CHAPTER-1

SEXUAL REPRODUCTION IN FLOWERING PLANTS

Topic-1

Sexual Reproduction in Flowering Plants

Concepts Covered ● *Structure of a flower, male and female reproductive structures, development of male and female gametophytes.*

Revision Notes

- **Flower**
  - Flowers are the site of sexual reproduction in flowering plants.
  - Parts of a typical angiospermic flower are: sepals, petals, stamens and pistils.
  - The four whorls of the flower are attached on a central axis called thalamus.
  - A flower can be bisexual (contains both male and female reproductive parts) or unisexual (only one of the reproductive parts is present).
- **Male Reproductive Structures**

  Androecium (Whorl of Stamens)
  - Androecium consists of a whorl of stamens.
  - The number and length of the stamens are variable in flowers of different species.
  - A stamen has three parts namely, anther, filament and connective.

  (a) Anther
  - It is the terminal and bilobed part of stamens attached with filament. A bilobed anther is called dithecous.
  - Each lobe has two pollen sacs or microsporangia. Therefore, the anther is tetrasporangiate.
  - A longitudinal groove runs lengthwise separating the theca.

  (b) Filament
  - It is the long and slender stalk part of the stamen.
  - Its proximal end is attached to the thalamus or petals of the flower.

  (c) Connective
  - The structure which connects the anther lobes is known as connective.
- **Transverse section of an anther**
  - The anther is tetragonal in a structure consisting of four microsporangia or pollen sacs located at the corners, two in each lobe.
  - The microsporangia develop to become pollen sacs.
  - They extend longitudinally throughout the length of an anther.
  - These are packed with pollen grains.
- **Structure of microsporangium or pollen sac**
  - It is circular and is generally surrounded by wall layers namely,

    (a) Epidermis **(b)** Endothecium

    (c) Middle layers **(d)** Tapetum
  - The first two layers perform the function of protection and help in **dehiscence** of anther to release the pollens.
  - The middle layers and the innermost layer, (tapetum) nourishes the developing pollen grains.
  - The cells of the tapetum possess dense cytoplasm and more than one nuclei.
  - When the anther is young, a group of compactly arranged **homogenous** cells called sporogenous tissues occupies the centre of each microsporangium.

Key Words

Homogenous: Common origin or environment.

Viability: Ability to survive.

Dehiscence: Splitting or bursting

- **Microsporogenesis**
  - When the anther develops, each cell of sporogenous tissue undergoes meiotic division to form microspore tetrads.
  - Each cell of sporogenous tissue is a microspore mother cell (MMC) or pollen mother cell (PMC).
  - The process of formation of microspores from a pollen mother cell (PMC) through meiosis is called microsporogenesis.
- **Dehiscence of anther**
  - The microspores get arranged in a group of four cells and each group is called microspore tetrad.
  - As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains.
  - From each microsporangium, thousands of pollen grains are formed and released due to the **dehiscence** of anther.
- **Pollen grain (Male gametophyte)**
  - Pollen grain germinate and give rise to male gametophyte.
  - These are spherical, measuring about 25-50 micrometers in diameter.
  - Pollen grains are well preserved as fossils due to the presence of sporopollenin, a tough, resistant and stable material.
  - A pollen grain has a two-layered wall namely, exine and intine.

  (a) Exine
  - Exine is the hard outer layer which is made up of sporopollenin.
  - The sporopollenin is one of the most resistant organic materials.
  - It can withstand high temperature and strong acids and alkali.
  - It cannot be degraded by enzymes.
  - The exine has apertures called germ pores where sporopollenin is absent.

  (b) Intine
  - It is the inner, thin and continuous layer that is made up of cellulose and pectin.
  - A mature pollen grain contains two cells namely, vegetative cell and generative cell.

  (i) Vegetative cell
  - It is the bigger cell having abundant food reserve and a large irregularly shaped nucleus.

  (ii) Generative cell
  - It is the smaller cell that floats in the cytoplasm of the vegetative cell.
  - It is spindle shaped with dense cytoplasm and a nucleus.
  - The pollen grains are generally shed at the 2-celled stage in flowering plants.
  - In other plants, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed in a 3-celled stage.
  - Once they are shed, pollen grains have to land on the stigma before they lose **viability**.
  - The period of pollen grains remaining viable varies and depends on the prevailing temperature and humidity.
  - The viability of pollen grains of some cereals such as rice, wheat, etc. is 30 minutes while some members of Leguminosae, Rosaceae & Solanaceae have viability for months.
  - Pollen grains of some plants like *Parthenium* are allergic for some people leading to chronic respiratory disorders such as asthma, **bronchitis**, etc.
  - Pollen grains are rich in nutrients.
  - Pollen tablets are used as food supplements.
  - Pollen consumption in the form of tablets and syrups increases the performance of athletes and race horses.
  - It is possible to store pollen grains for years in liquid nitrogen (–196°C).
  - The pollens stored in the pollen banks for **crop breeding** programmes.

Key Words

Bronchitis: Inflammation of the mucous membrane in the bronchial tubes.

Crop breeding: Deals with the production and selection of superior phenotypes for the development of improved and new varieties.

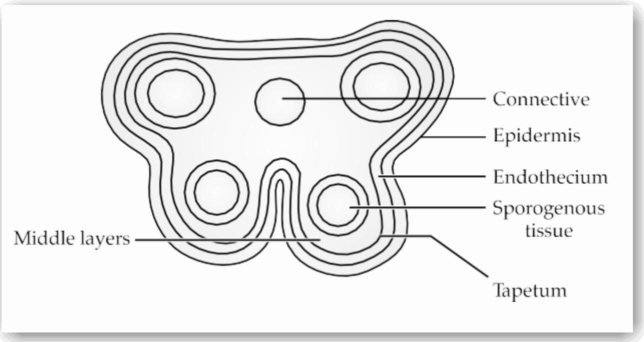

Fig 1.1: Transverse Section of a young anther

Mnemonics

Concept: Male Reproductive Structures
Mnemonic: **A**sk **F**or **C**onnectivity
Interpretation: Anther, Filament, Connective
Concept: Structures of microsporangium or pollen sac
Mnemonic: **E**ating **T**omato
Interpretation: Endothecium, Tapetum
Concept: Female Reproductive Structures
Mnemonic: **S**mall **S**oft **O**rnament
Interpretation: Stigma, Style, Ovary

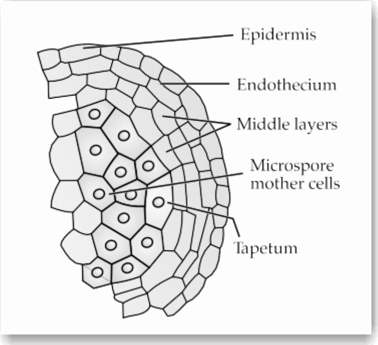

Fig 1.2: Enlarged view of an microsporangium

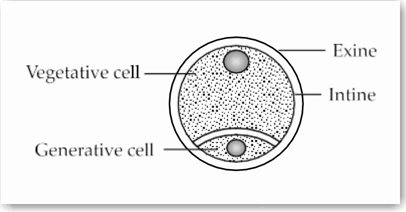

Fig 1.3: Structure of two-celled male gametophyte (pollen grain)

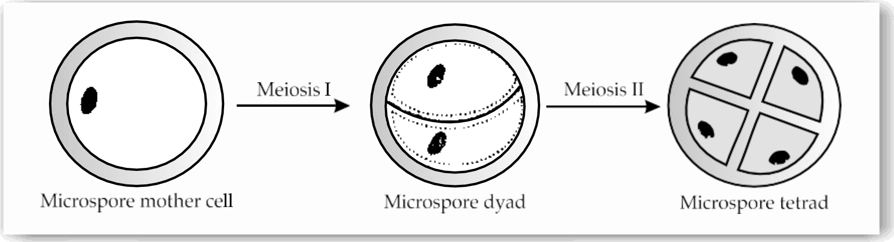

Fig 1.4: Microsporogenesis

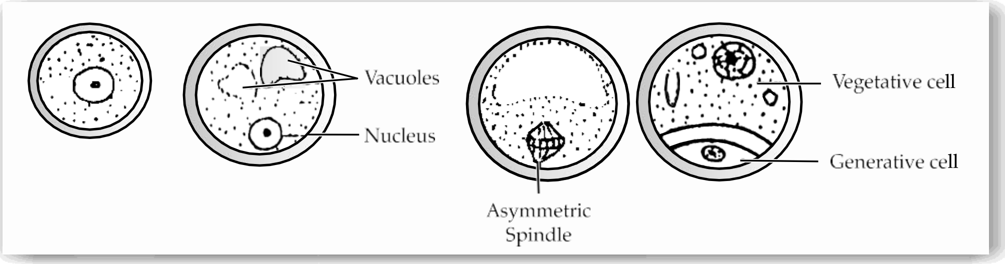

Fig 1.5: Stages of a microspore maturing into a pollen grain

- **Female Reproductive Structures**

  Gynoecium (Pistil)
  - It represents the female reproductive part of the flower.
  - If it consists of a single pistil or carpel then, it is known as monocarpellary or if it has more than one pistil or carpel then, it is called multicarpellary.
  - When there is more than one carpel, they may be fused then the pistil is known as syncarpous or may be free then, it is known as apocarpous.
  - Each carpel has three parts namely stigma, style and ovary.

  (a) Stigma

  It is a landing platform for pollen grains.

Key Words

Placenta: The surface of the carpel to which the ovules are attached.

Integuments: Outer hard protective layer in plants.

Degenerate: To loose structural or physical ability.

(b) Style

It is an elongated slender part beneath the stigma.

(c) Ovary

- It is the basal swollen part of the carpel.
- Inside the ovary is the ovarian cavity called the locule where the **placenta** is located.
- **Placenta** contains the ovules or megasporangia.
- The number of ovules in an ovary may be one as seen in wheat, paddy, mango, etc., or many as seen in papaya, watermelon, orchids, etc.

Megasporangium (Ovule)

- It is a small structure attached to the placenta by a stalk called the funicle.
- The junction where the body of the ovule and funicle fuse is called the hilum.
- Each ovule has one or two and some times three protective coverings called **integuments**.
- **Integuments** encircle the ovule except at the tip where a small opening called micropyle is organised.
- Opposite to the micropylar end is the chalaza which is the basal part of the ovule.
- Within the integuments, there is a mass of cells called nucellus which contains reserve food materials.
- Inside the nucellus there is an embryo sac, which is also called as the female gametophyte.
- An ovule has a single embryo sac usually formed from a single haploid megaspore.

Megasporogenesis

- The formation of haploid megaspores from the diploid megaspore mother cell (MMC) as a results of meiosis is called megasporogenesis.
- A single megaspore mother cell is differentiated in the micropylar region of the nucellus.
- The megaspore mother cell is a large cell containing dense cytoplasm and a prominent nucleus.
- The megaspore mother cell undergoes meiotic division resulting in the production of four haploid megaspores.

Female gametophyte (Embryo sac)

- In most of the flowering plants, only one megaspore is functional while the other three **degenerate**.
- The functional megaspore develops into the female gametophyte or embryo sac.
- This method of embryo sac formation from a single megaspore is termed as monosporic development.

Development of Female gametophyte

- The nucleus of the functional megaspore divides mitotically to form two nuclei which move towards the opposite poles, forming a two-nucleated embryo sac.
- Two more sequential mitotic nuclear divisions result in the formation of the four-nucleated and later the eight-nucleated stages of the embryo sac
- These divisions are strictly free nuclear, i.e., nuclear divisions are not followed immediately by cell wall formation.
- After eight-nucleate stage, the organisation of the typical female gametophyte or embryo sac takes place.
- Generally six of the eight nuclei are surrounded by cell walls and organised into cells.
- The remaining two nuclei called the polar nuclei are found below the egg apparatus in the large central cell.

Distribution of the cells within the embryo sac

- The three cells consisting of two synergids and one egg cell which are grouped at the micropylar end constitute the egg apparatus.
- The synergids have special cellular thickenings at the micropylar tip called filiform apparatus.
- The filiform apparatus helps to guide the pollen tubes into the synergid.
- Three cells at the chalazal end organise as the antipodals.
- Thus, a typical mature angiosperm embryo sac at maturity is eight-nucleate and seven-celled.

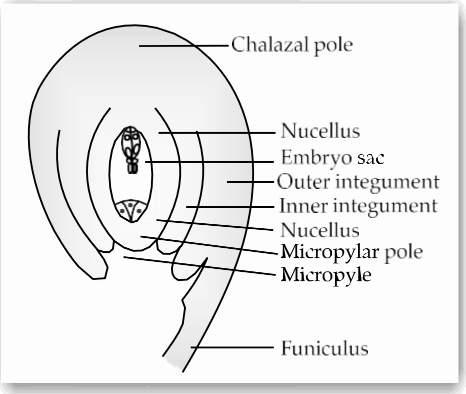

Fig 1.6: A diagrammatic view of a typical anatropous ovule

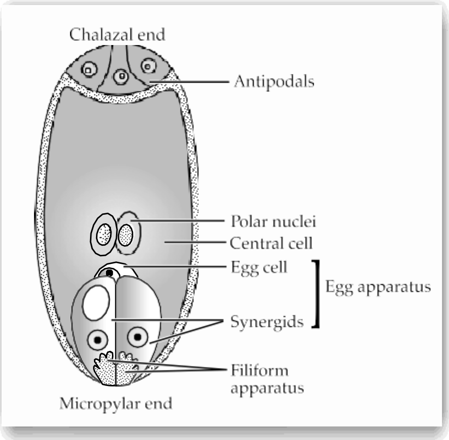

Fig 1.7: A diagrammatic view of the mature embryo

Topic-2 Pollination and Fertilisation

Concepts Covered ● *Modes of Pollination,* ● *Pollen-Pistil Interaction, Artificial Hybridisation, Double Fertilisation*

Revision Notes

- **Modes of Pollination**
  - The process of transfer of pollen grains from the anther to the stigma of a pistil is known as pollination.
  - There are few external agents which help the plants for pollination to take place.
  - Pollination is of three types based on the source of pollens namely,
    (a) Autogamy
    (b) Geitonogamy
    (c) Xenogamy
- **Autogamy**
  - When the pollen grains are transferred from the anther to the stigma of the same flower, it is known as autogamy.
  - In flowers with exposed anthers and stigma, a complete autogamy is rare and hence the anthers and stigma should lie close to each other to enable self-pollination. Along with this there should be **synchrony** in pollen release and **stigma receptivity**.
  - Plants like *Viola* (common pansy), *Oxalis* and *Commelina* produce two types of flowers namely Chasmogamous flowers and Cleistogamous flowers.

  (a) Chasmogamous flowers
  - They are similar to flowers of other species with exposed anthers and stigma.

  (b) Cleistogamous flowers
  - They do not open at all.
  - Anthers and stigma lie close to each other.
  - They are autogamous as there is no chance of cross-pollination.
  - When anthers dehisce in the flower buds, pollen grains come in contact with the stigma for pollination.
  - Cleistogamous flowers produce assured seed set even in the absence of pollinators.
- **Geitonogamy**
  - When the pollen grains are transferred from the anther to the stigma of another flower of the same plant, it is known as geitonogamy.
  - It involves pollination with the help of a pollinating agent. It is structurally cross-pollination but genetically self-pollination.
  - It is genetically similar to autogamy because the pollen grains come from the same plant.
- **Xenogamy**
  - When the pollen grains are transferred from anther to the stigma of a different plant, it is known as xenogamy. It brings about genetically different types of pollen grains to the stigma.
- **Agents of pollination:**
  - **There are two types of agents of pollination namely:**
    (a) Biotic agents
    (b) Abiotic agents
- **Abiotic Agents**
  - There are two abiotic agents namely, wind and water which help pollination to takes place.

- **Pollination by Wind**
  - The pollination taking place by the wind is called anemophily.
  - Wind and water pollinated flowers are not very colourful and do not produce nectar.
  - Wind pollinated flowers often have a single ovule in each ovary.
  - Numerous flowers remain packed into an inflorescence.
  - Example – In corn cob, the tassels are the stigma and style wave in the wind to trap pollen grains. Wind pollination is commonly seen in grasses.

Key Words

Synchrony: Fluctuation of multiple populations of different places in the same way.

Stigma receptivity: Ability of stigma to support viable anther for germination.

- **Characteristics of Anemophilous flowers**
  - The flowers produce an enormous amount of pollen.
  - The pollen grains are light and non-sticky so that they can be transported through wind currents.
  - They often possess well-exposed stamens for easy dispersal of pollens into wind currents.
  - They have large, feathery and sticky stigma to trap air-borne pollen grains.
- **Pollination by Water**
  - The pollination taking place by water is called hydrophily.
  - It is limited to about 30 genera, mostly monocotyledons.
  - In *Vallisneria*, the female flowers reach the surface of the water by the long stalk and the male flowers or pollen grains are released on to the surface of the water. These male flowers or pollen grains are carried by water currents and reach the female flowers.
  - In sea grasses, the female flowers remain submerged in water and the long, ribbon-like pollen grains are carried inside the water and reach the stigma.
  - The pollen grains of most of the water-pollinated species have a mucilaginous covering to protect from wetting.
  - Not all aquatic plants use hydrophily. For example, in aquatic plants like water hyacinth, water lily, etc., the flowers emerge above the level of water for entomophily or anemophily i.e., for pollination to takes place by insects or wind.
  - It is seen in *Vallisneria* & *Hydrilla* (freshwater), *Zostera* (marine sea-grasses), etc.
- **Biotic Agents**
  - Some flowering plants use animals as pollinating agents like Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds and hummingbirds) bats, some primates (lemurs), arboreal (tree-dwelling) rodents, reptiles (gecko lizard & garden lizard) etc.
  - When the pollination takes place by insects, it is known as entomophily.
  - Often flowers of animal pollinated plants are specifically adapted for a particular species of animal.
  - When the animal comes in contact with the anthers and the stigma, pollen grains may get stuck to the body of the animals, which results in pollination.
  - Some plants provide safe places as a floral reward to lay eggs as seen in *Amorphophallus*, the tallest flower.
  - There is a very close obligatory symbiotic relationship between the species of moth (*Pronuba*) and the plant *Yucca*. They cannot complete their life cycles without each other. The moth deposits its eggs in the locule of the ovary and the flower gets pollinated by the moth. The larvae of the moth come out of the eggs as the seeds start developing.
  - Many insects consume pollen or nectar without bringing about pollination. They are called pollen/nectar robbers.
- **Characteristics of Entomophilous Flowers**
  - Flowers are large, colourful, fragrant and rich in nectar.
  - When the flowers are small, they form inflorescence to make them visible.
  - The flowers pollinated by flies and beetles secrete foul odours to attract these animals.
  - The pollen grains are generally sticky.

Key Words

Unisexual flowers: Flower which contain only one i.e., either male or female reproductive parts in it.

Monoecious: An individual possessing both male and female reproductive organs.

- **Outbreeding Devices (Devices for promoting Cross-Pollination)**
  - To avoid self-pollination, cross-pollination is encouraged in plants as follows:

(a) Avoiding Synchronisation

- In some species, pollen release and stigma receptivity are not synchronised.
- Either the pollen is released before the stigma becomes receptive or the stigma becomes receptive before the release of pollen i.e., the anther and stigma mature at different times. This phenomenon is called dichogamy. It prevents autogamy.

(b) Arrangement of Anther and Stigma at different Positions

- In some species, the arrangement of anther and stigma at different positions prevents autogamy.

(c) Self-incompatibility

- It is a genetic mechanism that prevents pollen of one flower to germinate on the stigma of the same flower on of the same plant due to the presence of similar sterile genes in pollen and stigma.

(d) Production of Unisexual Flowers (Dicliny)

- **Monoecious** plants such as castor and maize, where the male and the female flowers are present on the same plant prevents autogamy but not geitonogamy. On the other hand, dioecious plants like papaya, where the male and female flowers are present on different plants prevent both autogamy and geitonogamy.

Pollen-pistil Interaction

- It is a dynamic process involving pollen recognition followed by promotion or inhibition of the pollen.
- This interaction takes place through the chemical components produced by them.
- If the pollen is compatible, then the pistil accepts it and promotes post-pollination events.
- The pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores.
- The contents of the pollen grain move into the pollen tube.
- The pollen tube grows through the tissues of the stigma and style and reaches the ovary.
- If the pollen is incompatible, then the pistil rejects the pollen by preventing pollen germination on the stigma or the pollen tube growth in the style.
- In some plants, the pollen grains are shed at the two-celled stage, the generative cell divides and forms the two male gametes during the growth of the pollen tube on the stigma.
- In plants that shed pollen in the three-celled stage, the pollen tubes carry two male gametes from the beginning.
- The pollen tube, after reaching the ovary, enters the ovule through the micropyle chalaza/integuments and then enters one of the synergids through the filiform apparatus.
- The filiform apparatus present at the micropylar part of the synergids guides the entry of the pollen tube.
- A plant breeder can manipulate pollen-pistil interaction, even in incompatible pollinations, to get desired hybrids.

Artificial Hybridisation

- It is one of the major approaches of crop improvement programme by using desired pollen grains for pollination.
- This is achieved by emasculation and bagging techniques.
- Emasculation is the removal of anthers by using forceps from the **bisexual flower** bud of female parent before the anther dehiscence.

Key Words

Bisexual flower: Flower containing both male and female reproductive organs.

Synergids: In angiospermic flowers, one of the two small cells lying near the micropyle in the embryo sac.

- The emasculated flowers are then covered with a suitable bag made up of butter paper to prevent contamination of its stigma with unwanted pollen. This is called bagging.
- When the stigma attains receptivity, the mature pollen grains collected from anthers of the male parent are dusted on the stigma. Then the flowers are rebagged and allowed to develop the fruits.
- If the female parent produces unisexual flowers, there is no need for emasculation.
- The female flower buds are bagged before the flowers open.
- When the stigma becomes receptive, pollination is carried out using the desired pollen and the flower rebagged.

Double Fertilisation

- The pollen tube after entering one of the **synergids** releases its contents including the two male gametes into the cytoplasm of the synergid.
- One of the male gametes moves towards the egg cell and fuses with its nucleus by the process of syngamy to form a diploid cell called the zygote.
- The other male gamete moves towards the two polar nuclei located in the central cell and fuses with them to produce a triploid primary endosperm nucleus (PEN).
- As this involves the fusion of three haploid nuclei, it is called triple fusion.
- Since two types of fusions viz. syngamy and triple fusion take place in an embryo sac, it is called double fertilisation.
- The central cell after triple fusion becomes the primary endosperm cell (PEC) and develops into the endosperm while the zygote develops into an embryo.
- It is an event unique to flowering plants.

Topic-3 Post-fertilisation Changes and Special Modes of Reproduction

Concepts Covered ● *Embryo and its Development* ● *Structure and types of Seed* ● *Fruit and its types* ● *Apomixis and Polyembryony*

Revision Notes

Embryo and its Development

- **Post-fertilisation Events**
  - The development of endosperm and embryo, the maturation of ovule(s) into seed(s) and ovary into fruit are post-fertilisation events.
- **Endosperm Development**
  - The primary endosperm cell divides repeatedly by mitosis to form a triploid endosperm tissue.
  - Endosperm cells are filled with reserve food materials that are used for the nutrition of the developing embryo.
  - During the endosperm development, the primary endosperm nucleus undergoes successive mitotic nuclear divisions to give rise to free nuclei. This stage is called free-nuclear endosperm.
  - Then the endosperm becomes cellular due to the cell wall formation.
  - For example, the tender coconut water is a free-nuclear endosperm that is made up of thousands of nuclei and the surrounding white kernel is the cellular endosperm.
- **Embryo Development**
  - The embryo develops at the micropylar end of the embryo sac where the zygote is situated.
  - The zygotes divides only after the formation of a certain amount of endosperm to provide nutrition to the developing embryo.
  - The development of embryo is similar in monocotyledons and dicotyledons up to the octant stage.
  - The zygote gives rise to the pro-embryo and subsequently to the globular, heart-shaped and mature embryo.
- **Dicotyledonous Embryo**
  - It has a central embryonal axis and two lateral cotyledons.
  - The portion of the embryonal axis above the level of cotyledons is the epicotyl, which terminates into the plumule (stem tip).
  - The cylindrical portion below the level of cotyledon is hypocotyl that terminates into the radicle (root tip).
  - The root tip is covered with a root cap.

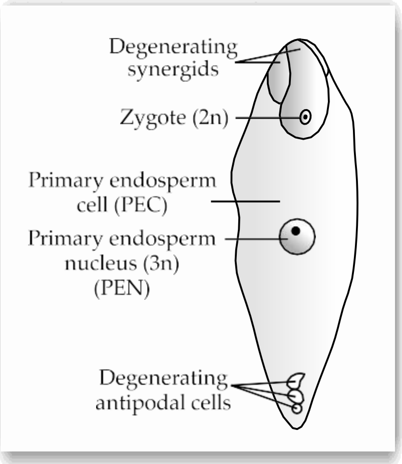

Fig 1.8: Fertilised embryo sac

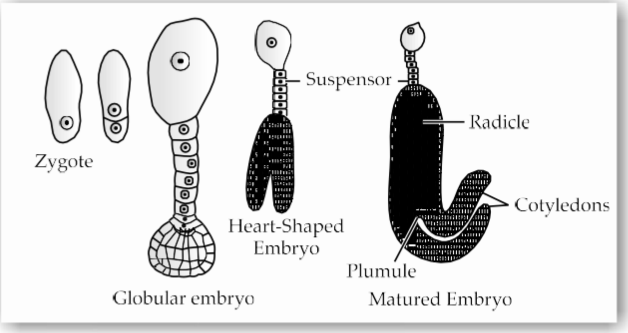

Fig. 1.9: Stages in embryo development in a dicot showing zygote and primary endosperm nucleus

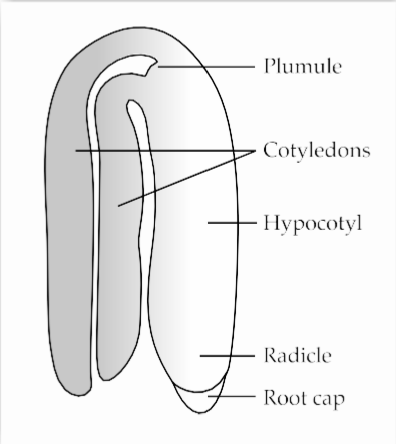

Fig 1.10: A typical dicot embryo

- **Monocotyledonous Embryo**
  - They possess only one cotyledon.
  - In the grass family, the cotyledon is called the scutellum which is situated lateral to the embryonal axis.
  - At its lower end, the embryonal axis has the radicle and root cap enclosed in an undifferentiated sheath called coleorhiza.
  - The portion of the embryonal axis above the level of attachment of the scutellum is the epicotyl.
  - It has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure called coleoptile.
- **Seed**
  - Seed is the final product of sexual reproduction.
  - It is the fertilised ovule formed inside fruits.
  - It consists of the seed coat(s), cotyledon(s) and an embryonal axis.
  - The cotyledons are simple, thick and swollen due to the storage of food as seen in most of the dicots.
  - Mature seeds may be non-albuminous or albuminous.

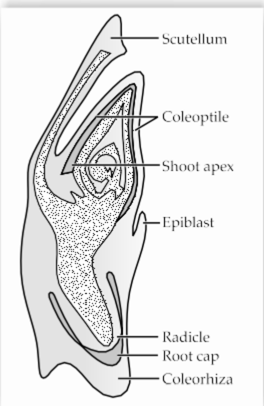

Fig 1.11: L.S of an embryo of grass

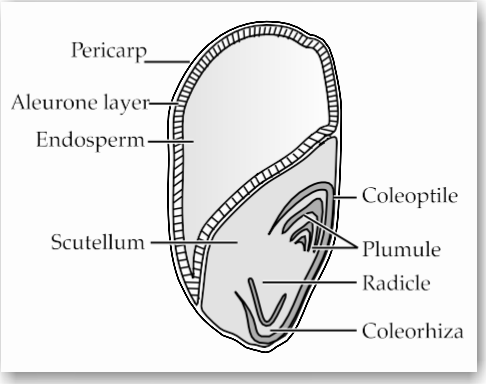

Fig 1.12: L.S (grain of maize)

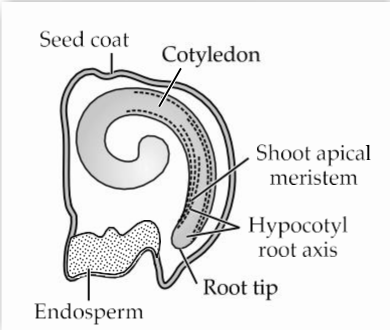

Fig 1.13: L.S. (monocot seed of onion)

- **Non-albuminous or Non-endospermic Seeds**
  - These seeds have no residual endosperm as it is completely consumed during embryo development. **Examples -** pea, groundnut, beans.

Key Word

Pericarp: Part of fruit formed from the wall of the ripened ovary.

- **Albuminous or Endospermic Seeds**
  - These seeds retain a part of the endosperm as it is not completely used up during embryo development. Examples: wheat, maize, barley, castor, coconut, sunflower.
  - In some seeds like black pepper, beet, etc., the remnants of nucellus also persistent. It is called the perisperm.
  - **I**nteguments of ovules harden as tough protective seed coats.
  - It has a small pore (micropyle) through which oxygen and water enter into the seed during germination.
  - As the seed matures, its water content gets reduced and the seeds become dry (10-15 % moisture by mass). The general metabolic activity of the embryo slows down.
  - The embryo may enter a state of inactivity (dormancy).
  - If favourable conditions are available such as adequate moisture, oxygen and suitable temperature, they germinate.
- **Fruit**
  - The ovary develops into a fruit after pollination and fertilisation.
  - The transformation of ovules into seeds and ovary into fruit proceeds simultaneously.
  - The wall of the ovary develops into a **pericarp**.
  - The fruits may be fleshy as seen in guava, orange, mango, etc., or may be dry as seen in groundnut, mustard, etc.,
  - Many fruits have mechanisms for the dispersal of seeds.
  - Fruits are of two types namely:
    - **(a) True fruits:** When the fruit develops only from the ovary and other floral parts degenerate and fall off, they are called true fruits. Examples- mango, maize, grape.
    - **(b) False fruits:** When parts of a flower other than the ovary also contribute to the fruit formation, they are called false fruits. Examples– apple, strawberry, cashew, etc.

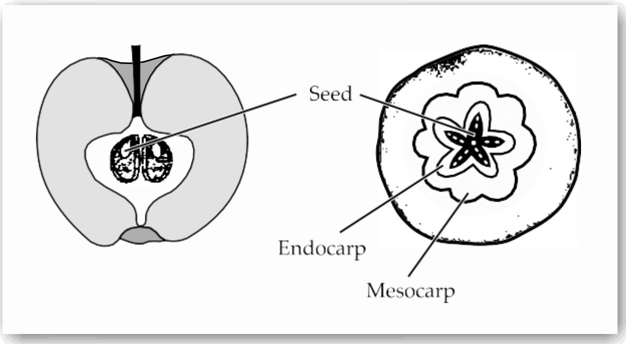

Fig 1.14: Sectional view of an apple

- In some species such as banana, the fruits develop without fertilisation, these fruits are called parthenocarpic fruits.
- Parthenocarpy can be induced through the application of **growth hormones**. Such fruits are seedless.

Advantages of Seeds

- The pollination and fertilisation processes are independent of water while the seed formation is more dependable.
- Seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas.
- They have food reserves and so young seedlings are nourished until they are capable of photosynthesis.
- The hard seed coat protects the young embryo.
- Since seeds are the products of sexual reproduction, they generate new genetic combinations leading to variations.
- The dehydration and dormancy of mature seeds are crucial for the storage of seeds.
- It can be used as food throughout the year and also to raise a crop in the next season.

Viability of Seeds after Dispersal

- In a few species, the seeds lose viability within a few months or live for several years.
- Some seeds remain alive for hundreds of years.
- The oldest is lupine (*Lupinus arcticus*) excavated from Arctic Tundra. The seed germinated and flowered after an estimated record of 10,000 years of dormancy.
- 2000 years old viable seed is of the date palm (*Phoenix dactylifera*) discovered during the archeological excavation at King Herod's palace near the Dead Sea.

Apomixis and Polyembryony

- Apomixis (apo = without; mixis = mixing together) means the production of seeds without fertilisation.
- It is seen in some species of Asteraceae and grasses.
- The apomixis is a form of asexual reproduction that mimics sexual reproduction.
- The occurrence of more than one embryos in a seed is called polyembryony.

Development of Apomictic Seeds

- In some species, the diploid egg cell is formed without reduction division and develops into the embryo without fertilisation.
- In species like Citrus and Mango varieties, some of the nucellar cells surrounding the embryo sac divide and protrude into the embryo sac and develop into the embryos. Hence, in these species, each ovule contains many embryos.

Key Word

Growth hormone: Hormones which stimulate cell division, flowering, enlargement, dormancy, abscission such as Auxins, Gibberellins, cytokinins, ethylene, ABA etc.

Importance of Apomixis in Hybrid Seed Industry

- Hybrid seeds have to be produced every year.
- If the seeds collected from hybrids are sown, the plants in the progeny will segregate and lose hybrid characters.
- The production of hybrid seeds is costly. Hence the cost of hybrid seeds is also expensive for the farmers.
- If the hybrids are made into apomict, there is no segregation of characters in the hybrid progeny. This helps farmers to use the hybrid seeds to raise new crop year after year without losing hybrid characteristics.

Mnemonics

1. Concept: Cells in Mature Embryo sac
Mnemonics: **A**ll **P**urpose **C**entral **E**ducation **S**enior **F**ederation
Interpretation: Antipodal, Polar nuclei, Central cell, Egg cell, Synergid, Filiform apparatus

2. Concept: L. S. of Grain of maize
Mnemonics: **P**ersonal **A**ssistant **E**ngineer and **S**enior **C**ommandant of **R**ailway **P**olice **C**rops.
Interpretation: Pericarp, Aleurone layer, Endosperm, Scutellum, Coleoptile, Radicle, Plumule, Coleorhiza