Difference between Exine and Intine

Exine	**Intine**
Outer layer	Inner to Exine
Sculptured & discontinuous layer	Smooth & continuous layer
Made up of sporopollenin (Most resistant biological material)	Made up of pectin and cellulose

Difference between Vegetative Cell and Generative Cell

Vegetative Cell	**Generative Cell**
Large size	Small size
Role – Food reserve and form pollen tube	Role – Divide by mitosis to give two male gamete
Nucleus irregular shape	Spindle shaped with dense cytoplasm and a nucleus, floats in the cytoplasm of vegetative cell

- Similarity between vegetative cell and generative cell is that both are haploid, genetically same, gametophytic generation.
- In over 60 per cent of angiosperms, pollen grains are shed at this 2-celled stage.
- In the remaining species, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed (3-celled stage).
- **Pollen allergy –** *Parthenium* or carrot grass that came into India as a contaminant with imported wheat, has become ubiquitous in occurrence and causes pollen allergy.
- **Pollen food supplement –** In western country pollen grains are used as tables or syrup as a source of nutrient. It also increases the performance of athletes and race horses.
- **Viability of Pollen –** Maximum time upto which pollen can form pollen tube.
  - Wheat, Paddy – short viability (about half an hour)
  - In some members of Rosaceae, Leguminoseae and Solanaceae, viability is for months.
- **Storage of Pollen grain –** Can be stored for years in liquid nitrogen (–196°C). Such stored pollen can be used as pollen banks in crop breeding programmes.

4. Carpel/Pistil :

- Gynoecium represents the female reproductive part of flower.
- **Monocarpellary –** Consist of single pistil.
- **Syncarpous –** When pistil are more than one and fused together.
- **Apocarpous –** When pistil is free.

- **Multicarpellary, Syncarpous pistil –** *Papaver*.
- **Multicarpellary, Apocarpous pistil –** *Michelia*.

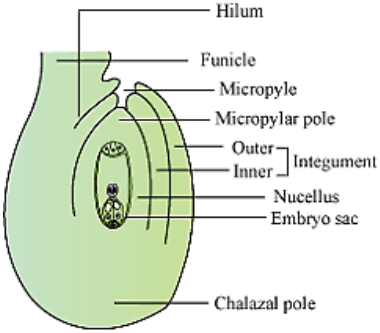
Carpel is unit of gynoecium and consist of three part-

(i) Stigma

(ii) Style

(iii) Ovary-one/many ovules attached with placenta inside the ovary

5. Megasporangium (Ovule):

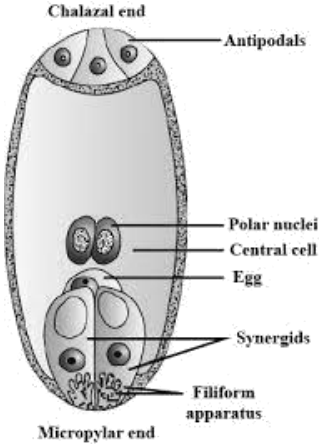


- Ovule represents integumented megasporangium.
- Ovule consist of funicle, integument; nucellus and an opening is called micropyle.
- Embryo sac formation from single megaspore is termed monosporic development.

6. Megasporogenesis:

- Formation of megaspores is called megasporogenesis.
- During the process only one cell of the nucleus [Micropylar] differentiate into megaspore mother cell.
- Megaspore mother cell [MMC] undergoes meiotic division to produce four megaspores.
- In most of flowering plants, three megaspores [Micropylar] degenerate and remaining one [Chalazal] becomes functional megaspore.

7. Megametogenesis:



- The nucleus of functional megaspore undergoes three mitotic division to form 8 nucleated stage [Free nuclear division].
- After cytokinesis, 7-celled and 8-nucleated female gametophyte or embryosac is formed.
- Out of the seven cells, three at micropylar end form-Egg apparatus [Two synergids and one egg cell].
- Three cells towards the chalazal end are called antipodals. The large central cell has two polar nuclei.
- In a typical angiosperm, mature embryosac is seven celled and eight nucleated stage.

Comparison between Male Gametophyte and Female Gametophyte

Male Gametophyte	**Female Gametophyte**
Also known as Pollen grain	Also known as Embryo sac
Haploid, Multicellular	Haploid, Multicellular
2-3 cell	7 cells
Number of male gamete = 2	Number of female gamete = 1
All cell of sporogenous tissue is PMC	Only one cell of nucellus is MMC

Meiosis gives 4 microspore cell which later develop into 4 pollen grain	Meiosis gives 4 megaspore but only one is functional (monosporic)

8. Pollination :

The transfer of pollen grains from anther to the stigma is called pollination.

Pollination is of two types-

1. Self pollination –

– Pollen from same plant.

– It involve autogamy & geitonogamy.

(i) Autogamy - Pollination within the same flower

(ii) Geitonogamy - Pollination in between the two different flowers of the same plant.

Types of flowers :

– **Cleistogamous flower –** which do not open at all, anther and stigma lie close to each other.

– Only Autogamy occurs.

Chasmogamous flower :

– Have exposed anthers and stigma.

– **Example :** *Viola* (common pansy), *Oxalis* and *Commelina* shows both types of flowers.

2. Cross pollination –

– Involves pollen from different plant (same species)

– Involves xenogamy

Xenogamy - Transfer of pollen grains from anther to the stigma of a different plant.

Types of flower :

Unisexual flower :

– Plant bisexual : when both male and female flowers are present on same plant.

– **Example :** Cucumber, Castor, Coconut, Maize

Plant unisexual flower (dioecy) :

- Male and female flowers present on different plants.
- **Example :** Papaya, Date palm, Mulberry, Vallisneria

Bisexual flower (monoecious) :

Example : Sweet potato, tomato, China rose

9. Agents of Pollination -

Geitnogamy and Xenogamy requires pollinator.

Two types of pollinating agents.

(a) **Abiotic agent (Non-living) :** Wind (Anemophily), Water (Hydrophily)

(b) **Biotic agent :** Animals (Zoophily), Bat (Chirepterophily), Bird (Ornithophily), Insect (Entomophily), Snail (Malacophily)

Seed plants – Gymnosperm (wind pollination)
– Angiosperm (abiotic + biotic)

10. Wind Pollination –

Features of flower – colour less, nectar less, odour less, small size present in cluster.

Stamen – Exerted from flower surface

Pollen are light weight, non-sticky, large in number, can be transferred by wind.

Pistil – large and feathery – so that it can capture pollen, mono ovular ovary (single ovule in ovary)

Example : Grass, Tassels (stigma and style) in maize.

11. Pollination in Aquatic Plants –

It is quite rare in flowering plants and is limited to about 30 genera, mostly monocotyledons.

Algae, Bryophyte, Pteriodophyte – Pollination by water.

1. Plant is aquatic but flower comes on surface - pollination by wind or insect.
   Example : Water lily, Water hyacinth
2. Plant is aquatic but pollination is by water –

– On surface of water
Example : *Vallisneria*, *Hydrilla*
In *Vallisneria*, female flower come in surface with long stalk and male flower detach and float on surface and carried passively with water current.
– Under water
Example : *Zostera* (Sea grass)
Pollen – Ribbon shape, Mucilagenous covering (non-wettable)

12. Biotic Agents :

- Majority of flowering plants use a range of animals as pollinating agents-Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds & humming birds) & bats.
- Among animals, insects particularly bees are dominant pollinating agents.
- Some primates (lemurs), arboreal (tree dwelling), rodents or even reptiles (gecko lizard & garden lizard) are also pollinators in some species.

Difference between Bat Pollination and Bird Pollination

Bat Pollination	**Bird Pollination**
Large size flower	Large size flower
Dull colour	Bright colour
Strong smell	Smell absent
Large sugary nectar	Nectar present
Ex. Kigelia, Adansonia	**Ex.** Sun bird, Humming bird

13. Rewards for pollinator :

To ensure regular visit of pollinator.

(a) Edible nectar (for Insect, Bird, Bat)
(b) Edible pollen – some plants have edible pollen.
(c) Safe place for egg laying –
Example : *Amorphophallus* – 6 Ft flower (insect lay egg)

(d) Yucca plant and Moth –
- Moth-pollination
- Yucca plant – safe place for egg laying
- Larvae of moth feed on pollen of yucca plant.

14. OUTBREEDING DEVICES –

- Flowering plants have developed many devices to discourage self pollination and to encourage cross pollination. For example:

- Pollen release and stigma receptivity are not synchronised.
- Anther and stigma are placed at different positions so that pollen cannot come in contact with stigma of the same flower.
- **Self-incompatibility** is a genetic mechanism which prevents self-pollen from fertilizing the ovules by inhibiting pollen germination or pollen tube growth in the pistil.
- Production of unisexual flowers.
  - In **castor & maize**, (monoecious) autogamy is prevented but not geitonogamy.
  - In **papaya** (Dioecious), both autogamy and geitonogamy are prevented.

15. POLLEN-PISTIL INTERACTION –

- All events after pollination till entry of pollen tube inside ovule.

It involve –

(a) Acceptance or rejection of pollen.
(b) If accepted – germination of pollen.
(c) Growth of pollen tube is stigma.
(d) Growth of pollen tube in style.
(e) Entry of pollen tube inside ovule.

ARTIFICIAL HYBRIDISATION

- In such crossing, desired pollen are used for pollination & stigma is protected from contamination from unwanted pollen by emasculation and bagging.
- If female parent bears bisexual flowers, emasculation is followed by bagging & rebagging after dusting mature pollen for fruit development.
- If female flowers are unisexual, there is no need of emasculation.

– Continued self-pollination result in inbreeding depressions.

16. Fertilization:

Pollen tube release both male gamete in one of the synergids

– One male gamete move into egg cell. Another move into central cell.

Syngamy – Fusion of one male gamete with nucleus of egg cell.

– Result of syngamy – Zygote (2n)

Triple Fusion – Male gamete fuse with polar nuclei (two).

– Result of triple fusion – PEN (Primary endosperm nucleus)

Double Fertilization – In one embryosac, triple fusion and syngamy both occurs known as double fertilization.

– Occurs only in angiosperm (Dicot and Monocot)

17. POST-FERTILISATION EVENTS :

Endosperm

- Endosperm development precedes embryo development.
- The cells of tripoid endosperm are filled with reserve food materials and used by developing embryo.
- The most common type of endosperm, is nuclear type (PEN undergoes successive nuclear divisions to

give free nuclei) eg., Coconut water and surrounding white kernel is cellular endosperm.

Embryo

- Develops at micropylar end of embryo sac where the zygote is situated.
- In dicots, the zygote forms → proembryo → globular → heart-shaped → mature embryo.
- A typical dicot embryo has embryonal axis & two cotyledons. Epicotyl terminates with plumule or stem tip.
- Hypocotyl terminates at its lower tip in radical or root tip, covered by root cap.
- Embryos of monocot has only one cotyledon. In grass family, it is called **scutellum** towards lateral side of the embryonal axis.
- Radicle or root cap enclosed with undifferentiated sheath called **coleorhiza**.
- Epicotyl has shoot apex & a few leaf primordia enclosed in foliar structure **coleoptile**.

Seed

- In angiosperms, seed (fertilised ovule) is the final product of sexual reproduction, formed inside fruits.
- A seed typically consists of seed coats, cotyledon(s) & an embryo axis.
- Mature seeds may be non-abuminous or ex-albuminous, having no residual endosperm, which is consumed completely during embryo development (eg. Pea, groundnut). Albuminous seeds retain a part of endosperm (eg. Wheat, maize, barley, castor, coconut).
- In black pepper & beet, remnants of nucellus are also persistent, called perisperm.

- Wall of ovary develops into pericarp. True fruits develop from ovary.
- In apple, strawberry, cashew, etc, thalamus also contributes to form fruit called false fruit.
- Parthenocarpic fruit develop without fertilisation eg. Banana.
- *Lupinus arcticus* seed germinated and flowered after estimated record 10,000 years of dormancy.
- *Phoenix dactytifera* (date palm) seed remained viable for 2000 years.
- Orchid, Parasitic species (*Orobanche* and *Strigga*) contain very large number of tiny seeds.

18. Asexual reproduction/Apomixis:

The formation of new individuals without fertilization is called asexual/apomixis.

(a) In many *Citrus* and Mango varieties some of the nucellar cells surrounding embryo sac develops into embryos.

(b) **Polyembryony**- In some of the angiosperms more than one embryos are formed inside the ovule. [**Example -** *Citrus*].