Flower Structure

Overview of Flower Parts

Flowers are the reproductive organs of flowering plants (angiosperms). They consist of four main whorls attached to a central axis called the thalamus: sepals, petals, stamens (male reproductive parts), and carpels or pistils (female reproductive parts). Flowers can be bisexual, containing both male and female parts, or unisexual, containing only one type of reproductive organ.

Male Reproductive Structure: Androecium

The androecium is the collective term for the stamens of a flower. Each stamen typically consists of three parts: the anther, filament, and connective. The anther is the terminal, bilobed part that produces pollen grains. It is dithecous, meaning it has two lobes, each containing two pollen sacs (microsporangia), making a total of four pollen sacs. The filament is a slender stalk that supports the anther. The connective is the tissue connecting the two lobes of the anther.

Structure of Anther and Microsporangium

The anther is tetragonal in cross-section, with four microsporangia located at the corners. Each microsporangium is surrounded by four wall layers: epidermis, endothecium, middle layers, and tapetum. The epidermis and endothecium protect the anther and assist in its dehiscence (splitting open to release pollen). The middle layers provide temporary support, while the tapetum nourishes developing pollen grains. Inside the microsporangium, sporogenous tissue gives rise to pollen mother cells (microspore mother cells) that undergo meiosis to form microspores.

Microsporogenesis

Microsporogenesis is the process by which pollen mother cells undergo meiosis to produce haploid microspores arranged in groups of four called tetrads. These microspores develop into pollen grains, which are the male gametophytes. As the anther matures and dehydrates, it undergoes dehiscence, releasing the pollen grains for pollination.

Pollen Grain Structure

Pollen grains are typically spherical and measure 25-50 micrometers in diameter. They have a two-layered wall: the outer exine and the inner intine. The exine is composed of sporopollenin, a highly resistant organic material that protects pollen grains from environmental damage. The exine has apertures called germ pores where sporopollenin is absent, allowing pollen tube emergence. The intine is made of cellulose and pectin and encloses two cells: the larger vegetative cell, which controls pollen tube growth, and the smaller generative cell, which divides to form two sperm cells for fertilization.

Female Reproductive Structure: Gynoecium (Pistil)

The gynoecium is the female reproductive part of the flower and may consist of one or more carpels. A single carpel is called monocarpellary, while multiple carpels may be fused (syncarpous) or free (apocarpous). Each carpel has three parts: stigma, style, and ovary. The stigma serves as the pollen-receptive surface. The style is a slender stalk connecting the stigma to the ovary. The ovary is the basal swollen part containing ovules attached to the placenta inside the ovarian cavity (locule).

Ovule Structure and Megasporangium

The ovule, or megasporangium, is attached to the placenta by a stalk called the funicle. It has one or more protective integuments surrounding the nucellus, which contains reserve food. The integuments leave a small opening called the micropyle. Inside the nucellus is the embryo sac, the female gametophyte, usually formed from a single haploid megaspore.

Megasporogenesis and Female Gametophyte Development

Megasporogenesis is the meiotic process by which a diploid megaspore mother cell in the ovule produces four haploid megaspores. Typically, three megaspores degenerate, and one functional megaspore develops into the embryo sac through mitotic divisions. The mature embryo sac is eight-nucleate and seven-celled, containing the egg apparatus (egg cell and two synergids), three antipodal cells, and a central cell with two polar nuclei.

Distribution of Cells in Embryo Sac

The egg apparatus is located at the micropylar end and consists of the egg cell and two synergids, which have a filiform apparatus to guide the pollen tube. The antipodal cells are at the chalazal end and help nourish the embryo sac. The central cell contains two polar nuclei that fuse with a sperm cell during fertilization to form the endosperm.

Solved Examples

Example 1: Describe the structure of a typical anther and explain the role of tapetum.

Solution: A typical anther is bilobed and dithecous, with each lobe containing two microsporangia, making four pollen sacs in total. The anther wall has four layers: epidermis, endothecium, middle layers, and tapetum. The tapetum is the innermost layer that nourishes developing pollen grains by providing nutrients and enzymes essential for their development.

Example 2: Explain the process of microsporogenesis.

Solution: Microsporogenesis is the formation of microspores from pollen mother cells (microspore mother cells) through meiosis. Each diploid pollen mother cell undergoes meiosis I and II to produce four haploid microspores arranged in a tetrad. These microspores separate and develop into pollen grains, the male gametophytes.

Example 3: What is the structure of the mature embryo sac in flowering plants?

Solution: The mature embryo sac is seven-celled and eight-nucleate. It contains one egg cell and two synergids at the micropylar end (egg apparatus), three antipodal cells at the chalazal end, and a central cell with two polar nuclei. The synergids have a filiform apparatus to guide the pollen tube during fertilization.

Practice Set

Conceptual Questions

- **Level 1:** What are the main parts of a stamen?
- **Level 2:** Explain the role of the integuments in an ovule.

Application-based Question

- **Level 3:** A pollen grain lands on the stigma but fails to germinate. Suggest possible reasons based on pollen-pistil interaction.

Answer Key

Conceptual Questions

- **Level 1:** The main parts of a stamen are the anther, filament, and connective.
- **Level 2:** Integuments are protective layers surrounding the ovule, leaving a small opening called the micropyle. They protect the developing embryo and regulate entry of pollen tubes.

Application-based Question

- **Level 3:** Possible reasons include incompatibility between pollen and stigma, absence of necessary chemical signals for pollen recognition, or physical damage to the pollen grain preventing germination.

Pollination and Fertilisation

Modes of Pollination

Pollination is the transfer of pollen grains from the anther to the stigma of a pistil. It can occur through various modes:

- **Autogamy:** Pollen transfer within the same flower.
- **Geitonogamy:** Pollen transfer between different flowers of the same plant.
- **Xenogamy:** Pollen transfer between flowers of different plants.

Agents of Pollination

Pollination agents are classified as abiotic and biotic:

- **Abiotic agents:** Wind (anemophily) and water (hydrophily).
- **Biotic agents:** Animals such as insects (entomophily), birds, bats, and others.

Pollination by Wind and Water

Wind-pollinated flowers produce large amounts of light, non-sticky pollen and have exposed stamens and feathery stigmas to catch pollen. Water-pollinated plants have pollen grains adapted to water transport, often with mucilaginous coverings.

Pollination by Animals

Animal-pollinated flowers are often colorful, fragrant, and produce nectar to attract pollinators. Pollen grains are sticky to adhere to animal bodies. Some plants have specialized relationships with specific pollinators.

Outbreeding Devices

To promote cross-pollination and avoid self-pollination, plants have developed mechanisms such as:

- Dichogamy: Temporal separation of pollen release and stigma receptivity.
- Spatial separation: Different positions of anther and stigma.
- Self-incompatibility: Genetic mechanisms preventing self-pollen germination.
- Production of unisexual flowers (dicliny).

Pollen-Pistil Interaction

This is a chemical and physiological process where the pistil recognizes compatible pollen. Compatible pollen germinates on the stigma, forming a pollen tube that grows through the style to the ovary. Incompatible pollen is rejected.

Artificial Hybridisation

Artificial hybridisation involves controlled pollination by removing anthers (emasculation) and bagging flowers to prevent unwanted pollen contamination. Desired pollen is then applied to the stigma to produce hybrids.

Double Fertilisation

Double fertilisation is unique to flowering plants. The pollen tube releases two male gametes into the embryo sac. One fuses with the egg cell to form a diploid zygote, and the other fuses with two polar nuclei to form a triploid primary endosperm nucleus, which develops into the endosperm.

Solved Examples

Example 1: Differentiate between autogamy and xenogamy.

Solution: Autogamy is pollination within the same flower, while xenogamy is pollination between flowers of different plants. Autogamy leads to self-pollination, and xenogamy leads to cross-pollination.

Example 2: What is double fertilisation? Explain its significance.

Solution: Double fertilisation involves two fusion events: one sperm fuses with the egg to form the zygote, and the other fuses with two polar nuclei to form the primary endosperm nucleus. This process ensures the formation of both the embryo and the nutritive endosperm, supporting seed development.

Example 3: Describe the role of outbreeding devices in plants.

Solution: Outbreeding devices prevent self-pollination and promote cross-pollination, increasing genetic diversity. Examples include dichogamy, spatial separation of reproductive organs, self-incompatibility, and production of unisexual flowers.

Practice Set

Conceptual Questions

- **Level 1:** Name two abiotic agents of pollination.
- **Level 2:** What is self-incompatibility in plants?

Application-based Question

- **Level 3:** Explain how artificial hybridisation can be used to develop new crop varieties.

Answer Key

Conceptual Questions

- **Level 1:** Wind and water are abiotic agents of pollination.
- **Level 2:** Self-incompatibility is a genetic mechanism that prevents pollen from the same plant from germinating on its stigma, promoting cross-pollination.

Application-based Question

- **Level 3:** Artificial hybridisation involves controlled pollination by emasculating flowers and applying desired pollen to produce hybrids with improved traits such as higher yield or disease resistance.

Post-Fertilisation Events

Embryo and Endosperm Development

After fertilisation, the zygote develops into an embryo, and the primary endosperm nucleus divides to form the endosperm, which nourishes the developing embryo. The endosperm initially undergoes free-nuclear divisions before cellularisation.

Embryo Development

The embryo develops through stages: pro-embryo, globular, heart-shaped, and mature embryo. Dicot embryos have two cotyledons, an epicotyl (shoot tip), hypocotyl (stem), radicle (root), and root cap. Monocot embryos have a single cotyledon called the scutellum, coleoptile (protective sheath for shoot), and coleorhiza (protective sheath for root).

Seed and Fruit Formation

The fertilised ovule develops into a seed, consisting of the embryo, cotyledons, and stored food. The ovary develops into a fruit, which may be fleshy or dry. Fruits are classified as true (developed only from ovary) or false (involving other floral parts). Parthenocarpic fruits develop without fertilisation and are seedless.

Apomixis and Polyembryony

Apomixis is seed formation without fertilisation, producing clones of the parent plant. Polyembryony is the occurrence of multiple embryos in a single seed, which can arise from nucellar cells or multiple fertilisation events.

Solved Examples

Example 1: Describe the stages of embryo development in dicot plants.

Solution: The zygote divides to form a pro-embryo, then a globular embryo, followed by a heart-shaped embryo with two cotyledons, and finally a mature embryo with distinct epicotyl, hypocotyl, radicle, and root cap.

Example 2: What is the difference between albuminous and non-albuminous seeds?

Solution: Albuminous seeds retain some endosperm at maturity (e.g., wheat, maize), while non-albuminous seeds consume all endosperm during embryo development (e.g., pea, groundnut).

Example 3: Explain the significance of apomixis in agriculture.

Solution: Apomixis allows production of seeds without fertilisation, maintaining hybrid vigour and uniformity in progeny, reducing the need for repeated hybrid seed production.

Practice Set

Conceptual Questions

- **Level 1:** What is the function of the endosperm?
- **Level 2:** Define parthenocarpy.

Application-based Question

- **Level 3:** How does polyembryony benefit plant propagation?

Answer Key

Conceptual Questions

- **Level 1:** The endosperm provides nutrition to the developing embryo.
- **Level 2:** Parthenocarpy is the development of fruit without fertilisation, resulting in seedless fruits.

Application-based Question

- **Level 3:** Polyembryony produces multiple embryos in a seed, increasing the chances of successful seedling establishment and enabling clonal propagation.

Quick Reference Table

Common Mistakes and Misconceptions

Glossary