Chapter

24 Sexual Reproduction in Flowering Plants

All flowering plants (angiosperms) show sexual reproduction. The flowers are the specialized organs that perform sexual reproduction in angiosperms. Flowers hold a special aesthetic, cultural and ornamental value in our lives.

PRE-FERTILISATION: STRUCTURES AND EVENTS

- Several hormonal and structural changes in plants lead to the differentiation and further development of a flower.
- Inflorescences are formed which bear the floral buds and then the flowers.

Flower

- A flower is a modified shoot. It is the main reproductive unit in angiosperms.
- Flowers carry out sexual reproduction in angiosperms.
- A typical flower has four different kinds of whorls arranged successively on the swollen end of the stalk, called thalamus.
- The different kinds of whorls are: Androecium, Gynoecium, Calyx and Corolla.

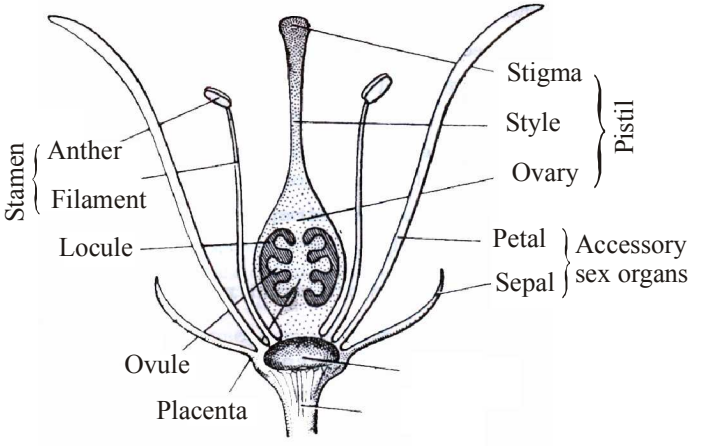


Fig. Structure of Flower

Male reproductive organ – Androecium

- Male reproductive organ is called androecium and their unit is called **stamen**.

Stamen is also known as **microsporophyll**.

- A stamen consists of anther and filament.
  (i) **Anther :** Anther is a sac-like structure that produces pollen grains. It is bilobed and each lobe have two theca i.e. they are dithecous. Theca is separated by a longitudinal groove running lengthwise.
  (ii) **Filament :** Filament is a thin stalk-like structure that supports anther. Its proximal end is attached to the thalamus or the petal of the flower.

Transverse section of an anther:

- Anther has 2 lobes (bilobed). Each lobe consists of 2 theca. Hence it is dithecous.
- The anther is a tetragonal structure consisting of four microsporangia. They are located at the corners, two in each lobe (theca).
- The microsporangia develop further and become pollen sacs, which contain pollen grains.

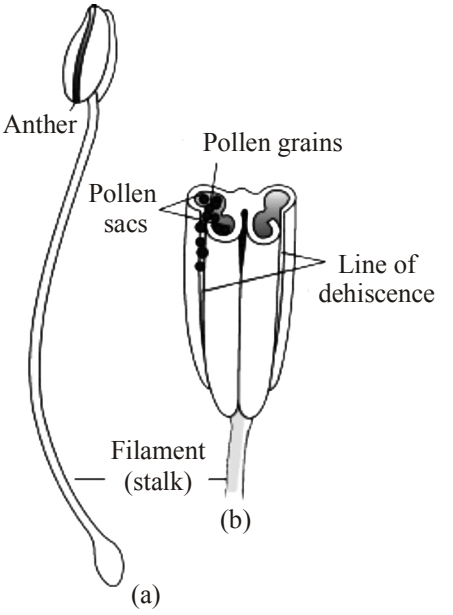


Fig. (a) A typical stamen;
(b) three–dimensional cut section of an anther

Structure of microsporangium:

- A typical microsporangium is generally surrounded by four wall layers: the **epidermis, endothecium, middle layers and tapetum.**
- The outer three layers are protective and help in indehiscence of anther to release the pollens.
- The tapetum, which is the innermost layer, nourishes the developing pollen grains. Cells of the tapetum possess dense cytoplasm and are multi-nucleated.
- The centers of each microsporangium contain homogenous cells called **sporogenous tissues.**

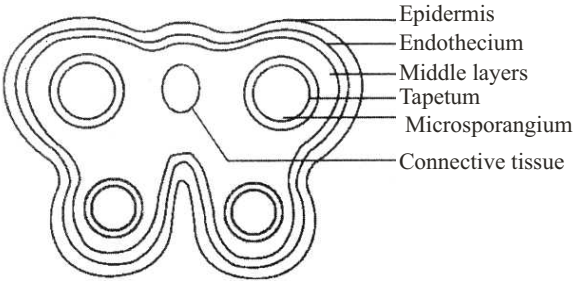


Fig. T. S. of young anther

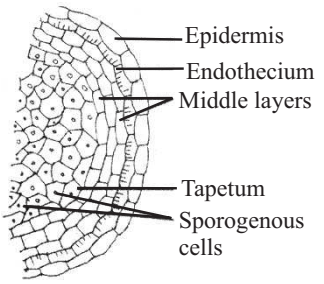


Fig. A portion of enlarged microsporangium showing wall layers

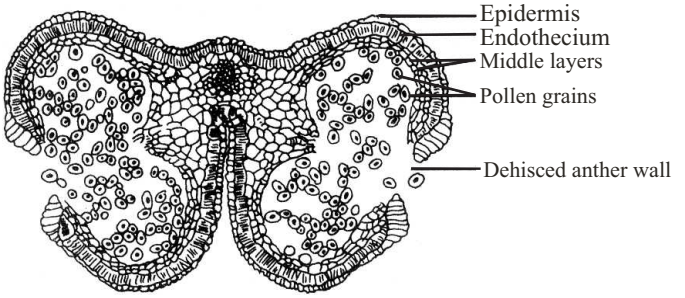


Fig. T. S. of a mature dehisced anther

Microsporogenesis

- It is the process of formation of microspores from a pollen mother cell (PMC) through meiosis.
- It occurs inside the pollen sac of the anther.
- During the development of microsporangium, each cell of sporogenous tissue acts as pollen mother cell and gives rise to a microspore tetrad, containing four haploid microspores by the process of meiosis.
- As the anthers mature and dehydrate, the microspores dissociate and develop into pollen grains. The pollen grain mature and give rise to male gametes.
- Inside each microsporangium thousands of pollen grains are formed that are released with the dehiscence of anther.

The development sequence is as follows:

Sporogenous tissue → Pollen mother cell → Microspore tetrad → Pollen grain → male gamete

Pollen grain(male gametophyte):

- It represents the male gametophyte and is generally spherical.
- A pollen grain has a two-layered wall, called exine and intine.
  - ➢ **Exine:**It is the hard outer layer made up of sporopollenin. Sporopollenin is a highly resistant organic material, which can withstand high temperature and strong acids and alkali. Enzymes cannot degrade sporopollenin. Exine has apertures called germpores where sporopollenin is absent.
    - ♦ Pollen grains are well preserved as fossils due to the presence of sporopollenin.
    - ♦ Exine exhibits a fascinating array of patterns and designs.
  - ➢ **Intine:** It is the inner wall of pollen grain. It is a thin and continuous layer made up of **cellulose** and **pectin.**
- A matured pollen grain contains two cells: Vegetative cell and Generative cell.
  - ➢ **Vegetative cell:** It is bigger, with large irregularly shaped nucleus. It has abundant food reserve.
  - ➢ **Generative cell:** It is small and floats in the cytoplasm of the vegetative cell. It is spindle shaped with dense cytoplasm and a nucleus.
- In over 60% of angiosperms, pollen grains are shed at the 2-celled stage. In others, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed (3-celled stage).
- The viability of pollen grains after they are shed depends on the prevailing temperature and humidity.
- Viability of pollen grains of some cereals (rice, wheat, etc) is 30 minutes. Some members of Leguminoseae, Rosaceae and Solanaceae have viability for months.

Economic importance of pollen grains

- Pollen grains of some plants are allergic for some people. *E.g. Parthenium* or carrot grass.
- It leads to chronic respiratory disorders, like asthma, bronchitis, etc.
- Pollen grains are rich in nutrients and hence used as Pollen tablets for food supplements. Pollen consumption (as tablets and syrups) increases performance of athletes and race horses.
- Pollen grains of a large number of species can be preserved for years in liquid nitrogen (–196°C). Such stored pollen can be used as pollen banks, similar to seed banks, in crop breeding programmes.

Female reproductive organ - Gynoecium

- **Gynoecium** is the female reproductive organ. The free unit of gynoecium is called pistil or carpel.
- Carpel is also known as **megasporophyll**.
- It may consist of a single pistil (monocarpellary) or more than one pistil (multicarpellary).
- When there are more than one, the pistils may be fused together (syncarpous) or may be free (apocarpous).
- Each pistil consists of stigma, style and ovary.
  - ➢ **Stigma:** It is the sticky surface that collects the pollen from the pollinating agent.
  - ➢ **Style:** It is a long tube-like structure within which pollen tube grows.
  - ➢ **Ovary:** It is the basal part of pistil. Inside the ovary is the ovarian cavity (locule) in which the placenta is located. Placenta contains the megasporangia or ovules. The number of ovules in an ovary may be one (wheat, paddy, mango etc) to many (papaya, water melon, orchids etc).

Fig. A dissected flower of *Hibiscus* showing pistil (other floral parts have been removed)

Megasporangium (Ovule):

- An ovule is a female megasporangium where the formation of megaspores takes place.
- The various parts of an ovule are:
  - ➢ **Funiculus:** It is a small stalk like structure which represents the point of attachment of the ovule to the placenta of the ovary.
  - ➢ **Hilum:** It is the point where the body of the ovule is attached to the Funiculus.
  - ➢ **Integument:** Integuments are outer layers surrounding the ovule that provide protection to the developing embryo.
  - ➢ **Micropyle:** It is a narrow pore formed by the projection of integuments. It marks the point where the pollen tube enters the ovule at the time of fertilisation.
  - ➢ **Chalaza:** It is the basal swollen part of the nucellus (opposite the micropylar end) from where the integuments originate.
  - ➢ **Nucellus:** It is a mass of parenchymatous tissue surrounded by integuments from the outside. Nucellus provides nutrition to the developing embryo.
  - ➢ **Embryo sac**: The embryo sac or female gametophyte is located inside the nucellus. An ovule generally has a single embryo sac formed from a megaspore through meiosis.

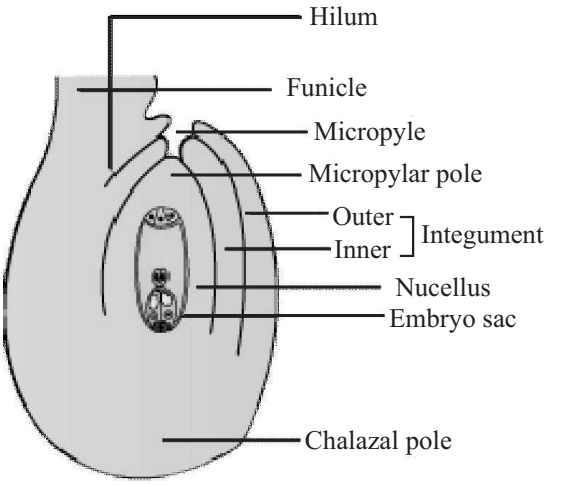


Fig. A diagrammatic view of a typical anatropous ovule.

Megasporogenesis:

- It is the process of formation of the four megaspores from the megaspore mother cell (MMC) in the region of nucellus through meiosis.
- It occurs inside the ovule.
- Megaspore mother cell (MMC) is large and contains dense cytoplasm and a prominent nucleus. The MMC undergoes meiotic division to produce four megaspores.
- In majority of flowering plants, only one megaspore is functional while the other three degenerate.

Female gametophyte (embryo sac):

- The embryo sac develops from the functional megaspore (n). This method of embryo sac formation from a single megaspore is termed monosporic development.

Formation of the embryo sac:

- The female gametophyte develops from a single functional megaspore. This megaspore undergoes three successive mitotic divisions to form 8-nucleated embryo sac.
- The first mitotic division in the nucleus of the functional megaspore forms two nuclei. One nucleus move towards the micropylar end, while the other nucleus move towards the chalazal end. This result into 2-nucleate embryo sac.
- Two more sequential mitotic nuclear divisions at their respective ends i.e. at the micropylar and chalazal end of the embryo sac result in the formation of the 4-nucleate and later the 8-nucleate stages of the embryo sac.

- These divisions are strictly free nuclear, i.e. nuclear divisions are not followed immediately by cell wall formation.
- After the 8-nucleate stage, cell walls are laid down leading to the organization of the typical female gametophyte or embryo sac.
- Six of the 8 nuclei get surrounded by the cell wall and remaining two nuclei called polar nuclei are situated below the egg apparatus in the large central cell.

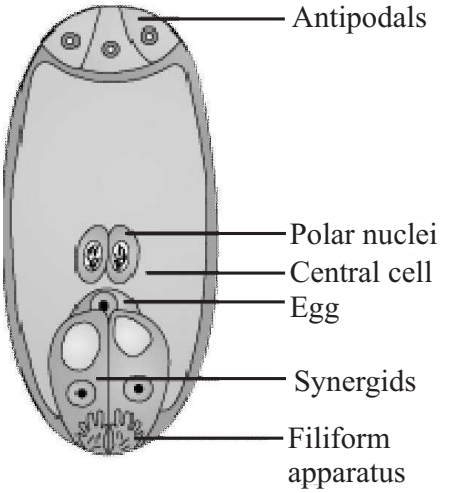


Fig. A diagrammatic representation of the mature embryo sac.

Structure of embryo sac:

- At the micropylar end out of the four nuclei, only three differentiate into two synergids and one egg cell. Together they are known as egg apparatus. Thus, the egg apparatus consists of 2 synergids and one egg cell.
- The synergids have special cellular thickenings at the micropylar tip. These are together called the filiform apparatus. It helps to guide the pollen tubes into the synergid.
- Similarly, at the chalazal end, three out of the four nuclei differentiate as antipodal cells.
- The remaining two cells (of the micropylar end and the chalazal end) move towards the center and are known as polar nuclei, which are situated in a large central cell.
- Hence, at maturity, a typical mature angiosperm embryo sac (the female gametophyte) appears as a 7-celled structure, though it has 8-nucleate.

POLLINATION

- It is the process of transfer of pollen grains from the anther to the stigma of a pistil.
- Some external agents help the plants for pollination.
- *Pollination is of two types: Self-pollination and cross pollination.*

(i) Self-pollination: It is the transfer of pollen from anther to the stigma of the same flower. It is also 'autogamy'.

- Complete autogamy is rare in flowers with exposed anthers and stigma. Autogamy in such flowers requires synchrony in pollen release and stigma receptivity. Also, the anthers and stigma should lie close to each other to enable self-pollination.
- *There are two types of flowers present in Plants like Viola (common pansy), Oxalis and Commelina:*
  - ➢ **Chasmogamous flowers:** They have exposed anthers and stigma similar to the flower of other species.
  - ➢ **Cleistogamous flowers:** They do not open at all. They have closed anthers and stigma, which lie close to each other.
    - ♦ They are autogamous as there is no chance of cross-pollination. This is because; cleistogamous flowers never open at all. Also, the anther and stigma lie close to each other in these flowers. Hence only self-pollination is possible in these flowers.
    - ♦ 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.

(ii) **Cross-pollination:** It is the process of transfer of pollen grain from one flower to the stigma of another flower. It is also called 'allogamy'.

Allogamy is further divided into two types: Geitonogamy and Xenogamy.

(i) Geitonogamy: It is the transfer of pollen grains from the anther to the stigma of another flower of the same plant. It is functionally cross-pollination involving a pollinating agent. It is genetically similar to autogamy since the pollen grains come from the same plant.

(ii) Xenogamy: It is the transfer of pollen grains from anther to the stigma of a different plant. This brings genetically different types of pollen grains to the stigma.

Contrivances of cross-pollination:

(i) Dicliny: Flowers contain either of the essential organs i.e. androecium or gynoecium. These flowers are called 'unisexual flowers'. *E.g. Vallisneria.*

(ii) Dichogamy: Androecium and gynoecium of a bisexual flower mature at different time. It is of two types.

(a) Protandry: It is the process of maturation of androecium earlier than gynoecium. *E.g. Helianthus, Clerodendron and Gossypium*

(b) Protogyny: It is the process of maturation of gynoecium earlier than androecium. *E.g.: Solanum, Scrophularia etc.*

(iii) Herkogamy: Male and female sex organs in a bisexual flower arranged at different levels.

(a) In some flowers stigma project beyond the stamen. *E.g.: Hibiscus.*

(b) In some flowers the stigmas bend in opposite direction to the stamens. *E.g.: Gloriosa.*

(iv) **Heterostyly:** The presence of styles in different lengths in the flowers of the same species.

(v) **Self-sterility:** Pollen fails to germinate on the stigma of the same flower *e.g.: Abutilon and Passiflora.*

Agents of Pollination

There are several ways by which a flower gets pollinated.

1. **Abiotic agents that include water and air (wind) for pollination.**

Pollination by wind (anemophily):

- ➢ It is the most common form of abiotic pollination.
- ➢ The flowers produce enormous amount of pollen.
- ➢ The pollen grains are light and non-sticky to be carried easily by wind currents.
- ➢ Plants possess well-exposed stamens (for easy dispersion of pollens into wind currents).
- ➢ Plants have large, feathery stigma to trap air-borne pollen grains.
- ➢ Wind pollinated flowers often have a single ovule in each ovary and numerous flowers packed into an inflorescence.*E.g.* Corncob – the tassels are the stigma and style which wave in the wind to trap pollen grains.
- ➢ Wind-pollination is quite common in grasses.

Pollination by water (hydrophily):

- ➢ It is quite rare in flowering plants. It is limited to about 30 genera, mostly monocotyledons.
- ➢ *Vallisneria* and *Hydrilla* (fresh water), *Zostera* (marine sea-grasses) etc are the common examples of hydrophily.
- ➢ In *Vallisneria,* the female flower reaches the surface of water by the long stalk and the male flowers or pollen grains are released on to the surface of water. They are carried by water currents and reach the female flowers.
- ➢ In sea grasses, female flowers remain submerged in water. Pollen grains are long and ribbon like. They 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.
- ➢ In most of aquatic plants, the flowers emerge above the level of water for entomophily or anemophily. *E.g.* water hyacinth, water lily etc.

2. **Biotic agents (animals) of pollination:** Pollination by animals is known as zoophily.

- Majority of flowering plants use animals as pollinating agents. *E.g.* Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds and humming birds) bats, some primates (lemurs), arboreal (tree-dwelling) rodents, reptiles (gecko lizard and garden lizard) etc.
- Among the animals, insect particularly by bees is more common agents for pollination. Pollination by insects is known as Entomophily.
- Often flowers of animal pollinated plants are specifically adapted for a particular species of animal.
- Depending on the type of animals which acts as an agent, it is of following types.
  - ➢ **Ornithophily:** Cross-pollination is favoured by birds. *E.g.: Bignonia.*
  - ➢ **Chiropterophily:** Cross-pollination is favoured by bats. E.g.: *Kigetia pinnata*
  - ➢ **Entomophily:** The cross-pollination takes place by insects. It is the most common type of zoophily. *E.g.: Cestrum nocturmum*

Features of insect-pollinated flowers:

- Flowers are large, colourful, fragrant and rich in nectar.
- Nectar and pollen grains are the usual floral rewards for insects.
- Small flowers form inflorescence to make them visible.
- The flowers pollinated by flies and beetles secrete foul odours to attract animals.
- The pollen grains are generally sticky and get stuck to the body of the pollinator.
- Some plants provide safe places as floral reward to lay eggs. *E.g.* Amorphophallus. It has the tallest flower of about 6 feet.
- A symbiotic relationship exists between the plant, Yucca and its pollinator moth. The moth is dependent on plant since, the moth deposits its eggs in the locule of the ovary of the plant and in return, 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**.

Outbreeding devices:

- Majority of flowering plants produces hermaphrodite flowers that can undergo self-pollination (autogamy). Repeated self-pollination results in inbreeding depression.
- Flowering plants have developed many devices to avoid self-pollination and to encourage cross-pollination. Such devices are called **Outbreeding devices.**

(a) **Pollen release and stigma receptivity not coordinated:** In some species, pollen release and stigma receptivity are not synchronized. Either the pollen is released before the stigma becomes receptive or stigma becomes receptive before the release of pollen. It prevents autogamy.

(b) **Different positioning of the anther and the stigma:** This prevents autogamy.

(c) **Self-incompatibility:** It is a genetic mechanism to prevent self-pollen (from the same flower or other flowers of the same plant) from fertilization by inhibiting pollen germination or pollen tube growth in the pistil.

(d) **Production of unisexual flowers:** Presence of male and female flowers on different plants such that each plant is either male or female (dioecy). If male and female flowers are present on the same plant (i.e., monoecious, e.g. castor and maize), it prevents autogamy but not geitonogamy. In dioecious plants (*e.g.* papaya), male and female flowers are present on different plants (dioecy). This prevents both autogamy and geitonogamy.

Pollen-pistil interaction:

- All the events – from pollen deposition on the stigma until pollen tubes enter the ovule – are together referred as **pollen-pistil interaction**.
- It is a dynamic process involving pollen recognition followed by promotion or inhibition of the pollen.
- Pollination does not guarantee the transfer of the right type of pollen grain to the right type of stigma.
- Hence, the pistil has the ability to recognize the right type of pollen to promote post-pollination events.
- This interaction takes place through the chemical components produced by them.
- If the pollen is compatible (right type), the pistil accepts it and allows the pollen to germinate.
- If the pollen is incompatible (wrong type), the pistil rejects the pollen by preventing pollen germination on the stigma or the pollen tube growth in the style.
- Following compatible pollination, the pollen grain produce pollen tube through one of the germ pore.
- Content of the pollen grain move into the pollen tube.
- Pollen tube grows through the tissues of the stigma and style and reaches the ovary.
- If the pollen grain is in 2-celled stage the generative cell divides and forms two male gametes inside the pollen tube.
- If the pollen grain is in 3- cell stage the pollen tube carry two male gametes from the beginning.
- Pollen tube enters into the ovule through micropyle and then into the embryo sac through synergids guided by filiform apparatus.
- A plant breeder can manipulate pollen-pistil interaction, even in incompatible pollinations, to get desired hybrids.

Artificial hybridisation:

- Artificial hybridisationis one of the major approaches of crop improvement programme to improve crop yield.
- In this method, desired pollen grains are used for pollination. This is achieved by emasculation and bagging techniques.
  - ➢ **Emasculation:** Emasculation is the process of removal of anthers (using forceps) from the bisexual flower bud without affecting the female reproductive part i.e. pistil.
  - ➢ **Bagging:** 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 of the bagged flower attains receptivity, 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 is unisexual, then there is no need for emasculation. In this case, the female flower buds are directly bagged before the flowers open. When the stigma becomes receptive, suitable pollens are dusted onto it so as to allow germination.

DOUBLE FERTILISATION

- When the pollen grain falls on the stigma, they germinate and give rise to the pollen tube that passes through the style and enter into the ovule.
- After this, the pollen tube enters one of the of the synergids and releases two male gametes.
- Out of the two male gametes, one gametes fuses with the nucleus of the nucleus of the egg cell and forms the zygote. The process is known as syngamy.
- The other male gamete fuses with the two polar nuclei located in the central cell to form a triploid primary endosperm nucleus (PEN). Since, the process involves the fusion of three haploid nuclei, it is known as triple fusion.
- Thus, triple fusion is the fusion of male gamete with two polar nuclei inside the embryo sac of the angiosperm.
- Since two kinds of fusions (syngamy and triple fusion) take place in an embryo sac it is known as double fertilisation.
- Double fertilisation is unique event to flowering plants.
- After triple fusion, the central cell becomes the primary endosperm cell (PEC).
- Primary endosperm nucleus develops into the endosperm while the zygote develops into an embryo.

Entry of pollen tube into the ovule

- The pollen tube enters in the ovary at the time when ovule becomes mature.
- Inside the ovary, obturators guides the passage of pollen tube towards the micropyle.
- A mature ovule in which embryo sac also matured, has three paths for the entry of pollen tube:
  (i) **Porogamy:** In this, pollen tube enters into the ovule through the micropyle. It is found in most of Angiospenns [*Capsella*].

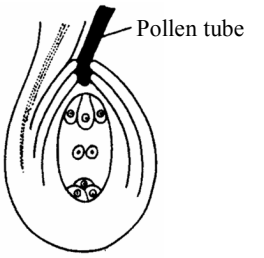


Fig.: Porogamy

  (ii) **Chalazogamy:** In this method, the pollen tube enter into the ovule through the chalaza. This method is discovered in *Casuarina* by Treub [1891], e.g., Betula and *Juglans* (walnut).

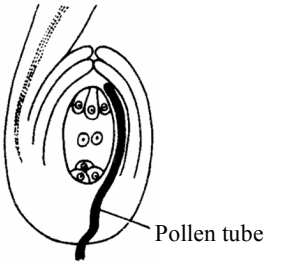


Fig.: Chalazogamy

(iii) **Mesogamy:** In this method, pollen tube enter into the ovule either through integuments (Cucurbita) or through the funiculus (*Pistacia and Populus*).

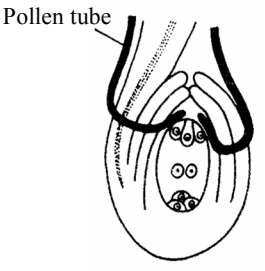


Fig.: Mesogamy

Post-fertilization: Structures and Events

- **Post-fertilization events includes**
  (a) Development of endosperm.
  (b) Development of embryo.
  (c) Maturation of ovule(s) into seed(s) and ovary into fruit.
  (d) Maturation of ovary into fruit

(a) Formation of endosperm

➢ The endosperm develops before the embryo because the cells of the endosperm are filled with reserve food materials. They are used for the nutrition of the developing embryo.

➢ The primary endosperm cell divides repeatedly and forms a triploid endosperm tissue.

➢ In common endosperm development, the PEN undergoes successive 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.

➢ The endosperm may be either fully consumed by the growing embryo (as in pea and bean) or retained in the mature seed (as in coconut and castor).

➢ The tender coconut water is a free-nuclear endosperm (made up of thousands of nuclei) and the surrounding white kernel is the cellular endosperm.

(b) Embryo development:

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

➢ The early embryonic developments (embryogeny)is similar in monocotyledons and dicotyledons, though the seeds differ greatly,

➢ The zygote gives rise to the proembryoand subsequently to the globular, heart-shaped and mature embryo.

(i) Dicotyledonous embryo

- A typical dicot embryo consists of an embryonal axis and two cotyledons.
- The portion of embryonal axis, which lies above the level of cotyledons is the known as epicotyl. It terminates with the plumule (shoot tip).
- The cylindrical portion of the embryonal axis, which lies below the level of cotyledons, is hypocotyl. It terminates withthe radicle (root tip). The root tip is covered with a root cap.

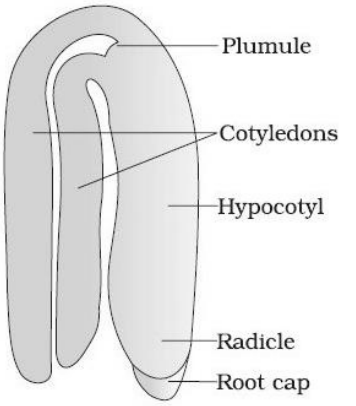


Fig.: A typical dicot embryo

(ii) Monocotyledonous embryo

- A typical monocot embryo possesses only one cotyledon.
- In the grass family, the cotyledon is commonly known asscutellum. It is situated lateral to the embryonal axis.
- At its lower end, the embryonal axis has the radicle and root cap enclosed in coleorrhiza (an undifferentiated sheath). Coleorrhiza is an undifferentiated sheath that encloses the radicle and root cap in a monocot seed.
- The epicotyl lies above the level of scutellum. It has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure called coleoptile. Coleoptile is a conical protective sheath that encloses the plumule in monocot embryo.

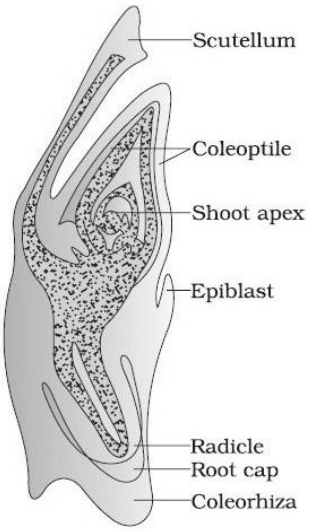


Fig.: L.S of an embroyo of grass

(c) Seed

- Seed is the final (last) product of sexual reproduction in angiosperms. It is the fertilized ovule that is developed inside a fruit.

- A seed consists of seed coat(s), cotyledon(s) and an embryonal axis.
- The cotyledons are simple, generally thick and swollen due to storage food (as in legumes).
- *Mature seeds may be non-albuminous or albuminous.*
  - ➢ **Non-albuminous seeds (Endosperm absent):** They have no residual endosperm as it is completely consumed during embryo development. *E.g.*, pea, groundnut, beans.
  - ➢ **Albuminous seeds (Endosperm present)**: They retain a part of endosperm as it is not completely used up during embryo development. *E.g.*, wheat, maize, barley, castor, coconut, sunflower, etc.
- Perisperm: Remnants of nucellus in matured seed are known as perisperm. *E.g.* black pepper, beet, etc.
- The integuments of ovules harden to form the tough protective seed coats. It has a small pore called micropyle which facilitates the entry of oxygen and water into the seed during germination.
- As the seed matures, its water content is reduced and seeds become dry i.e. 10-15 % moisture by mass. The general metabolic activity of the embryo slows down. As a result, the embryo may enter a state of inactivity, called as **dormancy**.
- If favourable conditions are available *i.e.* adequate moisture, oxygen and suitable temperature, then the seed germinate.

(d) Fruit:

- The ovary of a flower develops into a fruit. Transformation of ovules into seeds and ovary into fruit proceeds simultaneously.
- The wall of ovary develops into wall of the fruit called **pericarp**.
- The fruits may be fleshy (*E.g.* guava, orange, mango, etc.) or may be **dry** (*E.g.* groundnut, mustard, etc).
- Many fruits have mechanisms for dispersal of seeds.
- Fruits are of two types:
  - ➢ **True fruits:** Fruits that develop from the ovary are called true fruits.
  - ➢ **False fruits:** Fruits that develop from the thalamus are called as false fruits. *E.g.* apple, strawberry, cashew, etc.
- In apple, the fleshy receptacle forms the main edible part.
- **Parthenocarpic fruits:** Fruits that develop without fertilization are called **parthenocarpic fruits**. *E.g.*Banana, guava, apple, etc.
- **Parthenocarpy** can be induced through the application of growth hormones and such fruits are seedless.

Advantages of seeds:

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

Viability of seeds after dispersal:

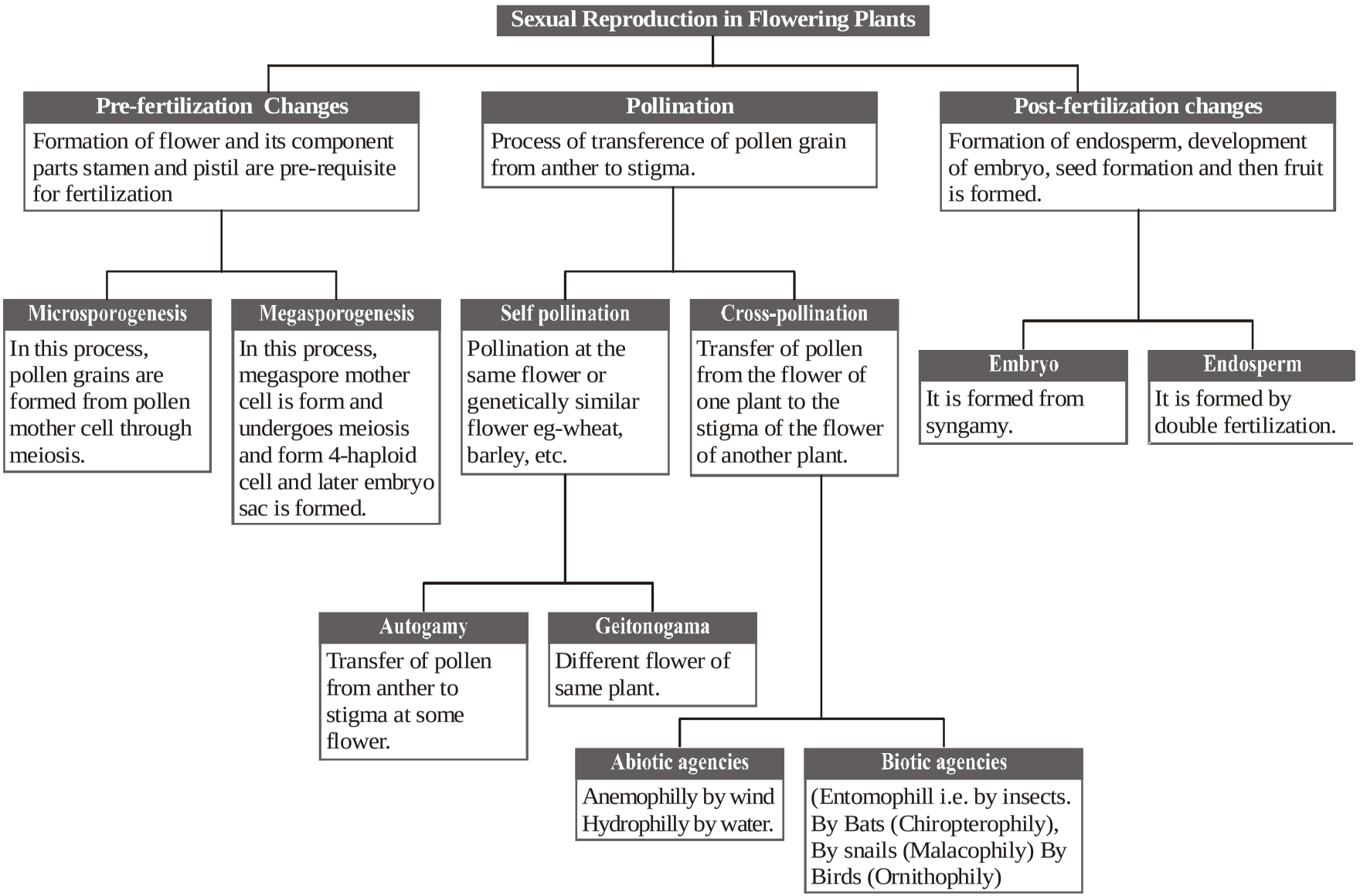
- In a few species the seeds lose viability within a few months. Seeds of many species live for several years.
- Some seeds can remain alive for hundreds of years. The oldest is that of a lupine (*Lupinusarcticus*) excavated from Arctic Tundra. The seed germinated and flowered after an estimated record 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** is the production of seeds without involving the process of meiosis and syngamy. *E.g.* Some species of Asteraceae and grasses.
- Apomixis is a form of asexual reproduction that mimics sexual reproduction.
- **Development of apomictic seeds:**
  - ➢ In some species, the diploid egg cell is formed without reduction division and develops into the embryo without fertilisation.
  - ➢ In many species (*E.g.* many *Citrus* & Mango varieties) some of the nucellar cells surrounding the embryo sac divide, protrude into the embryo sac and develop into the embryos. In such species each ovule contains many embryos.
- Occurrence of more than one embryo in a seed is called **polyembryony**.

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.
- Production of hybrid seeds is costly. Hence the cost of hybrid seeds is also expensive for the farmers.
- If the hybrids are made into apomicts, there is no segregation of characters in the hybrid progeny. Then the farmers can keep on using the hybrid seeds to raise new crop year after year.


Sexual Reproduction in Flowering Plants
Pre-fertilization Changes
Formation of flower and its component parts stamen and pistil are pre-requisite for fertilization
Pollination
Process of transference of pollen grain from anther to stigma.
Post-fertilization changes
Formation of endosperm, development of embryo, seed formation and then fruit is formed.
Microsporogenesis
In this process, pollen grains are formed from pollen mother cell through meiosis.
Megasporogenesis
In this process, megaspore mother cell is form and undergoes meiosis and form 4-haploid cell and later embryo sac is formed.
Self pollination
Pollination at the same flower or genetically similar flower eg-wheat, barley, etc.
Cross-pollination
Transfer of pollen from the flower of one plant to the stigma of the flower of another plant.
Embryo
It is formed from syngamy.
Endosperm
It is formed by double fertilization.
Autogamy
Transfer of pollen from anther to stigma at some flower.
Geitonogama
Different flower of same plant.
Abiotic agencies
Anemophilly by wind Hydrophilly by water.
Biotic agencies
(Entomophill i.e. by insects. By Bats (Chiropterophily), By snails (Malacophily) By Birds (Ornithophily)

EXERCISE - 1
Conceptual Questions

1. How many pollen grains will be formed after meiotic division in ten microspore mother cells?
(a) 10 (b) 20
(c) 40 (d) 80

2. Flowers showing ornithophily show few characteristic like
(a) blue flower with nectaries at base of corolla
(b) red sweet scented flower with nectaries
(c) bright red flower into thick inflorescence
(d) white flowers with fragrance

3. Which type of association is found in between entomophilous flower and pollinating agent ?
(a) Mutualism
(b) Commensalism
(c) Cooperation
(d) Co-evolution

4. Which is the most logical sequence with reference to the life cycle of angiosperm ?
(a) Germination, endosperm formation, seed dispersal, double fertilization
(b) Cleavage, fertilization, grafting, fruit formation
(c) Pollination, fertilization, seed formation & germination
(d) Maturation, mitosis, differentiation

5. Tapetum is
(a) parietal in origin usually the inner most layer of anther wall.
(b) modified endothecium of anther wall.
(c) modified outer most layer of sporogenous tissue.
(d) parietal in origin and is the inner most layer of ovule wall.

6. Which of the following pair has haploid structures?
(a) Nucellus and antipodal cells
(b) Antipodal cells and egg cell
(c) Antipodal cells and megaspore mother cell
(d) Nucellus and primary endosperm nucleus

7. Male gametophyte of angiosperms/monocots is
(a) Microsporangium (b) Nucellus
(c) Microspore (d) Stamen

8. The type of cells under going meiosis in the flowers are
(a) micro spore mother cell & mega spore mother cell
(b) ovule & stamen
(c) tapetal cells
(d) placental cell

9. Which ones produces androgenic haploids in anther cultures?
(a) Anther wall
(b) Tapetal layer of anther wall
(c) Connective tissue
(d) Young pollen grains

10. Generative cell was destroyed by laser but a normal pollen tube was still formed because
(a) vegetative cell is not damaged
(b) contents of killed generative cell stimulate pollen growth
(c) laser beam stimulates growth of pollen tube
(d) the region of emergence of pollen tube is not harmed

11. The embryo is carefully taken out of pea seed and sown in the soil and watered normally. New plant will
(a) be healthier (b) be weaker
(c) not be formed (d) be formed normally

12. Pea seeds are sown in a pot. After emergence of cotyledons, the pot is placed in an aerated dark chamber and watered normally, seedlings will
(a) form normal plants
(b) form healthier plants
(c) die
(d) grow very rapidly without forming leaves

13. If there are 4 cells in anther, what will be the number of pollen grains ?
(a) 8 (b) 4
(c) 16 (d) 12

14. A cutting of rose plant is thoroughly waxed and planted in the soil normally, it will form
(a) new rose plant.
(b) a dead piece of rose stem after some time.
(c) a rose plant of improved variety.
(d) None of these

15. In angiospermic plant having chromosome number of 12 will have chromosome number in integuments and nucellus of
(a) 4 (b) 6
(c) 12 (d) 24

16. What is the fate of the seven cells of the embryo sac ?
(a) All but one disintegrate upon fertilization.
(b) Two become fertilized; the others disintegrate.
(c) Two become fertilized; the others fuse to form endosperm.
(d) All are involved in nuclear fusion events.

17. The most common type of pollination is –
(a) entemophily
(b) ornithophily
(c) malacophily (by snails)
(d) chiropterophily (by bats)

18. When an ovary develops into a fruit, without fertilization, it is called
(a) apospory (b) apogamy
(c) parthenocarpy (d) porogamy

19. Which of the following has largest gametophyte ?
(a) *Oryza* (b) *Funaria*
(c) *Pinus* (d) *Selaginella*

20. Exine of pollen is formed by activity of
(a) tapetum (b) endothelium
(c) middle layers (d) endothecium

21. Which of the following statements about pollen and pollination is *false* ?
(a) Evolution of the pollen grain rejected the need for swimming sperm in flowering plants.
(b) At maturity, the pollen grain consists of two sperm nuclei and a tube nucleus.
(c) The pollen tube enters the female gametophyte through the style.
(d) The pollen grain makes twice the genetic contribution to endosperm cells than it does to the cells of the embryo.

22. Which of the following options is correct?
(a) Pollination gives the guarantee of the promotion of post-pollination events that lead to fertilization.
(b) The events – "from pollen deposition on stigma until pollen tubes enter the ovule" are together referred to as pollen-pistil interaction.
(c) Pollen-pistil interaction is a dynamic process involving pollen recognition followed by only promotion (not rejection) of the pollen.
(d) Pistil has no ability to recognise the pollen, whether right or wrong type.

23. Cross-pollination is preferred over self-pollination because
(a) it results in better offspring.
(b) the new varieties are formed.
(c) it is easy.
(d) parthenogenesis can be induced.

24. Seminiferous plant is
(a) having only staminate flowers.
(b) reproducing by seeds.
(c) reproducing by vegetative propagation.
(d) None of the above

25. Which is the correct order of events for female gametophytes?
(a) Megagametophyte; megasporocyte; megaspore
(b) Megagametophyte; megaspore; megasporocyte
(c) Megasporocyte; megaspore; megagametophyte
(d) Megaspore; megasporocyte; megagametophyte

26. Emasculation is not required when flowers are
(a) bisexual
(b) intersexual
(c) unisexual
(d) either (1) or (2)

27. Pollen grain (microspore) formation in *Cyperus* (Cypraceae) is
(a) very common.
(b) artificially induced by removal of anthers.
(c) similar to megasporogenesis in majority of angiosperms.
(d) similar to the microsporogenesis commonly present within angiosperms.

28. Male gametes or sperms are developed from generative cell by
(a) meiotic division (b) mitotic division
(c) amitotic division (d) None of these

29. From megasporocyte to egg cell, what processes are required ?
(a) Meiosis followed by mitosis
(b) Mitosis followed by meiosis
(c) Several meiotic divisions only
(d) Several mitotic divisions only

30. The study of formation, growth and development of new individual from an egg is called
(a) embryology (b) embryogenesis
(c) morphogenesis (d) embryolysis

31. Double fertilisation leading to initiation of endosperm in angiosperms require
(a) fusion of one polar nucleus and the second male gamete only
(b) fusion of two polar nuclei and the second male gamete
(c) fusion of four or more polar nuclei and the second male gamete only
(d) all the above kinds of fusion in different angiosperms

32. In angiosperms pollen tubes liberate their male gametes into the
(a) central cell (b) antipodal cell
(c) egg cell (d) synergids

33. Microspore in angiosperms contain
(a) two prothallial cells (b) one parietal cell
(c) 3 parietal cells (d) None of these

34. The cause of dormancy for sometime in fertilized ovule is
(a) presence of hormone, auxin.
(b) zygote divides only after certain amount of endosperm is formed.
(c) presence of growth inhibitor ABA.
(d) presence of least amount of water.

35. As a pollen tube grows into the female organ, the nucleus that enters the synergid first is called the
(a) sperm nucleus (b) generative nucleus
(c) tube nucleus (d) pollen nucleus

36. The advantage of cross-fertilization in plants is
(a) increased genetic recombination.
(b) that meiosis can occur.
(c) greater efficiency of pollination.
(d) that no flowering is needed.

37. Middle layers of the microsporangial wall
(a) shrivel at maturity of anther
(b) persist but remain thin-walled
(c) degenerate before maturity
(d) persist and become thickened

38. Pollen grain is liberated in
(a) one celled stage (b) two celled stage
(c) three celled stage (d) two or three celled stage

39. If an angiospermic male plant is diploid and female plant tetraploid, the ploidy level of endosperm will be
(a) haploid (b) triploid
(c) tetraploid (d) pentaploid

40. Fruit-eating bats tend to feed extremely rapidly on fruits and have relatively inefficient digestion (some times defecating seeds as early as an hour after feeding on them). Why are they good seed dispersal agents ?

(a) Seed survival in bat's guts is low.
(b) Undigested seeds are deposited in a heap at the bat's root site.
(c) Undigested seeds are deposited near the same plant that produced them.
(d) Digested seeds are dispersed in bat waste products.

41. In some dicots, no distinct endosperm can be seen. Why ?
(a) The embryo has digested the endosperm.
(b) The cotyledons have absorbed the endosperm.
(c) The seeds never produced endosperm.
(d) The endosperm has become the seed coat

42. Ovules are attached to a parenchymatous cushion called
(a) nucellus (b) obturator
(c) conducting tissue (d) placenta

43. Milky water of green coconut is
(a) liquid chalaza (b) liquid nucellus
(c) liquid endosperm (d) liquid female gametophyte

44. Scutellum is present in the embryo of
(a) Pea (b) *Ranunculus*
(c) *Triticum* (d) None of these

45. The suspensor
(a) gives rise to the embryo.
(b) is heart-shaped in dicots.
(c) separates the two cotyledons of dicots.
(d) ceases to elongate early in embryo development.

46. The point at which funiculus touches the ovule is
(a) chalaza (b) hilum
(c) raphe (d) endothelium

47. Adventive polyembryony in citrus is due to
(a) nucellus (b) integuments
(c) zygotic embryo (d) fertilised egg

48. Formation of gametophyte directly from sporophyte without meiosis is
(a) Apospory (b) Apogamy
(c) Parthenogenesis (d) Amphimixis

49. The seed in which endosperm is used by embryo is
(a) single (b) albuminous
(c) endospermic (d) non-endospermic

50. Formation of diploid embryo sac from diploid vegetative structure is called
(a) diplospory
(b) apospory
(c) adventive polyembryony
(d) apomixis

EXERCISE - 2
Applied Questions

1. Both, autogamy and geitonogamy are prevented in -
(a) Papaya (b) Cucumber
(c) Castor (d) Maize

2. In which one of the following pollination is autogamous?
(a) Geitonogamy (b) Xenogamy
(c) Chasmogamy (d) Cleistogamy

3. The scutellum observed in a grain of wheat or maize is comparable to which part of the seed in other monocotyledons?
(a) Cotyledon (b) Endosperm
(c) Aleurone layer (d) Plumule

4. Transfer of pollen grains from the anther to the stigma of another flower of the same plant is called
(a) Xenogamy (b) Geitonogamy
(c) Karyogamy (d) Autogamy

5. An example of a seed with endosperm, perisperm, and caruncle is
(a) coffee (b) lily
(c) castor (d) cotton

6. What does the filiform apparatus do at the entrance into ovule?
(a) It helps in the entry of pollen tube into a synergid.
(b) It prevents entry of more than one pollen tube into the embryo sac.
(c) It brings about opening of the pollen tube.
(d) It guides pollen tube from a synergid to egg.

7. Unisexuality of flowers prevents
(a) autogamy, but not geitonogamy
(b) both geitonogamy and xenogamy
(c) geitonogamy, but not xenogamy
(d) autogamy and geitonogamy

8. Megasporangium is equivalent to :
(a) Fruit (b) Nucellus
(c) Ovule (d) Embryo sac

9. Advantage of cleistogamy is :
(a) More vigorous offspring
(b) No dependence of pollinators
(c) Vivipary
(d) Higher genetic variability

10. Product of sexual reproduction generally generates :
(a) Prologned dormancy
(b) New genetic combination leading to variation
(c) Large biomass
(d) Longer viability of seeds

11. The viability of seeds is tested by
(a) Safranine
(b) 2, 6 dichlorophenol indophenols
(c) 2, 3, 5 triphenyl tetrazolium chloride
(d) DMSO

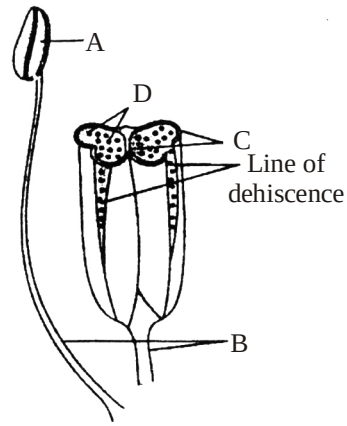
12. Which one of the following statements is **correct**?
(a) Geitonogamy involves the pollen and stigma of flowers of different plants
(b) Cleistogamous flowers are always autogamous
(c) Xenogamy occurs only by wind pollination
(d) Chasmogamous flowers do not open at all

13. Megaspores are produced from the megaspore mother cells after
(a) Meiotic division
(b) Mitotic division
(c) Formation of a thick wall
(d) Differentiation

14. Which of the following statements is **correct?**
(a) Sporopollenin can withstand high temperatures but not strong acids
(b) Sporopollenin can be degraded by enzymes
(c) Sporopollenin is made up of inorganic materials
(d) Sporopollenin can withstand high temperatures as well as strong acids and alkalis

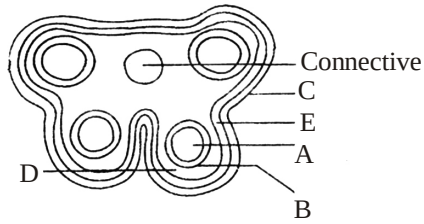
15. Which of the following statements is not true about somatic embryogenesis?
(a) A somatic embryo develops from a somatic cell
(b) The pattern of development of a somatic embryo is comparable to that of a zygotic embryo
(c) Somatic embryos can develop from microspores
(d) Somatic embryo is induced usually by an auxin such as 2, 4-D

16. Identify A to D respectively-



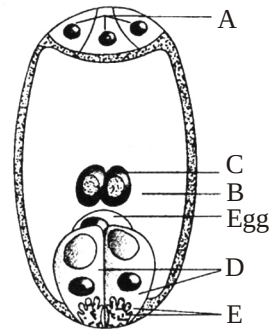
(a) Anther, Petiole, Pollen sac and Megaspore
(b) Anther, Petiole, Megasporangium and Pollen grains
(c) Anther, Pedicel, Megasporangium and Pollen grains
(d) Anther, Filament, Pollen sac and Pollen grains

17.



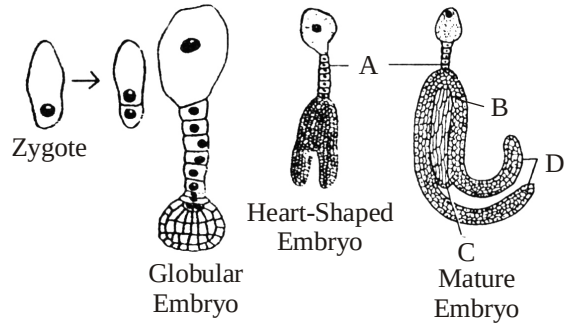
The above diagram refers to a T. S. of anther. Identify A to E respectively-
(a) Sporogenous tissue, tapetum, epidermis, middle layer, endothecium
(b) Sporogenous tissue, epidermis, tapetum, middle layer, endothecium
(c) Sporogenous tissue, epidermis, middle layer, tapetum, endothecium
(d) Sporogenous tissue, tapetum, middle layer, epidermis, endothecium

18. Identify A, B, C, D and E structures shown in figure of a female gametophyte respectively-



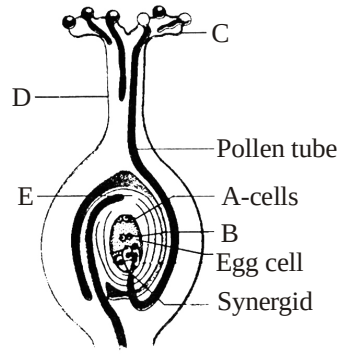
(a) Antipodal cells, Central cell, Polar nuclei, Synergids and Acrosome
(b) Antipodal cells, Central cell , Polar nuclei, Synergids and Filiform apparatus
(c) Synergids, Central cell, Polar nuclei, Antipodal cells and Filiform apparatus
(d) Synergids, Megaspore mother cell, Polar nuclei, Synergids, Filiform apparatus

19. Diagram given below shows stages in embryogenesis in a typical dicot (*Capsella*). Identify structures A to D respectively-



(a) Suspensor, Radicle, Plumule, Cotyledons
(b) Hypophysis, Radicle, Plumule, Cotyledons
(c) Suspensor, Plumule, Radicle, Cotyledons
(d) Suspensor, Radicule, Plumule, Hypocotyls

20. Identify A, B, C, D and E respectively-



(a) Antipodal cells, Secondary nuclei, Stigma, Style, Chalaza
(b) Antipodal cells, Secondary nuclei, Style, Stigma, Chalaza
(c) Antipodal cells, Secondary nuclei, Stigma, Chalaza, Style
(d) Antipodal cells, Secondary nuclei, Chalaza, Stigma, Style

21. Match Column -I with Column - II.

	Column I		Column II
A.	Zoophily	1.	Pollination by birds
B.	Ornithophily	2.	Pollination by insects
C.	Entomophily	3.	Pollination by bats
D.	Chiropterophily	4.	Pollination by animals

(a) A → 3; B → 2; C → 1; D → 4
(b) A → 1; B → 2; C → 3; D → 4
(c) A → 4; B → 1; C → 2; D → 3
(d) A → 4; B → 2; C → 1; D → 3

22. Match Column -I with Column - II.

	Column I		Column II
A.	Ovary	1	Groundnut, mustard
B.	Ovule	2.	Guava, orange, mango
C.	Wall of ovary	3.	Pericarp
D.	Fleshy fruits	4.	Seed
E.	Dry fruits	5.	Fruit

(a) A → 5; B → 4; C → 3; D → 2; E → 1
(b) A → 1; B → 2; C → 3; D → 4; E → 5
(c) A → 1; B → 3; C → 2; D → 4; E → 5
(d) A → 5; B → 4; C → 1; D → 2; E → 3

23. Which of the following statement(s) is/are false?
1. Pollen grains represents immatured male gametophyte.
2. In angiosperms partially developed male gametophytes are pollinated.
3. Generative cell is siponogenous while vegetative cell is spermatogenous.
4. Formation and differentiation of pollen grains is called microsporogenesis.
5. Pollen grains of some plants produce severe allergy and respiratory or bronchial diseases.
6. Pollen grains are poor in nutrients.

(a) 1 and 6 (b) 3 and 6
(c) 4 and 5 (d) 5 and 6

DIRECTIONS for Qs. 24 & 25 : Each questions contain STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

(a) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1
(b) Statement -1 is True, Statement -2 is True ; Statement-2 is NOT a correct explanation for Statement - 1
(c) Statement - 1 is True, Statement- 2 is False
(d) Both the Statements are False.

24. **Statement 1 :** The two cotyledons in seed are embryonic leaves.
Statement 2 : The embryo contains radicle and plumule.

25. **Statement 1 :** Nuclear endosperm is formed by subsequent nuclear division without wall formation.
Statement 2 : Coconut is an example of such endosperm, where the endosperm remains nuclear throughout the development of the fruit.

EXERCISE - 3
Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

1. Among the terms listed below, those that of are not technically correct names for a floral whorl are
(i) androecium (ii) carpel
(iii) corolla (iv) sepal
(a) (i) and (iv) (b) (iii) and (iv)
(c) (ii) and (iv) (d) (i) and (ii)

2. Embryo sac is to ovule as ..... is to an another.
(a) stamen (b) filament
(c) pollen grain (d) androecium

3. In a typical complete, bisexual and hypogynous flower the arrangement of floral whorls on the thalamus from the outermost to the innermost is
(a) calyx, corolla, androecium and gynoecium
(b) calyx, corolla, gynoecium and androecium
(c) gynoecium, androecium, corolla and calyx
(d) androecium, gynoecium, corolla and calyx

4. A dicotyledonous plant bears flowers, but never produces fruits and seeds. The most probable cause for the above situation is
(a) plant is dioecious and bears only pistillate flowers
(b) plant is dioecious and bears both pistillate and staminate flowers
(c) plant is monoecious
(d) plant is dioecious and bears only staminate flowers

5. The outermost and innermost wall layers of microsporangium in an anther are respectively.
(a) Endothecium and tapetum
(b) Epidermis and endodermis
(c) Epidermis and middle layer
(d) Epidermis and tapetum

6. During microsporogenesis, meiosis occurs in
(a) endothecium (b) microspore mother cells
(c) microspore tetrads (d) pollen grains

7. From among the sets of terms given below, identify those that are associated with the gynoecium.
(a) Stigma, ovule, embryo sac, placenta
(b) Thalamus, pistil, style, ovule
(c) Ovule, ovary, embryo sac, tapetum
(d) Ovule, stamen, ovary, embryo sac

8. Starting from the innermost part, the correct sequence of parts in a ovule are
(a) egg, nucellus, embryo sac, integument
(b) egg, embryo sac, nucellus, integument
(c) embryo sac, nucellus, integument, egg
(d) egg, integument, embryo sac, nucellus

9. From the statements given below choose the option that are true for a typical female gametophyte of a flowering plant.
(i) It is eight-nucleate and seven-celled at maturity.
(ii) It is free-nuclear during the development.

(iii) It is situated inside the integument, but outside the nucellus.
(iv) It has an egg apparatus situated at the chalazal end.
(a) (i) and (iv) (b) (ii) and (iii)
(c) (i) and (ii) (d) (ii) and (iv)

10. Autogamy can occur in a chasmogamous flower if:
(a) pollen matures before maturity of ovule
(b) ovules mature before maturity of pollen
(c) both pollen and ovules mature simultaneously
(d) both anther and stigma are of equal lengths

11. Choose the correct statement from the following.
(a) Cleistogamous flowers always exhibit autogamy.
(b) Chasmogamous flowers always exhibit geitonogamy.
(c) Cleistogamous flowers exhibit both autogamy and geitonogamy.
(d) Chasmogamous flowers never exhibit autogamy.

12. A particular species of plant produces light, non-sticky pollen in large numbers and its stigmas are long and feathery. These modifications facilitate pollination by
(a) insects (b) water
(c) wind (d) animals

13. From among the situations given below, choose the one that prevents both autogamy and geitonogamy.
(a) Monoecious plant bearing unisexual flowers.
(b) Dioecious plant bearing only male or female flowers.
(c) Monoecious plant with bisexual flowers.
(d) Dioecious plant with bisexual flowers.

14. In a fertilised embryo sac, the haploid, diploid and triploid structure are:
(a) synergid, zygote and primary endosperm nucleus
(b) synergid, antipodal and polar nuclei
(c) antipodal, synergid and primary endosperm nucleus
(d) synergid, polar nuclei and zygote

15. In an embryo sac, the cells that degenerate after fertilisation are:
(a) synergids and primary endosperm cell
(b) synergids and antipodals
(c) antipodals and primary endosperm cell
(d) egg and antipodals

16. While planning for an artificial hybridisation programme involving dioecious plants, which of the following steps would not be relevant?
(a) Bagging of female flower
(b) Dusting of pollen on stigma
(c) Emasculation
(d) Collection of pollen

17. In the embryos of a typical dicot and a grass, true homologous structures are
(a) coleorrhiza and coleoptile
(b) coleoptile and scutellus
(c) cotyledons and scutellum
(d) hypocotyl and radicle

18. The phenomenon observed in some plants where in parts of the sexual apparatus is used for forming embryo without fertilisation is called
(a) parthenocarpy (b) apomixis
(c) vegetative propagation (d) sexual reproduction

19. In a flower, if the megaspore mother cell forms megaspores without undergoing meiosis and if one of the megaspores develops into an embryo sac, its nuclei would be
(a) haploid
(b) diploid
(c) a few haploid and a few diploid
(d) with varying ploidy

20. The phenomenon wherein, the ovary develops into a fruit without fertilisation is called
(a) parthenocarpy (b) apomixis
(c) asexual reproduction (d) sexual reproduction

NEET/AIPMT (2013-2017) Questions

21. Perisperm differs from endosperm in; ***[2013]***
(a) having no reserve food
(b) being a diploid tissue
(c) its formatting by fusion of secondary nucleus with several sperms
(d) being a haploid tissue

22. Megasporangium is equivalent to : ***[2013]***
(a) Fruit (b) Nucellus
(c) Ovule (d) Embryo sac

23. Seed coat is not thin, membranous in : ***[2013]***
(a) Coconut (b) Groundnut
(c) Gram (d) Maize

24. Advantage of cleistogamy is : ***[2013]***
(a) More vigorous offspring
(b) No dependence of pollinators
(c) Vivipary
(d) Higher genetic variability

25. Product of sexual reproduction generally generates:
(a) Prolonged dormancy ***[2013]***
(b) New genetic combination leading to variation
(c) Large biomass
(d) Longer viability of seeds

26. Which one of the following statements is correct?
(a) Sporogenous tissue is haploid ***[2013]***
(b) Endothecium produces the microspores
(c) Tapetum nourishes the developing pollen
(d) Hard outer layer of pollen is called intine

27. The viability of seeds is tested by ***[NEET Kar. 2013]***
(a) Safranine
(b) 2, 6 dichlorophenol indophenols
(c) 2, 3, 5 triphenyl tetrazolium chloride
(d) DMSO

28. Which one of the following statements is **correct**? ***[NEET Kar. 2013]***
(a) Geitonogamy involves the pollen and stigma of flowers of different plants
(b) Cleistogamous flowers are always autogamous
(c) Xenogamy occurs only by wind pollination
(d) Chasmogamous flowers do not open at all

29. Megaspores are produced from the megaspore mother cells after *[NEET Kar. 2013]*
(a) Meiotic division
(b) Mitotic division
(c) Formation of a thick wall
(d) Differentiation

30. Animal vectors are required for pollination in *[NEET Kar. 2013]*
(a) Maize (b) *Vallisneria*
(c) Mulberry (d) Cucumber

31. Which of the following statements is **correct?** *[NEET Kar. 2013]*
(a) Sporopollenin can withstand high temperatures but not strong acids
(b) Sporopollenin can be degraded by enzymes
(c) Sporopollenin is made up of inorganic materials
(d) Sporopollenin can withstand high temperatures as well as strong acids and alkalis

32. Albuminous seeds store their reserve food mainly in
(a) Perisperm (b) Endosperm*[NEET Kar. 2013]*
(c) Cotyledons (d) Hypocotyl

33. Which of the following statements is not true about somatic embryogenesis? *[NEET Kar. 2013]*
(a) A somatic embryo develops from a somatic cell
(b) The pattern of development of a somatic embryo is comparable to that of a zygotic embryo
(c) Somatic embryos can develop from microspores
(d) Somatic embryo is induced usually by an auxin such as 2, 4-D

34. Geitonogamy involves: *[2014]*
(a) fertilization of a flower by the pollen from another flower of the same plant.
(b) fertilization of a flower by the pollen from the same flower.
(c) fertilization of a flower by the pollen from a flower of another plant in the same population.
(d) fertilization of a flower by the pollen from a flower of another plant belonging to a distant population.

35. Male gametopyte with least number of cell is present in:
(a) *Pteris* (b) *Funaria* *[2014]*
(c) *Lilium* (d) *Pinus*

36. Function of filiform apparatus is to: *[2014]*
(a) Recognize the suitable pollen at stigma
(b) Stimulate division of generative cell
(c) Produce nectar
(d) Guide the entry of pollen tube

37. Non-albuminous seed is produced in: *[2014]*
(a) Maize (b) Castor
(c) Wheat (d) Pea

38. Which one of the following may require pollinators, but is genetically similar to autogamy? *[2015 RS]*
(a) Xenogamy (b) Apogamy
(c) Cleistogamy (d) Geitonogamy

39. Which one of the following statements is not true? *[2015 RS]*
(a) Pollen grains of some plants cause severe allergies and bronchial afflictions in some people
(b) The flowers pollinated by flies and bats secrete foul odour to attract them
(c) Honey is made by bees by digesting pollen collected from flowers
(d) Pollen grains are rich in nutrients, and they are used in the form of tablets and syrups

40. The hilum is a scar on the : *[2015 RS]*
(a) Fruit, where it was attached to pedicel
(b) Fruit, where style was present
(c) Seed, where micropyle was present
(d) Seed, where funicle was attached

41. Which of the following are the important floral rewards to the animal pollinators? *[2015 RS]*
(a) Nectar and pollen grains
(b) Floral fragrance and calcium crystals
(c) Protein pellicle and stigmatic exudates
(d) Colour and large size flower

42. Filiform apparatus is characteristic feature of: *[2015 RS]*
(a) Nucellar embryo
(b) Aleurone cell
(c) Synergids
(d) Generative cell

43. Which one of the following statements is not true? *[2016]*
(a) Tapetum helps in the dehiscence of anther
(b) Exine of pollen grains is made up of sporopollenin
(c) Pollen grains of many species cause severe allergies
(d) Stored pollen in liquid nitrogen can be used in the crop breeding programmes

44. Which of the following statements is not correct? *[2016]*
(a) Pollen grains of many species can germinate on the stigma of a flower, but only one pollen tube of the same species grows into the style.
(b) Insects that consume pollen or nectar without bringing about pollination are called pollen/nectar robbers.
(c) Pollen germination and pollen tube growth are regulated by chemical components of pollen interacting with those of the pistil.
(d) Some reptiles have also been reported as pollinators in some plant species.

45. Functional megaspore in an angiosperm develops into ?
(a) Endosperm (b) Embryo sac *[2017]*
(c) Embryo (d) Ovule

46. Attractants and rewards are required for : *[2017]*
(a) Entomophily (b) Hydrophily
(c) Cleistogamy (d) Anemophily

47. Flowers which have single ovule in the ovary and are packed into inflorescence are usually pollinated by: *[2017]*
(a) Bee (b) Wind
(c) Bat (d) Water

48. A dioecious flowering plant prevents both : *[2017]*
(a) Autogamy and geitonogamy
(b) Geitonogamy and xenogamy
(c) Cleistogamy and xenogamy
(d) Autogamy and xenogamy

Hints & Solutions

EXERCISE - 1

1. (c) Each microspore mother cell gives rise to 4 microspores which develop into pollen grains.
2. (a) Transfer of pollen grains by birds is known as ornithophily. They usually have bright coloured flowers, tubular or cup shaped with a large quantity of nectar.
3. (a) Commensalism is an interaction between two individuals in which one is benefitted while the other is unaffected. In mutualism both individuals are beneficial for each other. The pollinating insect gets nectar from flower and in turn helps in pollination of flowers.
4. (c) 5. (a)
6. (b) (a) Nucellus-2n, antipodal cells-n
   (b) Antipodal cells-n, egg cell-n
   (c) Antipodal cells-n, megaspore mother cell-2n
   (d) Nucellus-2n, primary endosperm nucleus-3n
   Antipodal and egg cell are the product of meiotic division and rest are not.
7. (c) Microspore is haploid, uninucleate, minute spore produced in large number as a result of meiosis in microspore mother cell inside the microsporangia. These are the first cell of gametophytic generation in angiosperms.
8. (a)
9. (d) Androgenic haploids are produced by young pollen grains because rest all are the diploid tissue.
10. (a) Each microspore divide by mitotic division making a smaller generative cell and a larger vegetative cell or tube cell. If generative cell is damaged then the normal pollen tube will be formed because pollen tube is formed by vegetative cell, not by generative cell of microspore.
11. (c) Embryo cannot grow without food stored in cotyledons.
12. (c) Cotyledons form food for seedling growth in light.
13. (c) Four microspore mother cells in anther on reductioning division will give rise to 16 microspores.
14. (b) Water absorption and gaseous exchange stop due to wax.
15. (c) Integument and nucellus develop from sporophytic tissue.
16. (b) 17. (a)
18. (c) Parthenocarpy is the development of a fruit without the formation of seeds as a result of lack of pollination, lack of fertilization and lack of development. This condition can be artificially induced by application of hormones.
19. (b) Bryophytes have gametophyte as their dominant stage. Thus, *Funaria* has the largest gametophyte.
20. (a) Ubisch bodies provided by tapetum help in thickening of exine.
21. (d) 22. (b)
23. (a) Crossing leads to hybrid vigour or superiority.
24. (b) Seed producing plants are called seminiferous plants.
25. (c) 26. (c)
27. (c) In family cypraceae, only one nucleus (out of 4) remains functional after meiotic division of microspore mother cell (similar to megaspore formation).
28. (b) Generative cell is haploid and 2 male gametes are formed from it by mitotic division.
29. (a) 30. (a)
31. (b) The second male gamete entering the ovary fuses with two haploid polar nuclei to form triploid primary endosperm nucleus which develops into endosperm. This fusion of two male gametes with two different structures (egg and secondary nucleus) in the same female gametophyte is called double fertilization.
32. (d)
33. (d) Prothallial cell is absent in male gametophyte of angiosperms.
34. (b) 35. (c) 36. (a) 37. (c) 38. (d)
39. (d) The male gamete will be haploid (*n*). 2 polar nuclei will be diploid (2*n*). Endosperm formed by fusion of male gamete with two polar nuclei will be pentaploid.

$$\underset{n}{\text{Male gamete}} + \underset{(2n)+(2n)}{\text{2 polar nuclei}} \longrightarrow \underset{(5n)}{\text{Endosperm}}$$

40. (c) 41. (b) 42. (d) 43. (c)
44. (c) Single cotyledon of grass embryo is called scutellum.
45. (d) 46. (b)
47. (a) The embryos arising from the maternal sporophyte tissues are called adventive embryos. In polyembryonic species the adventive embryo arises by the proliferation of the nucellus cells.
48. (a) A somatic cell in the nucellus directly forms an unreduced embryo sac and the diploid egg parthenogenetically develops into embryo *i.e.* formation of gametophyte from sporophyte without meiosis. It is known as apospory and it is a type of apomixis.
49. (d)
50. (b) When a diploid vegetative cell (nucellus cell) gives rise to diploid embryo sac directly, it is called apospory.

EXERCISE - 2

1. (a) Papaya is dioecious *i.e.* male and female flowers occurs in separate plants so that it prevents both autogamy and geitonogamy (method of self pollination).
2. (d) Cleistogamy is autogamous pollination. When pollination and fertilization occur in unopened flower bud, it is known as cleistogamy. It ensures self-pollination and prevents cross-pollination.
3. (a) Scutellum is the modified cotyledon observed in a grain of wheat or maize. It lies between embryo and the endosperm.

4. (b) Geitonogamy is the process of transfer of pollen grains from the anther to the stigma of another flower of the same plant. Example, maize.
5. (c) An example of a seed with endosperm, perisperm, and caruncle is castor. Castor seed is the source of castor oil, which has a wide variety of uses.
6. (a) Filiform apparatus helps in the entry of pollen tube into a synergid in ovule.
Filiform apparatus is in form of finger like projection comprising a core of microfibrils enclosed in a sheath. The filiform apparatus resembles transfer cells meant for short distance movement of metabolites. The filiform apparatus is responsible for the absorption of food from the nucleus.
7. (a) Unisexuality of flowers prevents. autogamy, but not geitonogamy. In self fertilisation , the male and female gametes are derived from the same individual. Among plants, self fertilization also called autogamy is common in many cultivated species, *eg*., wheat and oats. However, self fertilization is a form of inbreeding and does not allow for the mixing of genetic material; if it occurs over a number of generations it will result in offspring being less vigorous and productive than those resulting from cross fertilization.
8. (c) Ovule is also called integumented megasporangium. It develops into seed after fertilisation in spermatophytes. It occurs singly or in a cluster inside ovary with parenchymatous cushions called placenta.
9. (b) Cleistogamy favours no dependence on pollinator because flowers never open. In such flowers, the anthers and stigma lie close to each other. When anthers dehisce in flower buds pollen grains come in contact with the stigma to effect pollination.
10. (b) Sexual reproduction leads to formation of new combination and appearance of variations. Genetic recombination, interaction etc. during sexual reproduction provides vigour and vitality to the offsprings. They better adapt themselves to changing environmental conditions and also plays an important role in evolution.
11. (c) Dehydrogenase enzymes present in living tissue reduce the tetrazolium chloride to formazan, a reddish, water insoluble compound. This reaction occurs in or near living cells which are releasing hydrogen in respiration processes. Viable tissues produce a normal red-colour, weak living tissue produce an abnormal colour. Dead tissues do not stain, remaining usually white.
12. (b) Cleistogamous flowers do not expose their reproductive parts. Anthers and stigma lie close to each other. Pure autogamy occurs since there is no chance of cross-pollination. Cleistogamy is the most efficient floral adaptation for promoting self-pollination. E.g., *Viola mirabilis* and *Oxalis autosella*.
13. (a) Single Megaspore Mother Cell (MMC) with dense cytoplasm and a prominent nucleus gets differentiated from nucellus near the micropylar region. This Megaspore Mother Cell (MMC) undergoes meiosis to form '4' haploid cells called **megaspores** and the process of formation is known as **megasporogenesis.**
14. (d) Pollen grains are generally spherical and a prominent two-layered wall. The hard outer layer called the exine is made up of sporopollenin which is one of the most resistant organic material known. It can withstand high temperatures and strong acids and alkali.
15. (c) Somatic embryogenesis is a process where a plant or embryo is derived from a single somatic cell or group of somatic cells. Somatic embryos are formed from plant cells that are not normally involved in the development of embryos, *i.e*., ordinary plant tissue. No endosperm or seed coat is formed around a somatic embryo.
16. (d) 17. (a) 18. (b) 19. (a) 20. (a)
21. (c) 22. (a) 23. (b)
24. (b) In angiosperms, cotyledons are embryonic leaves. Embryo also has radicle and plumule which gives rise to root and shoot respectively.
25. (c) In nuclear type of endosperm the division of the primary endosperm nucleus and a few subsequent nuclear division are not accompanied by wall formation. So numerous nuclei are freely suspended in its sap. In coconut, the primary endosperm nucleus undergoes a number of free nuclear divisions. When the fruit is about 50 mm long before the embryo sac gets filled with a clear fluid in which float numerous nuclei of various sizes. At a later stage (about 100 mm long fruit) the suspension shows in addition to free nuclei, several cells each enclosing variable number of nuclei. Gradually these cells and free nuclei start setting at the periphery of the cavity and layers of cellular endosperm start appearing. In mature coconuts the liquid endosperm becomes milky and it does not contain free nuclei or cell.

EXERCISE - 3

Exemplar Questions

1. (c) Sepals collectively form a whorl, called as calyx while technically the carpel is known as gynoecium. The floral whorls formed by petals and stamens are called as corolla and androecium respectively.
2. (c) The pollen grains represent the male gametophytes. As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains. So, embryo sac is to ovule as pollen grains is to an anther.
3. (a) In a typical complete, bisexual and hypogynous flower the arrangement of floral whorls on the thalamus from the outermost to the innermost is
(i) The calyx, a whorl of sepals (outermost).
(ii) The corolla, a whorl of petals present inside the calyx.
(iii) The androecium, a whorl of stamens present inside the corolla.
(iv) The gynoecium, a whorl of pistils present in the centre of the flower forming innermost whorl.

4. (d) The unisexual male flower is staminate, in dioecious plants *i.e*., bearing stamens only, while the female is pistillate or bearing pistils only. For the production of fruits and seeds fertilisation must take place, that is possible only in the presence of both male and female flowers.

When the plant is dioecious, it will give rise to the following situations

(i) If the plant is dioecious and bears only pistillate flowers, fertilisation will take place with the help of pollinators.

(ii) If the plant is dioecious and bears only staminate flowers, fertilisation can't take place, because female gamete is non-motile which can't reach the male gamete in order to fuse with it.

When the plant is monoecious (i.e., that carrys both stamen and pistil together, it may lead to self-fertilisation and production of seed.

5. (d) A typical microsporangium is generally surrounded by four-wall layers, *i.e*., the epidermis (outermost protective layer) endothecium, (middle fibrous layers) and the tapetum (innermost nutritive layer).

6. (b) As the anther develops, the microspore mother cells of the sporogenous tissue undergoes meiotic divisions to form microspore tetrads. After dehydration, the microspore tetrad is separated into pollen grains.

Endothecium is the layer that is present present between epidermis and middle layer, and is formed by columner cells.

7. (a) The gynoecium represents the female reproductive part of the flower that consists of pistil. Each pistil comprises three parts, *i.e.*, **stigma, style** and **ovary.** The **placenta** is located inside the ovarian cavity.

There are the megasporangia, arising from the placenta commonly called **ovules**. The functional megaspore undergoing the meiotic division develops into the female gametophyte of **embryo sac**.

In option 'b' thalamus is not a part of gynoecium. Thalamus forms the base of flower on which all the floral whorls rest upon, it is not associated with gynoecium. In option 'c' tapetum is not a part of gynoecuim.

Tapetum is the inner most nutritive layer of microsporangium and in option 'd' stamen is not a part of gynoecium. **Stamen** is male reproductive part (androecium) of plant. therefore, the other options are wrong.

8. (b) Starting from the innnermost part, the correct sequence of parts in an ovule is egg, embryo sac, nucellus, integument.

9. (c) Inside the nucellus, the female gametophyte of embryo sac is located and enclosed within the integuments. In a majority of flowering plants, one of the megaspore is functional while the other three degenerates. Three repeated mitotic divisions of the functional megaspore results in the formation of **seven-celled** or **eight-nucleate** embryo sac.

Six of the eight nuclei are organised at the two poles. Three cells grouped at micropylar end forms **egg-apparatus** and 3 at the **chalazal end** forms **antipodal cells**. The large central cell at the centre has two polar nuclei.

In the formation of embryo sac the meiotic divisions are strictly free nuclear, *i.e* nuclear divisions are not followed immediately by cell-wall formation. Gametophyte is situated at micropylar end not at chalazal end.

10. (c) The method of self-pollination in which the stigma of a flower receive pollens from the anther of same flower is known as autogamy. For autogamy both sex organs of a chasmogamous flower should mature at the same time.

As chasmogamous flowers open at maturity, pollen release and for the process of autogamy stigma receptivity should be synchronised.

In such flowers, the length of anther and stigma plays secondary role in autogamy. *e.g*., in case of protandry (pollens nature early) and protogyny (stigma matures early) leads to cross-pollination.

11. (a) Chasmogamy is a process of pollination that occurs in opened flowers. It is most common type of pollination in all types of flowers. It is of two types *i.e.*, **self-pollination** (autogamy) and **cross-pollination**. Cross-pollination is of two types *i.e*., **geitonogamy** and **xenogamy**.

So, we can say that chasmogamous flowers exhibit both autogamy (self-pollination) and allogamy (cross-pollination). While, in cleistogamous flower, the anthers and stigma lie close to each other within the closed flowers.

When anthers dehisces in the flower buds, pollen grains come in contact with the stigma for effective pollination. Thus, these flowers are invariably autogamous as there is no chance of cross-pollen landing on the stigma.

12. (c) Plants use two abiotic (wind and water) and one biotic (animals) agent to achieve pollination. Majority of plants use biotic agents for pollination.

Wind pollination is more common amongst abiotic pollination. Wind pollination requires the light and non-sticky pollen grains so that, they can be easily transported in wind currents.

They often consists well-exposed stamens so that the pollens are easily dispersed into wind currents and large often-feathery stigma to easily trap air-borne pollen grains. Wind pollination is common in grasses.

These types of pollens are not pollinated by means of other three options

(i) Water pollination (hydrophily) is quite rare in flowering plants but exess in aquatic plants.

(ii) Zoophily is pollination through the agency of animals.

(iii) Entomophily is the most common type of zoophily occurs through the agency of insects.

13. (b) The method of self-pollination in which the transfer of pollen grains from anther to stigma of the same flower takes place is called autogamy. While geitonogamy, is the transfer of pollen grains from anther to stigma of another flower of the same plant.

In the above condition, dioecious plants, that bear only male or female flowers prevent both autogamy and

geitonogamy. Geitonogamy is ecologically cross-pollination which is supposed to be equivalent to self-pollination because all flowers on a plant are genetically identical.

14. (a) (i) Synergid – haploid
(ii) Polar nuclei – haploid
(iii) Antipodal – haploid
(iv) Zygote – diploid
(v) Primary Endosperm Nucleus (PEN).
Diploid secondary nucleus fertilises with a haploid male gamete to form a triploid PEN.

15. (b) In unfertilised embryo sac, the antipodals and synergids are present at chalazal end distinctly and micropylar end respectively. While, in fertilised embryo sac antipodals and synergids gradually degenerate after the formation of zygote.

16. (c) There is no need for emasculation, if the female parent produces unisexual flowers. 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. This protects them from contamination by unwanted pollen grains.

17. (c) A typical dicotyledonous embryo consists of two cotyledons. While, embryos of monocotyledons possess only one cotyledon and it is called scutellum i.e. in grass.

18. (b) The phenomenon of formation of seeds without fertilisation is known as apomixis. These embryos are genetically identical to the parental plant.
Parthenocarpy is the formation of fruits without fertilisation and hence the fruits are seedless. e.g., banana.
(i) Vegetative propagation or reproduction is a form of asexual reproduction in plants, in which new organisms are produced without production of seeds or spores.
(ii) Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse to form the zygote which develops to form the new organism.

19. (b) In some species, without reduction division the diploid egg cell is formed and without fertilisation, it develops into an embryo.
It is an asexual reproduction which occurs in the absence of pollinators or in extreme environments. In some species like citrus plants, nucellar cells surrounding the embryo sac start dividing and develops into embryos.
It occurs in the megaspore mother cell without undergoing meiosis, and produces diploid embryo sac through mitotic divisions. It helps in the preservation of desirable characters for indefinite period.
Thus, it can be concluded that apomictic species produce diploid cells. Haploid cells will be formed during sexual reproduction when cell will undergo meiosis.

20. (a) The formation of seedless fruits without fertilisation is parthenocarpy. The fruits developed from unfertilised ovary are called parthenocarpic fruits.

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21. (b) Perisperm is remnants of nucellus which is diploid (2n) but endosperm is triploid (3n). Perisperm occurs in the seeds of black pepper, coffee, castor, cardamum, *Nymphaea.* Endosperm is the food laden tissue which is meant for nourishing the embryo in seed plants. In angiosperms the endosperm is formed as a result of vegetative fertilization, triple fusion or fusion of a male gamete with diploid secondary nucleus of the central cell.

22. (c) Ovule is also called integumented megasporangium. It develops into seed after fertilisation in spermatophytes. It occurs singly or in a cluster inside ovary with parenchymatous cushions called placenta.

23. (a) The seed coat develops from integuments originally surrounding the ovule. It is thick and hard in coconut which protects the embryo from mechanical injury and from drying out.

24. (b) Cleistogamy favours no dependence on pollinator because flowers never open. In such flowers, the anthers and stigma lie close to each other. When anthers dehisce in flower buds pollen grains come in contact with the stigma to effect pollination.

25. (b) Sexual reproduction leads to formation of new progeny with appearance of variations by genetic recombination, of two different organisms interaction etc. During sexual reproduction provides vigour and vitality to the offsprings. They better adapt themselves to changing environmental conditions and also play an important role in evolution.

26. (c) Sporogenous tissue is always diploid, endothecium is second layer of anther wall and performs the function of protection and help in dehiscence of anther to release the pollen. Hard outer layer of pollen is called exine but tapetum always nourishes the developing pollen.
Cells of the tapetum possess dense cytoplasm and generally have more than one nucleus (polypoid).

27. (c) Dehydrogenase enzymes present in living tissue reduce the tetrazolium chloride to formazan, a reddish, water insoluble compound. This reaction occurs in or near living cells which are releasing hydrogen in respiration processes. Viable tissues produce a normal red-colour, weak living tissue produce an abnormal colour. Dead tissues do not stain, remaining usually white.

28. (b) Cleistogamous flowers do not expose their reproductive parts. Anthers and stigma lie close to each other. Pure autogamy occurs since there is no chance of cross-pollination. Cleistogamy is the most efficient floral adaptation for promoting self-pollination. E.g., *Viola mirabilis* and *Oxalis autosella*.

29. (a) Single Megaspore Mother Cell (MMC) with dense cytoplasm and a prominent nucleus gets differentiated from nucellus near the micropylar region. This Megaspore Mother Cell (MMC) undergoes meiosis to form '4' haploid cells called **megaspores** and the process of formation is known as **megasporogenesis.**

30. (d) There are different types of vectors involved in pollination.
For example, Maize, mulberry → pollination by wind. *Vallisneria* → pollination through water (hydrophily). Cucumber → Bees are brought for the commercial plantings of cucumber.

31. (d) Pollen grains are generally spherical and a prominent two-layered wall. The hard outer layer called the exine is made up of sporopollenin which is one of the most resistant organic material known. It can withstand high temperatures and strong acids and alkali.

32. (b) Endosperm is the nutritive tissue which provides nourishment to the embryo in seed plant. Albuminous seeds retain a part of endosperm as it is not completely used up during embryo development (*e.g.*, wheat, maize, barley, castor, sunflower).

33. (c) Somatic embryogenesis is a process where a plant or embryo is derived from a single somatic cell or group of somatic cells. Somatic embryos are formed from plant cells that are not normally involved in the development of embryos, *i.e.*, ordinary plant tissue. No endosperm or seed coat is formed around a somatic embryo.

34. (a) **Geitonogamy** is the transfer of pollen grains in different flowers of same plant.

35. (c) Male gametophyte is highly reduced in angiosperm and is known as pollen grain. It is 2 or 3-celled.

36. (d) Filiform apparatus helps in the entry of pollen tube into a synergid in ovule. Filiform apparatus is in the form of finger like projections comprising a core of micro fibrils enclosed in a sheath. It resembles transfer cells meant for short distance movement of metabolites. It is responsible for the absorption of food from the nucleus.

37. (d) **Exalbuminous (non-endospermic) seeds** usually store reserve food material in cotyledons. In these seeds, the endosperm is used up and not present in mature seeds, *e.g.*, bean, gram and pea.

38. (d) Geitonogamy, genetically, shows similarity with autogamy because the pollen grains are born on the same plant.

39. (c) Honey is produced by worker bees using nectar (fructose) of flowering plants.

40. (d) The hilum is a scar found on the seed coat through which the developing seeds are attached to the fruit.

41. (a) Nectar and pollen grains are the usual floral rewards which the animal pollinators get.

42. (c) Synergids have filiform apparatus.

43. (a) Tapetum is important for the nutrition and development of pollen grains, as well as a source of precursors for the pollen coat.

44. (a) Pollen grains of different species are incompatible, so they fail to germinate. If the pollen-stigma interaction is compatible, the pollen grain hydrates and germinates shortly following landing on the stigma.

45. (b) The first cell of female gametophytic generation in angiosperm is megaspore. It undergoes three successive mitotic division to form 8-nucleated and 7-celled embryo sac.

46. (a) Insect pollinated plants provide rewards as edible pollen grain and nectar as usual rewards. In order to materialize and maximize pollination flowers have developed a set of attributes which are aimed at attracting the pollinators called attractants.

47. (b) Wind pollination or anemophily occurs in flowers which have a single ovule in each ovary, and numerous flowers packed in an inflorescence. It is a non-directional pollination.

48. (a) Autogamy occurs in bisexual flowers. Geitonogamous flowers are unisexual but present in the same plant. Dioecious condition is observed when unisexual male and female flowers are present on different plants and it prevents both autogamy and geitonogamy.