Sexual Reproduction in Flowering Plants

1. Pre-Fertilisation: Male Reproductive Structures

Structure	Key Characteristics & Functions
Stamen	The male reproductive organ, consisting of a long, slender stalk (filament) and a terminal, generally bilobed structure (anther).
Anther & Microsporangium	A typical angiosperm anther is bilobed and dithecous (two microsporangia per lobe, making it tetrasporangiate). Microsporangia develop into pollen sacs.
Microsporangium Wall Layers	1. Epidermis (outermost, protective) 2. Endothecium (helps in dehiscence) 3. Middle Layers (1-3 layers, ephemeral) 4. Tapetum (innermost, nourishes developing pollen grains; cells have dense cytoplasm and are often multinucleate).
Pollen Grain	Represents the male gametophyte. Has a prominent two-layered wall: • Exine: Hard outer layer made of sporopollenin (highly resistant organic material). Has prominent apertures called germ pores (where sporopollenin is absent). • Intine: Inner, thin, continuous layer made of cellulose and pectin.

Microsporogenesis

The process of formation of microspores from a pollen mother cell (PMC) through meiosis.

- Process: Sporogenous tissue (diploid, 2n) undergoes meiotic divisions to form microspore tetrads (haploid, n). As the anther matures and dehydrates, the microspores dissociate and develop into pollen grains.
- Shedding Stage: In over 60% of angiosperms, pollen is shed at the 2-celled stage (Vegetative cell + Generative cell). In the rest, the generative cell divides mitotically to form two male gametes before shedding (3-celled stage).

2. Pre-Fertilisation: Female Reproductive Structures

Structure	Key Characteristics & Functions
Pistil (Gynoecium)	The female reproductive part. Consists of three parts: 1. Stigma: Landing platform for pollen. 2. Style: Elongated slender part beneath the stigma. 3. Ovary: Basal bulged part containing ovarian cavity (locule) and placenta.
Megasporangium (Ovule)	Arises from the placenta. Key parts: • Funicle: Stalk attaching ovule to placenta. • Hilum: Junction between ovule and funicle. • Integuments: Protective envelopes (usually one or two). • Micropyle: Small opening where integuments are absent. • Chalaza: Basal part of the ovule opposite the micropyle. • Nucellus: Mass of cells enclosed within integuments, abundant reserve food.

Megasporogenesis & Embryo Sac Formation

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

- Process: A single MMC (2n) in the micropylar region of the nucellus undergoes meiosis to form four haploid megaspores.
- Monosporic Development: Usually, three megaspores degenerate, and only one functional megaspore develops into the female gametophyte (embryo sac).
- Mature Embryo Sac Structure: It undergoes three free-nuclear mitotic divisions, resulting in a 7-celled, 8-nucleate structure.

- Micropylar end: Egg apparatus (1 Egg cell + 2 Synergids with filiform apparatus to guide pollen tube).
- Chalazal end: 3 Antipodal cells.
- Center: 1 Large Central Cell with 2 polar nuclei.

3. Pollination & Interactions

Pollination is the transfer of pollen grains to the stigma of a pistil.

Pollination Type	Description & Characteristics
Autogamy	Pollination within the same flower. Requires synchrony in pollen release and stigma receptivity. (e.g., Viola, Oxalis, Commelina produce both open chasmogamous and closed cleistogamous flowers).
Geitonogamy	Pollination between different flowers of the same plant. Functionally cross-pollination (requires agent), but genetically similar to autogamy.
Xenogamy	Pollination between flowers of different plants. Brings genetic variation.

Agents of Pollination

1. Abiotic (Wind & Water):
   - Wind (Anemophily): Pollen is light, non-sticky; stigmas are large, feathery. Often have a single ovule per ovary. Example: Corn cob, grasses.
   - Water (Hydrophily): Rare (about 30 genera, mostly monocots). Examples: Vallisneria (surface pollination), Zostera (submerged marine seagrass).
2. Biotic (Animals): Majority of plants. Flowers are large, colorful, fragrant, and rich in nectar to attract insects (entomophily), birds, or bats.

Outbreeding Devices & Interactions

Plants develop mechanisms to discourage self-pollination (which causes inbreeding depression):

- Dichogamy: Pollen release and stigma receptivity are not synchronized.
- Herkogamy: Physical barriers between anther and stigma.
- Self-Incompatibility: Genetic mechanism preventing self-pollen from fertilizing ovules.
- Pollen-Pistil Interaction: A dynamic process involving pollen recognition (compatible vs. incompatible) followed by promotion or inhibition of pollen tube growth. Mediated by chemical components.

4. Double Fertilisation

This is a unique and characteristic event strictly found in angiosperms. After entering one of the synergids, the pollen tube releases two male gametes into the cytoplasm.

Event	Process & Result
Syngamy (True Fertilisation)	1 Male Gamete (n) + 1 Egg Cell (n) $\rightarrow$ Zygote (2n). The zygote develops into the Embryo.
Triple Fusion	1 Male Gamete (n) + 2 Polar Nuclei (n+n) $\rightarrow$ Primary Endosperm Nucleus / PEN (3n).

	The PEN develops into the Endosperm.

5. Post-Fertilisation Events

Endosperm and Embryo Development

- Endosperm: Develops before the embryo to ensure a guaranteed food supply. Most common type is free-nuclear endosperm (e.g., coconut water), which later becomes cellular (e.g., white kernel of coconut).
- Embryo: Develops at the micropylar end from the zygote.
    - Dicot Embryo: Consists of an embryonal axis and two cotyledons. The portion above cotyledons is the epicotyl (terminates in plumule); the portion below is the hypocotyl (terminates in radicle/root tip).
    - Monocot Embryo: Possesses only one cotyledon (called the scutellum in grasses). Has a protective sheath for the plumule (coleoptile) and radicle (coleorhiza).

Seeds, Fruits, and Special Mechanisms

Concept	CUET Definition & Examples
Seed Formation	Ovules mature into seeds. The integuments harden into seed coats (testa and tegmen). The micropyle remains as a small pore for water/oxygen entry.
Albuminous vs. Non-albuminous	Albuminous: Retain a part of endosperm (e.g., Wheat, Maize, Castor). Non-albuminous: Endosperm is completely consumed during development (e.g., Pea, Groundnut).
Perisperm	Remnants of nucellus that are persistent in some seeds (e.g., Black pepper, Beet).
Fruit Formation	The ovary develops into a fruit. The ovary wall develops into the fruit wall (pericarp).
True vs. False Fruits	True: Develops only from the ovary (e.g., Mango). False: Thalamus or other floral parts contribute to fruit formation (e.g., Apple, Strawberry, Cashew).
Parthenocarpy	Development of fruit without fertilisation. Fruits are seedless (e.g., Banana). Can be induced by growth hormones.
Apomixis	A form of asexual reproduction that mimics sexual reproduction; produces seeds without fertilisation (e.g., some species of Asteraceae and grasses). Can occur if a diploid egg cell is formed without meiosis and develops into an embryo.
Polyembryony	Occurrence of more than one embryo in a seed. Often happens when nucellar cells surrounding the embryo sac start dividing and protrude into the sac (e.g.,