classmate
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Page 1

Sexual Reproduction in Flowering Plants

Reproduction ensures continuity of species generation after generations as the older individuals undergo senescence and die. Flowering plants show sexual mode of reproduction and bears complex reproductive units as male and female reproductive units along with accessory structures.

- Flower is a modified stem which functions as a reproductive organ and produces ova and/or pollen. A typical angiospermic flower consists of four whorls of floral appendages attached to the receptacle: calyx, corolla, androecium and gynoecium.

Pre-fertilisation: Structures and Events

- Several structural and hormonal changes leads to formation and development of the floral primordium. Inflorescence is formed that bears Floral buds and then flower.

- In flowers, male and female differentiate and develops in which male and female gametes are produced.

Stamen, Microsporangium and Pollen Grain:

- Stamen consists of long and slender stalk called Filament and generally bilobed anthers. Each lobe contains two theca (dithecious).

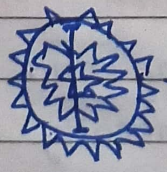
- The anther is four-sided structure consisting of four microsporangia, two in each lobes.
- Microsporangia develop further and become pollen sacs which contain pollen grains.
- Microsporangium is generally surrounded by four layered walls - the epidermis, endothelium, middle layer and tapetum. Innermost layer tapetum nourishes the developing pollen grains.
- Sporogenous tissues -

  It is compactly arranged homogenous cells which are present at centre of each microsporangium when the anther is young.

- Microsporogenesis -

  The process of the formation and differentiation of microspore (pollen grains) from microspore mother cells (MMC) by reductional division is called microsporogenesis.

- The cells of sporogenous tissues undergo meiotic division to form microspore tetrad. As the anther mature and dehydrate, the microspore dissociates and develops into pollen grains.



→ 25 - 50 micrometers

Pollen Grain

Pollen grain represents the male gametophytes.
Pollen grains are made of 2 layered wall.

1. Exine :-

Made of sporopollenin - most resistant organic matter known. It can withstand high temperature and strong acids and alkali. No enzyme can degrade sporopollenin.

2. Intine :-

Thin and continuous layer. made up of cellulose and pectin.

- Germ pores :
  - apertures on exine where sporopollenin is absent.
  - forms pollen tube.
  - numbers varies as 1 in monocots and 3 in dicots.

- A plasma membrane surrounds cytoplasm of pollen grain.

Mature Pollen

A mature pollen consists of 2 cells with nucleus (vegetative and generative)

Vegetative cell

- Bigger
- Abundant food reserve
- Large irregular nucleus
- Responsible for the development of pollen grains

Generative cell

- Small
- Involves in syngamy (fuse with an egg)
- Dense cytoplasm and nucleus.

- Pollen grains of many species e.g. Parthenium cause severe allergies and bronchial disease in some people and leads to chronic respiratory disorders - asthma, bronchitis, etc.

- Pollen grains are rich in nutrients and are used as pollen tablets as food supplements. → race horses → athletes

- Viability of pollen grains varies with species to species and should land on stigma before there period to germinate. Pollen grains of large number of species are stored in liquid nitrogen at temperature -196°. called pollen back.

In about 60% of Angiosperms, Pollen grains are shed at 2-celled ~~level~~ stage.

In about 40% of Angiosperms, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed at 3-celled stage.

Pistil, Megasporangium and Embryo sac:

- Gynoecium may consists of single pistil (monocarpellary) or more than one pistil (poly-carpellary) which may be fused (syncarpous) or free (apocarpous).
- Examples: Multicarpellary and syncarpous pistil - Papaver
  Multicarpellary and apocarpous pistil - Michelia
- Each pistil has three parts - stigma, style and ovary. Inside the ovary is ovarian cavity (locule). The placenta is inside the ovarian cavity. Megasporangia (ovules) arise from placenta.

Megasporangium (ovule)

- Ovule is a small structure attached to placenta.
- Funicle: stalk by which ovule is attached to placenta.
- Hilum: junction between ovule and funicle.
- Integuments: protective envelops.
- Micropyle: small opening at the tip of ovule into where pollen tube enters.
- Chalaza: basal part of ovule
- Nucellus (2n): mass of cells enclosed in integument. Has abundant food reserve.

Megasporogonesis -

The process of formation of megaspore from megaspore mother cell by meiotic division is known as megasporogenesis. The process takes place in ovule.

Ovule differentiates a single megaspore mother cell (MMC) in the micropylar region of nucellus. MMC undergoes meiotic division that results into the production of four megaspores.

- In most of the flowering plants, three megaspores degenerate. 1 megaspore develops into female gametophyte (embryo sac).
- The nucleus of functional megaspore divides mitotically to form two nuclei which move to opposite poles to form 2-nucleate embryo sac. Two more sequential mitotic division results into 8-nucleate embryo sac.
- Six of the eight nuclei surrounded by cell wall and remaining two nuclei (polar nuclei) are situated below the egg apparatus.
- Three cells are grouped at micropylar end to constitute egg apparatus at three cells at chalazal end forms antipodal cells. At maturity, embryo sac is 8-nucleate and 7 celled.
- The egg apparatus consists of two synergids and one egg cell.

Pollination :

Transfer of pollen grains from Anther to Stigma is called pollination.

a) Autogamy -

Transfer of pollen grains from anther to stigma of same flower.

i. Cleistogamy -

Flowers which do not open. Cleistogamous flowers are autogamous as there is no chances of cross pollination on the stigma. Cleistogamous flowers produce assured seed set even in the absense of pollinators. e.g. Viola (common pansy), Oxalis and Commelina.

ii. Chasmogamy -

Flowers with exposed anther and stigma. Flower remains open always. Example : Hibiscus.

b) Geitonogamy -

Transfer of pollen grains from anther to stigma of different flower of same plant. Geitonogamy is functionally cross-pollination involving a pollinating agent. Genetically, It is similarly to autogamy since the pollen grains come from the same plant. Example: Maize, Coconut.

c) Xenogamy -

Transfer of pollen grains from anther of a flower of a plant to stigma of another flower of another plant. It is also called Allogamy.

Modification of Cross Pollination:

1. Unisexuality
2. Dichogamy
3. Herkogamy
4. Heterostyly
5. Self - sterility.

- Plants bearing unisexual flowers such as Vallisneria have no other option than to cross pollinate.
- In some plants, the stigma and anthers mature at different times. This condition is 'Dichogamy'.
- When anthers matures before stigma, the condition is called protrandry. E.g. Sunflower.
  When stigma matures before anther, the condition is called protogyny. E.g. Potato flower.
  Since, the maturity of male and female gametophyte is not at the same time, self - pollination cannot take place.
- Herkogamy is an adaptation in dimorphic plants (flowers) where the anther and stigma are placed in different positions to ensure pollination. It can be seen in hibiscus flowers.
- Heterostyly is a special type of adaptation in dimorphic ~~flowe~~ flowers where styles are positioned at different lengths.
  Example: Primula vulgaris.

- Self sterility is a genetic mechanism in all flowering plants where during cross-pollination stigma sorts compatible or functional pollen from incompatible pollens landing on it to prevent selfing.

Agents of Pollination includes abiotic (water, wind) and biotic (insects, butterflies, honey bees, etc.). Large numbers of pollen grains are produced by plants using abiotic mode of pollination as most of pollen grains are wasted during transfer.

Adaptations in flowers for pollination

1. Wind Pollination (Anemophily)

- pollen grains :- light, non-sticky, winged
- anther :- well exposed
- stigma :- large and feathery
- flower :- one ovule, arranged as inflorescence

Example : corn, cotton, date palm

2. Water Pollination (Hydrophily)

- Bryophytes, Pteridophytes, Algae

- pollen grains :- protected by mucilaginous covering

Example : Fresh water plants - Vallisneria, Hydrilla
Sea grass - Zostera

Main features of wind and water pollinated plants
- produces pollen grains in large number.
- do not produce nectar.

3. Insect Pollination (Entomophily)

- Flowers :- large, colourful, fragrent, rich in nectar
- Pollen grains :- sticky
- Stigma :- sticky

Certain rewards to pollinators :

- nectar and edible pollen grains as foods.
- provide safe place for laying eggs.

Example : Amorphophallus, Yucca.

Outbreeding Devices -

The various mechanisms take discourage self-pollination and encourage cross pollination as continued self pollination leads to inbreeding depression. It includes

- Pollen release and stigma receptivity not synchronize
- Anther and stigma are placed at different position
- Inhibiting pollen germination in pistil.
- Production of unisexual flowers.

Pollen - Pistil Interaction -

The pistil have ability to recognize the compatible pollen to initiate post-pollination events that leads to fertilisation. Pollen grains produce pollen tube through germ pores to facilitate transfer of male gametes to embryo sac.

Artificial Hybridization

- Crossing different varieties of species - hybrid individual - with desirable characters of the parents plant.
- Desired pollen grains for pollination - stigma protected from contamination.
- Emasculation : removal of anther

- Bagging : Flower covered - bag made up of butter - prevent contamination of stigma from unwanted pollen. Bagged flower - attains receptivity - mature pollen grains - dusted on the stigma - rebagged - fruits allowed to develop.

Double Fertilisation :

After entering one of the synergids, each pollen grains releases two male gametes. One male gametes fuse with egg (syngamy) and other male gametes fuse with two polar nuclei (triple fusion) to produce triploid primary endosperm nucleus (PEN). Since, two types of fusion takes place in an embryo sac, the phenomenon is called double fertilisation. The PEN develops into the endosperm and zygote develops into embryo.

Post Fertilisation : Structures and Events

- Post - fertilisation events include endosperm and embryo development, maturation of ovules into seeds and ovary into fruits.

Endosperm :

The primary endosperm cell divides many times to form triploid endosperm tissue having reserve food materials.

Two types of Endosperm development :

(i) Free nucleus type [common method]

(ii) Cellular type

(a) Non-albuminous :

Endosperm (completely utilised - before maturation of seeds, e.g. pea and groundnut)

(b) Albuminous :

A portion of endosperm remains in mature seeds. e.g. wheat, maize, castor, etc.

Embryo :

Embryo develops at the micropylar end of the embryo sac where the zygote is located.

Embryogeny -

Early stage of embryo development. The zygote give rise to the proembryo and subsequently to the globular, heart-shaped and then mature embryo.

Embryo consists of :

- embryonal axis
- cotyledons
- plumule
- radicle

In monocotyledonous seed,

- ~~Scte~~ Scutellem = Cotyledon
- ~~Cole~~ Coleorrhiza : undifferentiated sheath covering radicle and root cap
- Coleoptile : sheath covering plumule.

Seed:

Fertilized and mature ovule develops into seed.

Seed consists of :

- cotyledon (s)
- embryonal axis
- seed coat is double layered formed by integuments
  - Testa (outer coat)
  - Tegmen (inner coat)

- Micropyle : small opening on seed coat, it facilitates entry of H_2O and O_2 into seeds. (for germination)
- Hilum : scar on seed coat.
- Seed : Albuminous / Non-Albuminous
- Perisperm : remnants of nucellus that is persistent.
  Example : Black pepper.
- Dormancy : state of inactivity.

- The wall of ovary develops into wall of fruit called pericarp. In true fruits, only ovary contributes in fruit formation. In false fruits, thalamus also contributes in fruit formation.

Polyembryony:

- The condition in which more than one embryo is present in a seed is called as polyembryony.
- First discovered by Antonie van leeuwenhoek in 1790.

Types:
① Clearage polyembryony
② Other than the egg cell
③ Adventive polyembryony

Clearage Polyembryony:

The splitting or clearage of the proembryo gives rise to more than one embryo.
Example: Water Lily

Other than the egg cell:

The embryo can be originate from the cells of the embryo sac other than the egg cell. Most commonly, the additional embryo develops from the synergids.
Example: Saggitaria

Adventive polyembryony:

The development of embryo from any sporophytic cell i.e., from nucellus or integuments of the ovule can occur.
Example: Citrus

Apomixis :

- Apomixis is a form of asexual reproduction, it mimics sexual reproduction, seed is formed without fertilisation.
- No segregration and recombination of chromosome.
- Apomictic plants are deprived of evolution.
- Facultive apomictic species can switch between sexual reproduction and apomixis.
- Formation of apomictic seeds :

– diploid cell (formed without meiosis) develops into embryo without fertilization.

– cells of nucellus (2n) surrounding embryo sac protude into embryo sac and develops into embryos. Examples : Citrus and Mango.

- Polyembryony is the resulting condition and apomixis is the process that lead to it.