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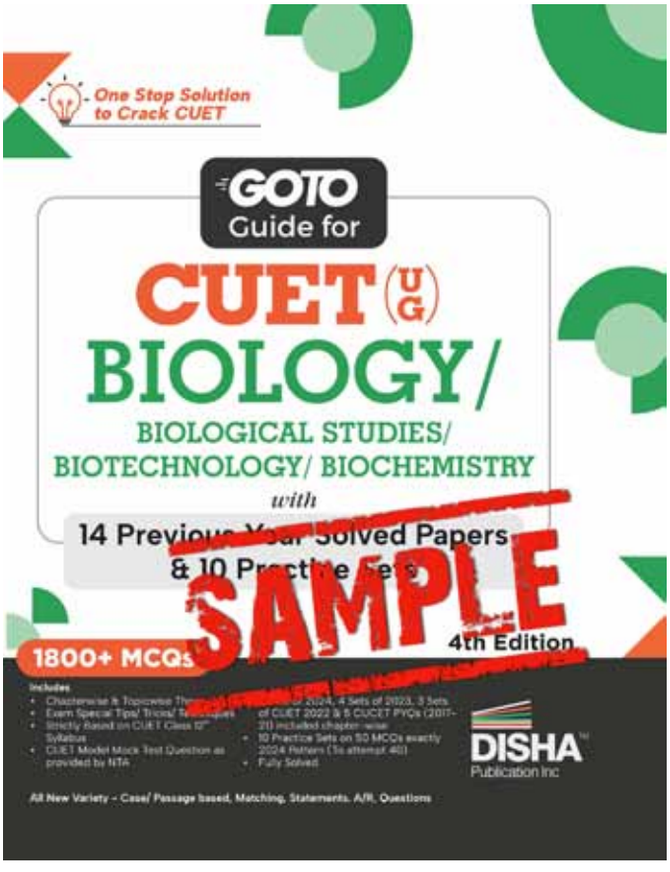

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Mock Tests

CHAPTER

2 Sexual Reproduction in Flowering Plants

Flower- A Fascinating Organ of Angiosperms

- To a biologist, flowers are morphological and embryological marvels and the sites of sexual reproduction.

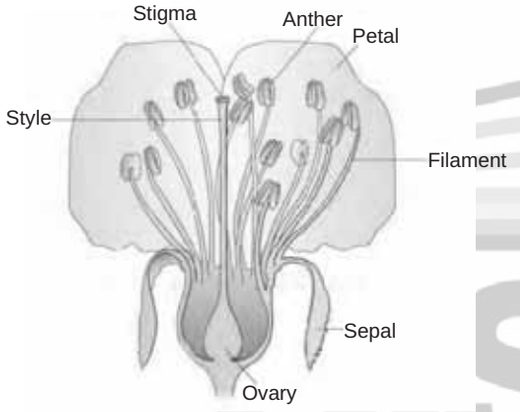


Fig.: A diagrammatic representation of L.S. of a flower

Pre-fertilisation: Structures and Events

- Several hormonal and structural changes are initiated which lead to the differentiation and further development of the **floral primordium**.
- **Inflorescences** are formed which bear the floral buds and then the flowers.
- In the flower the male and female reproductive structures, the **androecium** and the **gynoecium** differentiate and develop.

Stamen, Microsporangium and Pollen Grain

- The two parts of a typical **stamen** – the long and slender stalk called the **filament**, and the terminal generally bilobed structure called the **anther**. The proximal end of the filament is attached to the thalamus or the petal of the flower.
- The number and length of stamens are variable in flowers of different species.

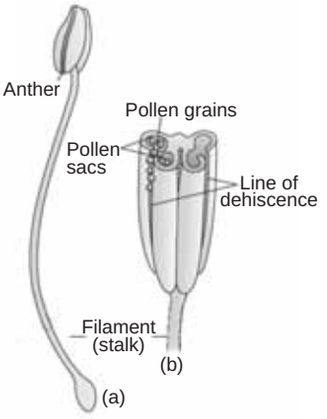


Fig. (a) A typical stamen;
(b) three–dimensional cut section of an anther

- A typical angiosperm anther is **bilobed** with each lobe having two theca, i.e., they are **dithecous**.
- Often a longitudinal groove runs lengthwise separating the theca.
- The bilobed nature of an anther is very distinct in the transverse section of the anther. The anther is a four-sided (tetragonal) structure consisting of four **microsporangia** located at the corners, two in each lobe.
- The microsporangia develop further and become **pollen sacs**. They extend longitudinally all through the length of an anther and are packed with pollen grains.
- **Structure of microsporangium:** In a transverse section, a typical microsporangium appears near circular in outline.
- It is generally surrounded by four wall layers – the **epidermis**, **endothecium**, **middle layers** and the **tapetum**.
- The outer three wall layers perform the function of protection and help in dehiscence of anther to release the pollen.
- The innermost wall layer is the **tapetum**. It nourishes the developing pollen grains. Cells of the tapetum possess dense cytoplasm and generally have more than one nucleus.
- When the anther is young, a group of compactly arranged homogenous cells called the **sporogenous tissue** occupies the centre of each microsporangium.

- **Microsporogenesis :** As the anther develops, the cells of the sporogenous tissue undergo meiotic divisions to form microspore tetrads.

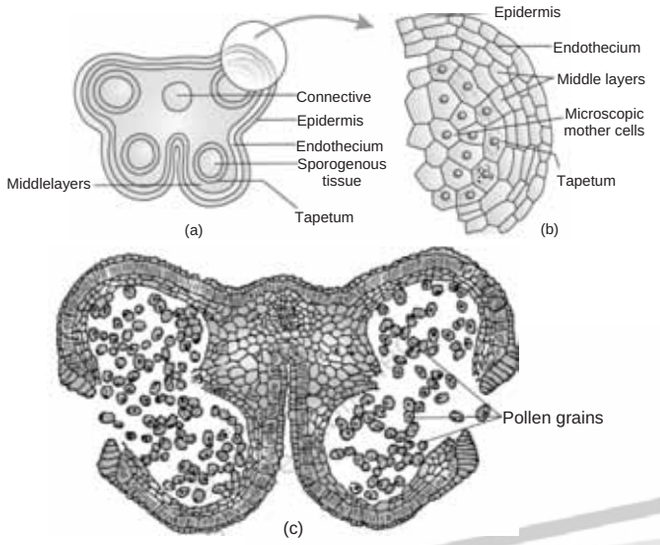


Fig.: (a) Transverse section of a young anther; (b) Enlarged view of one microsporangium showing wall layers; (c) A mature dehisced anther

- As each cell of the sporogenous tissue is capable of giving rise to a microspore tetrad. Each one is a potential pollen or microspore mother cell. The process of formation of microspores from a **pollen mother cell (PMC)** through meiosis is called **microsporogenesis**.
- The microspores, as they are formed, are arranged in a cluster of four cells–the **microspore tetrad**. As the anthers mature and dehydrate, the microspores dissociate from each other and develop into **pollen grains**.
- Inside each microsporangium several thousands of microspores or pollen grains are formed that are released with the dehiscence of anther.
- **Pollen grain:** The pollen grains represent the male gametophytes.

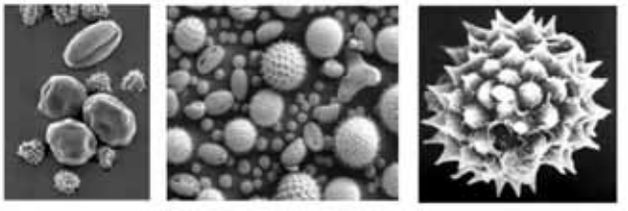


Fig.: Scanning electron micrographs of a few pollen grains

- Pollen grains are generally spherical measuring about 25-50 micrometers in diameter. It has 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.
- No enzyme that degrades **sporopollenin** is so far known. Pollen grain exine has prominent apertures called **germ pores** where **sporopollenin** is absent.
- Pollen grains are well preserved as fossils because of the presence of sporopollenin. The exine exhibits a fascinating array of patterns and designs.
- The inner wall of the pollen grain is called the **intine**. It is a thin and continuous layer made up of cellulose and pectin.
- The cytoplasm of pollen grain is surrounded by a plasma membrane. When the pollen grain is mature it contains two cells, the **vegetative cell** and **generative cell**.
- The vegetative cell is bigger, has abundant food reserve and a large irregularly shaped nucleus.
- The **generative cell** is small and floats in the cytoplasm of the vegetative cell. It is spindle shaped with dense cytoplasm and a nucleus. In over 60 per cent of angiosperms, pollen grains are shed at this **2-celled stage**.
- In the remaining species, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed (**3-celled stage**).
- Pollen grains of many species cause severe allergies and bronchial afflictions in some people often leading to chronic respiratory disorders– asthma, bronchitis, etc.
- *Parthenium* or carrot grass that came into India as a contaminant with imported wheat, has become ubiquitous in occurrence and causes **pollen allergy**.

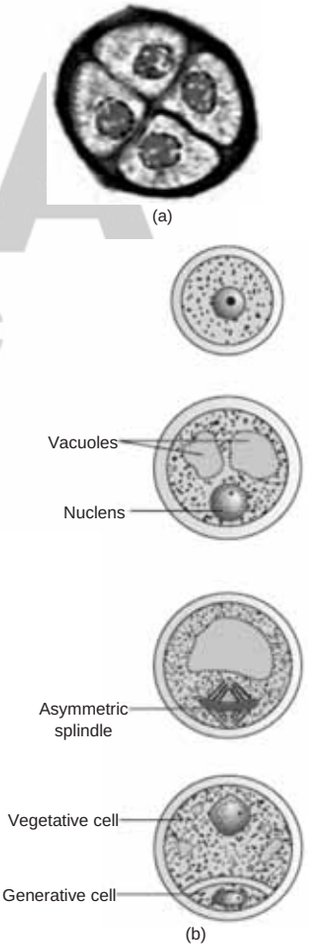


Fig.: (a) Enlarged view of a pollen grain tetrad; (b) stages of a microspore maturing into a pollen grain

- Pollen grains are rich in nutrients. It has become a fashion in recent years to use pollen tablets as food supplements.
- In western countries, a large number of pollen products in the form of tablets and syrups are available in the market.
- Pollen consumption has been claimed to increase the performance of athletes and race horses.

Fig.: Pollen products

- When once they are shed, pollen grains have to land on the stigma before they lose viability if they have to bring about fertilisation.
- The period for which pollen grains remain viable is highly variable and to some extent depends on the prevailing temperature and humidity.
- In some cereals such as rice and wheat, pollen grains lose viability within 30 minutes of their release, and in some members of Rosaceae, Leguminoseae and Solanaceae, they maintain viability for months.
- Pollen grains of a large number of species store for years in liquid nitrogen (**–196°C**). Such stored pollen can be used as pollen banks, similar to seed banks, in crop breeding programmes.

The Pistil, Megasporangium (ovule) and Embryo sac

- The gynoecium represents the female reproductive part of the flower. The gynoecium may consist of a single pistil (**monocarpellary**) or may have 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 has three parts, **the stigma, style and ovary**. The **stigma** serves as a landing platform for pollen grains.
- The style is the elongated slender part beneath the stigma. The basal bulged part of the pistil is the **ovary**. Inside the ovary is **the ovarian cavity (locule)**.
- **The placenta** is located inside the ovarian cavity.
- Arising from the placenta are the **megasporangia**, commonly called **ovules**.
- The number of ovules in an ovary may be one (wheat, paddy, mango) to many (papaya, water melon, orchids).

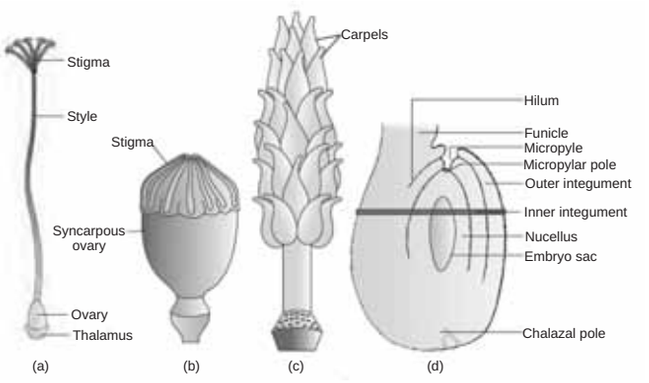


Fig.: (a) A dissected flower of *Hibiscus* showing pistil (other floral parts have been removed);
(b) Multicarpellary, syncarpous pistil of *Papaver*;
(c) A multicarpellary,
apocarpous gynoecium of *Michelia*;
(d) A diagrammatic
view of a typical anatropous ovule

- **The Megasporangium (Ovule) :** The ovule is a small structure attached to the placenta by means of a stalk called **funicle**.
- The body of the ovule fuses with funicle in the region called **hilum**. Thus, hilum represents the junction between ovule and funicle.
- Each ovule has one or two protective envelopes called **integuments**.
- Integuments encircle the nucellus except at the tip where a small opening called the **micropyle** is organised.
- Opposite the micropylar end, is the **chalaza**, representing the basal part of the ovule.
- Enclosed within the integuments is a mass of cells called the **nucellus**.
- Cells of the nucellus have abundant reserve food materials.
- Located in the nucellus is the **embryo sac** or **female gametophyte**.
- An ovule generally has a single embryo sac formed from a megaspore.
- **Megasporogenesis :** The process of formation of megaspores from the **megaspore mother cell** is called **megasporogenesis**. Ovules generally differentiate a single megaspore mother cell (MMC) in the micropylar region of the nucellus. It is a large cell containing dense cytoplasm and a prominent nucleus. The MMC undergoes meiotic division.
- Meiosis results in the production of four **megaspores**.

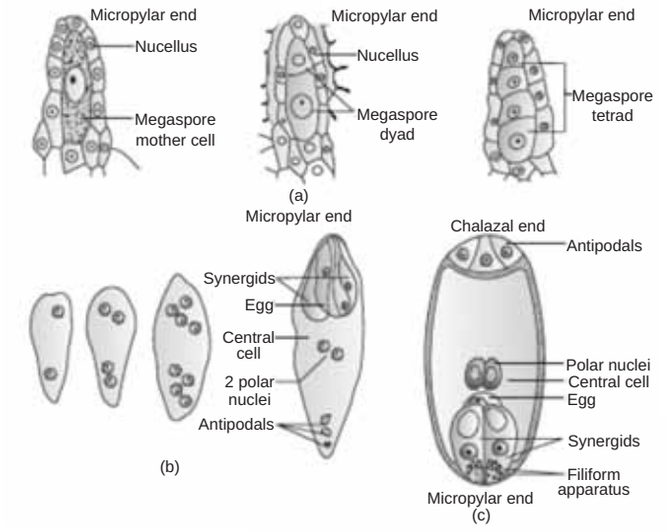


Fig.: (a) Parts of the ovule showing a large megaspore mother cell, a dyad and a tetrad of megaspores; (b) 2, 4, and 8-nucleate stages of embryo sac and a mature embryo sac; (c) A diagrammatic representation of the mature embryo sac.

- **Female gametophyte :** In a majority of flowering plants, one of the megaspores is **functional** while the other three degenerate. Only the **functional megaspore** develops into the female **gametophyte** (**embryo sac**). This method of embryo sac formation from a single megaspore is termed **monosporic** development.
- The nucleus of the functional megaspore divides mitotically to form two nuclei which move to the opposite poles, forming the **2-nucleate** embryo sac.
- Two more sequential mitotic nuclear divisions result in the formation of the **4-nucleate** and later the **8-nucleate** stages of the embryo sac.
- After the 8-nucleate stage, cell walls are laid down leading to the organisation of the typical **female gametophyte** or **embryo sac**.
- Six of the eight nuclei are surrounded by cell walls and organised into cells; the remaining two nuclei, called **polar nuclei** are situated below the egg apparatus in the large **central cell**.
- There is a characteristic distribution of the cells within the embryo sac.
- Three cells are grouped together at the micropylar end and constitute the **egg apparatus**. The egg apparatus, in turn, consists of two **synergids** and one **egg cell**.
- The synergids have special cellular thickenings at the micropylar tip called **filiform apparatus**, which play an important role in guiding the pollen tubes into the synergid. Three cells are at the chalazal end and are called the **antipodals**. The large central cell, as mentioned earlier, has **two polar nuclei**. Thus, a typical angiosperm embryo sac, at maturity, though 8-nucleate is **7-celled**.

Pollination

- Transfer of pollen grains (shed from the anther) to the stigma of a pistil is termed **pollination**.
- **Kinds of Pollination :** Depending on the source of pollen, pollination can be divided into three types.
  - (i) **Autogamy :** In this type, pollination is achieved within the same flower. Transfer of pollen grains from the anther to the stigma of the same flower.
    - ❖ In a normal flower which opens and exposes the anthers and the stigma, complete autogamy is rather rare.
    - ❖ Autogamy in such flowers requires synchrony in pollen release and stigma receptivity and also, the anthers and the stigma should lie close to each other so that self-pollination can occur.
    - ❖ Some plants such as Viola (common pansy), Oxalis, and Commelina produce two types of flowers – **chasmogamous** flowers which are similar to flowers of other species with exposed anthers and stigma, and **cleistogamous** flowers which do not open at all.
    - ❖ In such flowers, the anthers and stigma lie close to each other. When anthers dehisce in the flower buds, pollen grains come in contact with the stigma to effect pollination.
    - ❖ Thus, cleistogamous flowers are invariably autogamous as there is no chance of cross-pollen landing on the stigma. Cleistogamous flowers produce assured seed-set even in the absence of pollinators.
  - (ii) **Geitonogamy** – Transfer of pollen grains from the anther to the stigma of another flower of the same plant. Although geitonogamy is functionally cross-pollination involving a pollinating agent, genetically it is similar to autogamy since the pollen grains come from the same plant.
  - (iii) **Xenogamy** – Transfer of pollen grains from anther to the stigma of a different plant. This is the only type of pollination which during pollination brings genetically different types of pollen grains to the stigma.

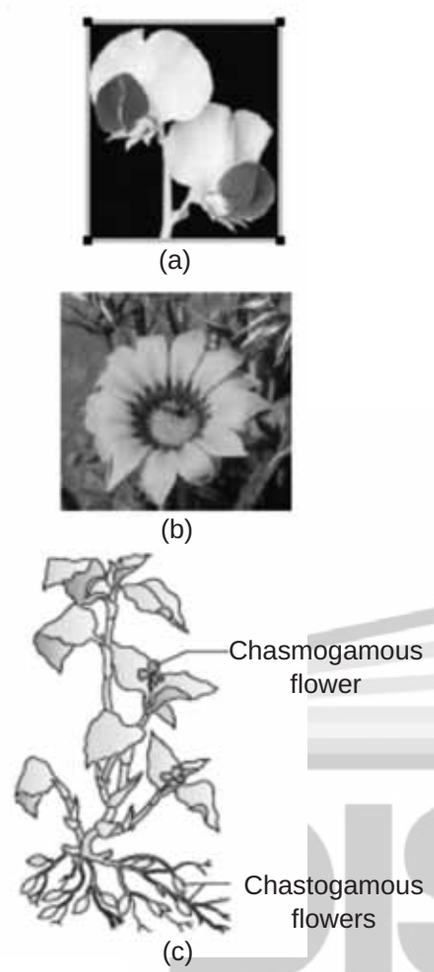


Fig.: (a) Self-pollinated flowers; (b) Cross pollinated flowers; (c) Cleistogamous flowers

- **Agents of Pollination :** Plants use two abiotic (wind and water) and one biotic (animals) agents to achieve pollination.
- Majority of plants use biotic agents for pollination. Only a small proportion of plants use abiotic agents.
- Pollen grains coming in contact with the stigma is a chance factor in both wind and water pollination.
- Pollination by wind is more common amongst abiotic pollinations.
- Wind pollination also requires that the pollen grains are light and non-sticky so that they can be transported in wind currents. They often possess 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 pollinated flowers often have a single ovule in each ovary and numerous flowers packed into an inflorescence; a familiar example is the *corn* **cob** – the tassels you see are nothing but the stigma and style which wave in the wind to trap pollen grains. Wind-pollination is quite common in grasses.

Fig.: A wind-pollinated plant showing compact inflorecence and wellexposed stamens

- Pollination by water is quite rare in flowering plants and is limited to about 30 genera, mostly monocotyledons.
- Some examples of water pollinated plants are *Vallisneria* and *Hydrilla* which grow in fresh water and several marine sea-grasses such as Zostera.
- Not all aquatic plants use water for pollination. In a majority of aquatic plants such as water hyacinth and water lily, the flowers emerge above the level of water and are pollinated by insects or wind as in most of the land plants.
- In *Vallisneria*, the female flower reach 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 passively by water currents, some of them eventually reach the female flowers and the stigma.
- In another group of water pollinated plants such as seagrasses, female flowers remain submerged in water and the pollen grains are released inside the water.
- Pollen grains in many such species are long, ribbon like and they are carried passively inside the water; some of them reach the stigma and achieve pollination.
- In most of the water-pollinated species, pollen grains are protected from wetting by a mucilaginous covering.
- Majority of flowering plants use a range of animals as pollinating agents. Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds and humming birds) and bats are the common pollinating agents.
- Among the animals, insects, particularly bees are the dominant biotic pollinating agents. Even larger animals such as some primates (lemurs), arboreal (tree-dwelling) rodents, or even reptiles (gecko lizard and garden lizard) have also been reported as pollinators in some species.
- Often flowers of animal pollinated plants are specifically adapted for a particular species of animal.

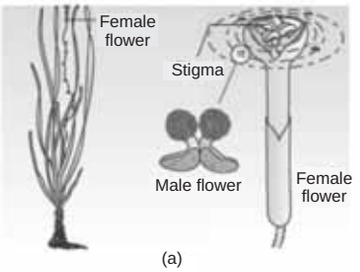


Fig.: (a) Pollination by water in *Vallisneria*; (b) Insect pollination

- Majority of insect-pollinated flowers are large, colourful, fragrant and rich in nectar.
- When the flowers are small, a number of flowers are clustered into an inflorescence to make them conspicuous.
- Animals are attracted to flowers by colour and/or fragrance.
- The flowers pollinated by flies and beetles secrete foul odours to attract these animals. To sustain animal visits, the flowers have to provide rewards to the animals.
- **Nectar** and **pollen grains** are the usual floral rewards.
- For harvesting the reward(s) from the flower the animal visitor comes in contact with the anthers and the stigma.
- The body of the animal gets a coating of pollen grains, which are generally sticky in animal pollinated flowers. When the animal carrying pollen on its body comes in contact with the stigma, it brings about pollination.
- In some species floral rewards are in providing safe places to lay eggs; an example is that of the tallest flower of *Amorphophallus* (the flower itself is about 6 feet in height).
- A similar relationship exists between a species of moth and the plant *Yucca* where both species – moth and the plant – cannot complete their life cycles without each other.
- The moth deposits its eggs in the locule of the ovary and the flower, in turn, gets pollinated by the moth. The larvae of the moth come out of the eggs as the seeds start developing.
- Many insects may consume pollen or the nectar without bringing about pollination. Such floral visitors are referred to as **pollen/nectar robbers**.
- **Outbreeding Devices :** Majority of flowering plants produce hermaphrodite flowers and pollen grains are likely to come in contact with the stigma of the same flower. Continued self-pollination result in **inbreeding depression**.
- Flowering plants have developed many devices to discourage selfpollination and to encourage cross-pollination. In some species, pollen release and stigma receptivity are not synchronised.
- Either the pollen is released before the stigma becomes receptive or stigma becomes receptive much before the release of pollen.
- In some other species, the anther and stigma are placed at different positions so that the pollen cannot come in contact with the stigma of the same flower. Both these devices prevent **autogamy**.
- The third device to prevent inbreeding is **self-incompatibility**. This is a genetic mechanism and prevents self-pollen (from the same flower or other flowers of the same plant) from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil.
- Another device to prevent self-pollination is the production of unisexual flowers. If both male and female flowers are present on the same plant such as castor and maize (monoecious), it prevents autogamy but not geitonogamy.
- In several species such as papaya, male and female flowers are present on different plants, that is each plant is either male or female (dioecy). This condition prevents both autogamy and geitonogamy.
- **Pollen-pistil Interaction :** Pollination does not guarantee the transfer of the right type of pollen (compatible pollen of the same species as the stigma).
- Often, pollen of the wrong type, either from other species or from the same plant (if it is self-incompatible), also land on the stigma.
- The pistil has the ability to recognise the pollen, whether it is of the right type (compatible) or of the wrong type (incompatible).
- If it is of the right type, the pistil accepts the pollen and promotes post-pollination events that leads to fertilisation.
- If the pollen is of the wrong type, the pistil rejects the pollen by preventing pollen germination on the stigma or the pollen tube growth in the style.
- The ability of the pistil to recognise the pollen followed by its acceptance or rejection is the result of a continuous dialogue between pollen grain and the pistil. This dialogue is mediated by chemical components of the pollen interacting with those of the pistil.

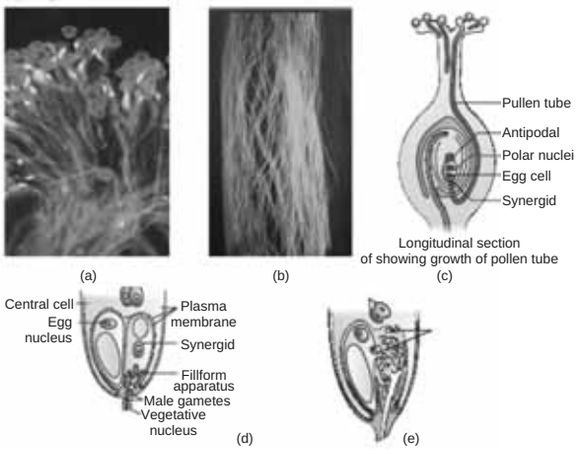


Fig.: (a) Pollen grains germinating on the stigma; (b) Pollen tubes growing through the style; (c) L.S. of pistil showing path of pollen tube growth; (d) enlarged view of an egg apparatus showing entry of pollen tube into a synergid; (e) Discharge of male gametes into a synergid and the movements of the sperms, one into the egg and the other into the central cell

- The compatible pollination, 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. Pollen tube grows through the tissues of the stigma and style and reaches the ovary.
- In plants which shed pollen in the three-celled condition, pollen tubes carry the two male gametes from the beginning. Pollen tube, after reaching the ovary, enters the ovule through the micropyle and then enters one of the synergids through the filiform apparatus.
- Filiform apparatus present at the micropylar part of the synergids guides the entry of pollen tube.
- All these events–from pollen deposition on the stigma until pollen tubes enter the ovule–are together referred to as **pollen-pistil interaction**.
- **Pollen-pistil interaction** is a dynamic process involving pollen recognition followed by promotion or inhibition of the pollen.
- **Artificial hybridisation** is one of the major approaches of crop improvement programme. In such crossing experiments it is important to make sure that only the desired pollen grains are used for pollination and the stigma is protected from contamination (from unwanted pollen). This is achieved by **emasculation** and **bagging techniques**.
- If the female parent bears bisexual flowers, removal of anthers from the flower bud before the anther dehisces using a pair of forceps is necessary. This step is referred to as **emasculation**.
- Emasculated flowers have to be covered with a bag of suitable size, generally made up of butter paper, to prevent contamination of its stigma with unwanted pollen. This process is called **bagging**.
- When the stigma of bagged flower attains receptivity, mature pollen grains collected from anthers of the male parent are dusted on the stigma, and the flowers are rebagged, and the fruits allowed to develop.
- 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

- After entering one of the synergids, the pollen tube releases 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 thus completing the **syngamy**. This results in the formation of a diploid cell, 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 termed **triple fusion**.
- Since two types of fusions, syngamy and triple fusion take place in an embryo sac the phenomenon is termed **double fertilisation**, an event unique to flowering plants.
- The central cell after triple fusion becomes the **primary endosperm cell** (PEC) and develops into the **endosperm** while the zygote develops into an **embryo**.

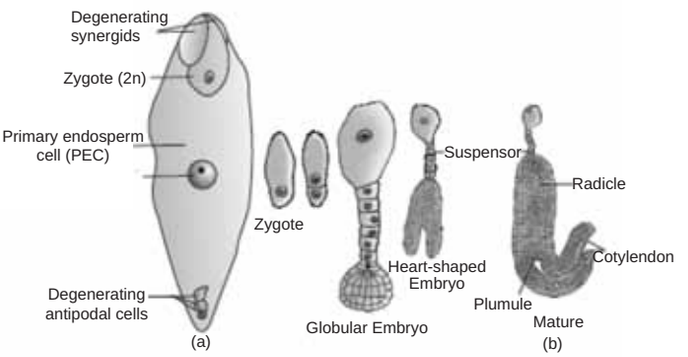


Fig.: (a) Fertilised embryo sac showing zygote and Primary Endosperm Nucleus (PEN); (b) Stages in embryo development in a dicot [shown in reduced size as compared to (a)]

Post-fertilisation: Structures and Events

- Following double fertilisation, events of endosperm and embryo development, maturation of ovule(s) into seed(s) and ovary into fruit, are collectively termed **post-fertilisation events**.

Endosperm

- Endosperm development precedes embryo development.
- The primary endosperm cell divides repeatedly and forms a triploid endosperm tissue.
- The cells of this tissue are filled with reserve food materials and are used for the nutrition of the developing embryo.
- In the most common type of endosperm development, the PEN undergoes successive nuclear divisions to give rise to free nuclei.
- This stage of endosperm development is called **free-nuclear endosperm**.
- Subsequently cell wall formation occurs and the endosperm becomes cellular. The number of free nuclei formed before cellularisation varies greatly.
- The coconut water from tender coconut that you are familiar with, is nothing but free-nuclear endosperm (made up of thousands of nuclei) and the surrounding white kernel is the **cellular endosperm**.
- Endosperm may either be completely consumed by the developing embryo (e.g., pea, groundnut, beans) before seed maturation or it may persist in the mature seed (e.g. castor and coconut) and be used up during seed germination.
- Split open some seeds of castor, peas, beans, groundnut, fruit of coconut and look for the endosperm in each case.

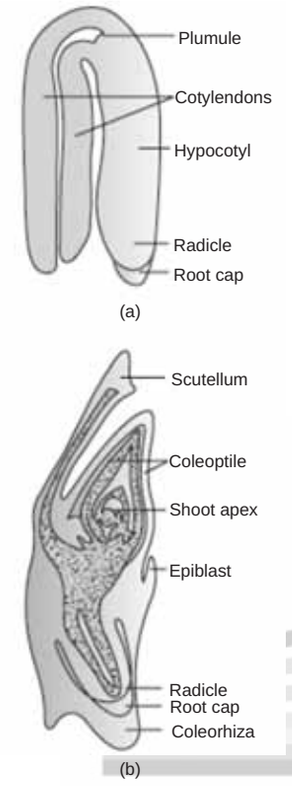


Fig.: (a) A typical dicot embryo; (b) L.S. of an embryo of grass

Embryo

- **Embryo** develops at the micropylar end of the embryo sac where the zygote is situated.
- Most zygotes divide only after certain amount of endosperm is formed. This is an adaptation to provide assured nutrition to the developing embryo.
- Though the seeds differ greatly, the early stages of embryo development (**embryogeny**) are similar in both monocotyledons and dicotyledons.
- Figure depicts the stages of embryogeny in a dicotyledonous embryo. The zygote gives rise to the **proembryo** and subsequently to the **globular, heart-shaped** and **mature embryo**.
- A typical dicotyledonous embryo, consists of an **embryonal axis** and two **cotyledons**.
- The portion of embryonal axis above the level of cotyledons is the epicotyl, which terminates with the **plumule** or stem tip.
- The cylindrical portion below the level of cotyledons is **hypocotyl** that terminates at its lower end in the **radicle** or **root tip**. The root tip is covered with a **root cap**.
- Embryos of monocotyledons possess only one cotyledon. In the grass family the cotyledon is called **scutellum** that is situated towards one side (lateral) of the embryonal axis.
- At its lower end, the embryonal axis has the radical and root cap enclosed in an undifferentiated sheath called **coleorrhiza**.
- The portion of the embryonal axis above the level of attachment of scutellum is the epicotyl.
- **Epicotyl** has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure, the **coleoptile**.

Seed

- In angiosperms, the seed is the final product of sexual reproduction. It is often described as a fertilised ovule. Seeds are formed inside fruits.
- A seed typically consists of seed coat(s), cotyledon(s) and an embryo axis. The cotyledons of the embryo are simple structures, generally thick and swollen due to storage of food reserves (as in legumes).
- Mature seeds may be **non-albuminous** or **ex-albuminous**. Non-albuminous seeds have no residual endosperm as it is completely consumed during embryo development (e.g., pea, groundnut).
- Albuminous seeds retain a part of endosperm as it is not completely used up during embryo development (e.g., wheat, maize, barley, castor).
- Occasionally, in some seeds such as black pepper and beet, remnants of nucellus are also persistent. This residual, persistent nucellus is the **perisperm**.
- Integuments of ovules harden as tough protective seed coats.
- The micropyle remains as a small pore in the seed coat. This facilitates entry of oxygen and water into the seed during germination.
- As the seed matures, its water content is reduced and seeds become relatively dry (10-15 per cent moisture by mass).
- The general metabolic activity of the embryo slows down. The embryo may enter a state of inactivity called **dormancy,** or if favourable conditions are available (adequate moisture, oxygen and suitable temperature), they germinate.
- As ovules mature into seeds, the ovary develops into a fruit, i.e., the transformation of ovules into seeds and ovary into fruit proceeds simultaneously.
- The wall of the ovary develops into the wall of fruit called **pericarp**.
- The fruits may be fleshy as in guava, orange, mango, etc., or may be dry, as in groundnut, and mustard, etc.
- Many fruits have evolved mechanisms for dispersal of seeds.
- In most plants, by the time the fruit develops from the ovary, other floral parts degenerate and fall off. However, in a few species such as apple, strawberry, cashew, etc., the thalamus also contributes to fruit formation. Such fruits are called false fruits.
- Most fruits however develop only from the ovary and are called **true fruits**.

- Although in most of the species, fruits are the results of fertilisation, there are a few species in which fruits develop without fertilisation. Such fruits are called **parthenocarpic fruits**.
- Banana is one such example.
- Parthenocarpy can be induced through the application of growth hormones and such fruits are seedless.

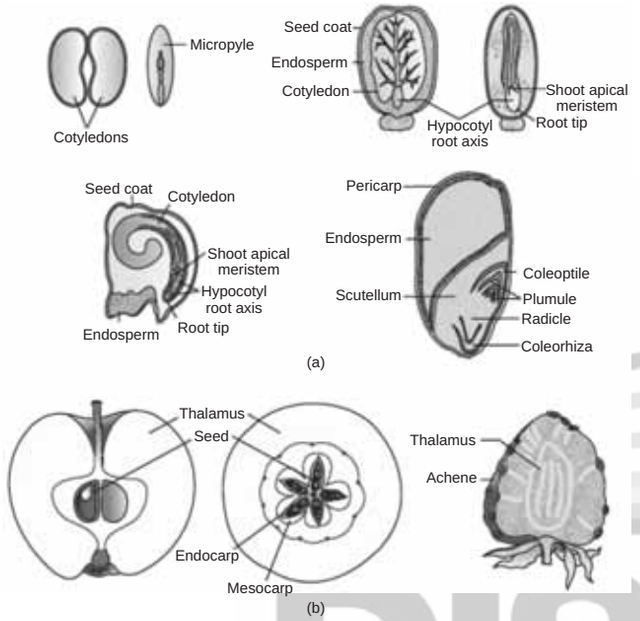


Fig.: (a) Structure of some seeds.
(b) False fruits of apple and strawberry

- Seeds offer several advantages to angiosperms.
- Firstly, since reproductive processes such as pollination and fertilisation are independent of water, seed formation is more dependable.
- Also seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas.
- As they have sufficient food reserves, young seedlings are nourished until they are capable of photosynthesis on their own.
- The hard seed coat provides protection to the young embryo. Being products of sexual reproduction, they generate new genetic combinations leading to variations.
- Seed is the basis of our agriculture. **Dehydration** and **dormancy** of mature seeds are crucial for storage of seeds which can be used as food throughout the year and also to raise crop in the next season.
- In a few species the seeds lose viability within a few months. Seeds of a large number of species live for several years.
- Some seeds can remain alive for hundreds of years. There are several records of very old yet viable seeds.
- The oldest is that of a lupine, Lupinus arcticus excavated from Arctic Tundra.
- The seed germinated and flowered after an estimated record of 10,000 years of dormancy. A recent record of 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

- Although seeds, in general are the products of fertilisation, a few flowering plants such as some species of Asteraceae and grasses, have evolved a special mechanism, to produce seeds without fertilisation, called **apomixis**.
- Apomixis is a form of asexual reproduction that mimics sexual reproduction.
- There are several ways of development of apomictic seeds.
- In some species, the diploid egg cell is formed without reduction division and develops into the embryo without fertilisation.
- Citrus and Mango varieties some of the nucellar cells surrounding the embryo sac start dividing, 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 referred to as **polyembryony**.

Shortcut, Tips & Tricks

- Multicarpellary, syncarpous, gynoecium is found in *Papaver* and *Hibiscus*.
- Multicarpellary, apocarpous gynoecium is found in rose, lotus and Michelia.
- Nucellar adventative embryony is found in *Citrus* and mango.
- Three germspores are present in pollen grain of most of the dicots, (Capsella). This type of pollen grains are called tricolpate.
- Ploidy of cells : Nucellus (2n), MMC (2n), Functional megaspore (n), Female gametophyte (n).
- Yellow clouds of pollens are formed by *Pinus* tree due to the pollen grains which is called 'sulphur shower'.
- Favourable color of honey bees is yellow, but they are blind to red colour.

Exercise

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

2. 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

3. 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.

4. Match the items given in column-I with those given in column-II and choose the correct option given below.

Column-I		Column-II	
A.	Tapetum	I.	Irregular in shape with abundant food reserve
B.	Exine	II.	Acts as nutritive layer
C.	Pollenkit	III.	Thick, rigid protective layer
D.	Vegetative cell	IV.	Involve in the formation of microspores
		V.	Oily and sticky layer, tissue help in pollination.

(a) A – II; B – III; C – V; D – IV
(b) A – I; B – III; C – II; D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – II; B – IV; C – V; D – I

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

6. Endosperm is generally
(a) diploid (b) triploid
(c) haploid (d) polyploid

7. Which of the following is an example of false fruit?
(a) apple and pear (b) strawberry
(c) cashewnut (d) All of these

8. 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)

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

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

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

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

13. **Assertion:** The megaspore mother cell divides mitotically to produce four spores.

Reason: Megaspore mother cells are diploid and megaspore is haploid.
(a) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(b) (A) is correct but (R) is not correct
(c) (A) is not correct but (R) is correct
(d) Both (A) and (R) are correct and (R) is the correct explanation of (A)

14. In angiosperms, female gametophyte is represented by
(a) synergids (b) carpel
(c) egg (d) pollen grains

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. One of the most resistant known biological material is.
(a) lignin
(b) hemicellulose
(c) sporopollenin
(d) lignocellulose

17. **Statement I:** The primary endosperm cell (PEC) and develops into the endosperm

Statement II: the zygote develops into an embryo.
(a) Both Statement I and Statement II are incorrect
(b) Statement I is correct but Statement II is incorrect
(c) Statement I is incorrect but Statement II is correct
(d) Both Statement I and Statement II are correct

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

19. Match column-I with column-II and select the correct answer using the codes given below.

	Column-I		Column-II
A.	Funicle	I.	Chalazogamy
B.	Hilum	II.	One or 2 protective layers of ovule
C.	Integument	III.	Region where body of ovule fuses with funicle
D.	Chalaza	IV.	Stalk of ovule

(a) A – I; B – II; C – III; D – IV
(b) A – IV; B – III; C – II; D – I
(c) A – IV; B – II; C – III; D – I
(d) A – I; B – III; C – II; D – IV

20. The "embryo sac" is also called the
(a) megagametophyte (b) megaspore
(c) megasporangium (d) megasporocyte

21. Match column-I with column-II and choose the correct option given below.

	Column-I		Column-II
A.	Calyx	I.	Carpel
B.	Corolla	II.	Petal
C.	Androecium	III.	Sepal
D.	Gynoecium	IV.	Stamen

(a) A – II; B – I; C – IV; D – III
(b) A – I; B – II; C – III; D – IV
(c) A – III; B – II; C – IV; D – I
(d) A – III; B – IV; C – I; D – II

22. Self-pollination results in progeny that
(a) are identical to the parent.
(b) are somewhat different because mutations are common.
(c) may express a recessive gene if the parent is heterozygous.
(d) may be heterozygous in a locus where the parent is homozygous.

23. The structure of bilobed anther consists of
(a) 2 thecae, 2 sporangia
(b) 4 thecae, 4 sporangia
(c) 4 thecae, 2 sporangia
(d) 2 thecae, 4 sporangia

24. Study the following statements and select the correct option.
(i) Tapetum nourishes the developing pollen grains.
(ii) Hilum represents the junction between ovule and funicle.
(iii) In aquatic plants, such as water hyacinth and water lily, pollination is by water.
(iv) The primary endosperm nucleus is triploid.
(a) (i) and (ii) are correct but (iii) and (iv) are incorrect.
(b) (i), (ii) and (iv) are correct but (iii) is incorrect.
(c) (ii), (iii) and (iv) are correct but (i) is incorrect.
(d) (i) and (iv) are correct but (ii) and (iii) are incorrect.

25. Geitonogamy involves:
(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.

26. 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.

27. Which one of the following statements is not true?
(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

28. Female gametophyte of angiosperms is represented by
(a) Ovule
(b) Megaspore mother cell
(c) Embryo sac
(d) Nucellus

29. 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

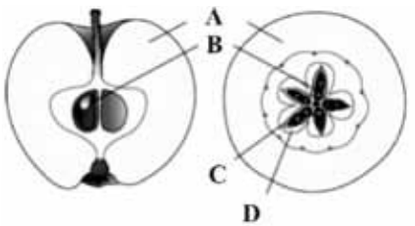
30. The functional megaspore undergoes
(a) 3 meiotic divisions to form embryo sac
(b) 3 meiotic divisions to form embryo sac
(c) 3 mitotic divisions
(d) 2 mitotic divisions

31. Which of the following statement(s) is/are correct about self-incompatibility?
(i) It is a device to prevent inbreeding.
(ii) It is governed by series of multiple alleles.
(iii) It ensures cross fertilisation.
(iv) It is governed by pollen-pistil interaction.
(v) It prevents self pollen (from the same flower of other flowers of the same plant) from fertilising the ovules by inhibiting pollen germination of pollen tube growth in the pistil.
(a) All are correct
(b) All are incorrect
(c) (i), (ii) and (iii) are correct
(d) (iv) and (v) are incorrect

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

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

34. Identify A, B, C and D in the given figure of false fruit of apple



(a) A – Mesocarp; B – Endocarp; C – Seed; D – Thalamus
(b) A – Seed; B – Thalamus; C – Mesocarp; D – Endocarp
(c) A – Thalamus; B – Seed; C – Endocarp; D – Mesocarp
(d) A – Mesocarp; B – Endocarp; C – Seed; D – Thalamus

35. 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

36. Which of the following statement is incorrect regarding artificial hybridisation.
(a) Desired pollen grains are used for pollination.
(b) Anther is protected from contamination.
(c) This is achieved by emasculation and bagging techniques.
(d) It is major approaches of crop improvement programme.

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

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

39. An organic substance that can withstand environmental extremes and cannot be degraded by any enzyme is :
(a) Cuticle (b) Sporopollenin
(c) Lignin (d) Cellulose

40. Wind pollinated flowers are
(a) small, brightly coloured, producing large number of pollen grains
(b) small, producing large number of dry pollen grains
(c) large producing abundant nectar and pollen
(d) small, producing nectar and dry pollen

41. Which of the following statement(s) is/are false?
(i) Pollen grains represents immatured male gametophyte.
(ii) In angiosperms, partially developed male gametophytes are pollinated.
(iii) Formation and differentiation of pollen grains is called microsporogenesis.
(iv) Pollen grains of some plants produce severe allergy and respiratory or bronchial diseases.
(v) Pollen grains are poor in nutrients.
(a) Only (i) (b) Only (v)
(c) Only (iv) and (v) (d) Only (ii)

42. Which one of the following pairs of plant structures has haploid number of chromosomes?
(a) Megaspore mother cell and antipodal cells
(b) Egg cell and antipodal cells
(c) Nucelus and antipodal cells
(d) Egg nucleus and secondary nucleus

43. The arrangement of the nuclei in a normal embryo sac in the dicot plants is
(a) 3 + 2 + 3 (b) 2 + 3 + 3
(c) 3 + 3 + 2 (d) 2 + 4 + 2

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

45. Which of the following statements are correct about self pollination?
(i) Self pollination is the most economic method as wastage of pollen grain is minimum.
(ii) Genetic stability can be maintained in the progeny through self pollination.
(iii) Undersirable characters can be eliminated through self pollination.
(iv) Continued self pollination may result in weaker progeny.
(v) Self pollination favours evolution.
(a) (i), (ii), (iv) are correct.
(b) (iii), (v) are correct.
(c) (i), (iii), (v) are correct.
(d) All are correct.

Case/Passage Based Questions (46-50)

Read the following passage and answer the questions (46 to 50)

After entering one of the synergids, the pollen tube releases 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 thus completing the syngamy. This results in the formation of a diploid cell, 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 termed triple fusion. Since two types of fusions, syngamy and triple fusion take place in an embryo sac the phenomenon is termed double fertilisation, an event unique to flowering plants. The central cell after triple fusion becomes the primary endosperm cell (PEC) and develops into the endosperm while the zygote develops into an embryo.

46. In a fertilized ovule, *n*, 2*n* and 3*n* conditions occur respectively in
(a) antipodal, egg and endosperm.
(b) egg, nucellus and endosperm.
(c) endosperm, nucellus and egg.
(d) antipodals, synergids and integuments.

47. Endosperm is generally
(a) diploid (b) triploid
(c) haploid (d) polyploid

48. Double fertilization is
(a) Fusion of two male gametes of a pollen tube with two different eggs
(b) Fusion of one male gamete with two polar nuclei
(c) Syngamy and triple fusion
(d) Fusion of two male gametes with one egg

49. The total number of nuclei involved in double fertilisation in angiosperms are
(a) two (b) three
(c) four (d) five

50. If a diploid female plant and a tetraploid male plant are crossed, the ploidy of endosperm shall be
(a) tetraploid (b) triploid
(c) diploid (d) pentaploid

Past Years Questions

51. 3-celled male gamete develops in : **[2017]**
(a) *Cycas* (b) *Pinus*
(c) *Ephedra* (d) *Hibiscus*

52. Parthenocarpic fruit formation would not be desirable in the cultivation of **[2019]**
(a) Guava (b) Cucurbits
(c) Apples (d) Pomegranates

53. Filiform apparatusis a highly thickened structure commonly present in **[2019]**
(a) Synergids cells (b) Egg cells
(c) Antipodal cells (d) Secondary nucleus

54. Pollination in Ficus plant is dependent on **[2020]**
(a) Air (b) Water
(c) Insect (d) Bird

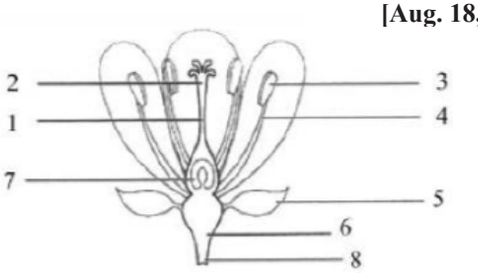
55. Seed dispersal in squirting cucumber occurs via **[2021]**
(a) wind (b) water
(c) ballistic mechanism (d) animal consumption

56. Silique is the fruit of the family **[2021]**
(a) Cucurbitaceae (b) Malvaceae
(c) Brassicaceae (d) Leguminosae

57. Fruit which develop only from the ovary are called- **[Aug. 18, 2022]**
(a) False fruits (b) Parthenocarpic fruits
(c) True fruits (d) Apomictic fruits

58. Perisperm differs from endosperm is that it is- **[Aug. 18, 2022]**
(a) Haploid having reserve food
(b) Polyploid having reserve food
(c) Triploid having no reserve food
(d) Diploid having no reserve food

59. Identify and name the two parts in a flower which are most important units of sexual reproduction? **[Aug. 18, 2022]**



(a) 1 - Style, 3 - stamen
(b) 4 - filament, 6 - thalamus
(c) 3 - Anther, 7 - ovary
(d) 2 – Stigma, 5 - sepals

60. Which layer of microsporangium is nutritive in function? **[Aug. 18, 2022]**
(a) Epidermis (b) Endothecium
(c) Middle Layers (d) Tapetum

61. _____ is aquatic plant showing insect pollination **[Aug. 20, 2022]**
(a) *Hydrilla* (b) *Vallisneria*
(c) Zostera (d) Water hyacinth

62. Which of the following is NOT a feature of insect pollinated plant? **[Aug. 20, 2022]**
(a) Light and non sticky pollen grains
(b) Flowers are large and colourful
(c) Presence of nectar
(d) Flower with fragrance

63. Grasses show pollination by **[Aug. 20, 2022]**
(a) Water (b) Insect
(c) Wind (d) Animals

64. Which of these are the carriers of male gametes in some seed plants? **[Aug. 30, 2022]**
(a) Microspore mother cells
(b) Pollen Grains
(c) Anthers
(d) Megaspore mother cells

65. Select the appropriate options with reference to post fertilisation changes in angiosperms. **[Aug. 30, 2022]**
A. Inner integument of ovule develops into tegmen.
B. Ovary wall forms pericarp

C. Ovule forms fruit
D. Zygote forms endosperm
E. Outer integument of ovule develops into Testa

Choose the correct answer from the options given below:
(a) B, E only (b) A, B, E only
(c) C, D, B only (d) A, C, B only

66. In flowering plants, the egg apparatus consists of: **[Aug. 30, 2022]**
(a) Three antipodals and one egg cell
(b) Two synergids and one central cell
(c) Two synergids and one egg cell
(d) Three antipodals and two synergids

ANSWER KEYS																			
1	(a)	**8**	(c)	**15**	(c)	**22**	(c)	**29**	(d)	**36**	(b)	**43**	(a)	**50**	(a)	**57**	(c)	**64**	(b)
2	(b)	**9**	(c)	**16**	(c)	**23**	(b)	**30**	(c)	**37**	(d)	**44**	(d)	**51**	(d)	**58**	(d*)	**65**	(b)
3	(b)	**10**	(b)	**17**	(d)	**24**	(b)	**31**	(a)	**38**	(c)	**45**	(a)	**52**	(d)	**59**	(c)	**66**	(c)
4	(a)	**11**	(c)	**18**	(b)	**25**	(a)	**32**	(b)	**39**	(b)	**46**	(b)	**53**	(a)	**60**	(d)		
5	(a)	**12**	(d)	**19**	(d)	**26**	(a)	**33**	(d)	**40**	(b)	**47**	(b)	**54**	(c)	**61**	(d)		
6	(b)	**13**	(c)	**20**	(a)	**27**	(a)	**34**	(c)	**41**	(b)	**48**	(c)	**55**	(d)	**62**	(a)		
7	(d)	**14**	(c)	**21**	(c)	**28**	(c)	**35**	(d)	**42**	(b)	**49**	(d)	**56**	(c)	**63**	(a)		

Solutions

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

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

4. **(a)** A – II; B – III; C – V; D – IV

5. **(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.

6. **(b)**

7. **(d)** In some, the thalamus also contributes to fruit formation & such fruits are called false fruits. for example : apple, pear, strawberry and cashewnut.

8. **(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.

10. **(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.

13. **(c)** The megaspore mother cell is diploid. This divides by meiotic division and produces four haploid megaspores.

16. **(c)** Sporopollenin is the most resistant known biological material. It is resistant to several biological & chemical decomposition & can be preserved as fossils.

17. **(d)** Both statements are correct.

19. **(d)**

21. **(c)** A – III; B – II; C – IV; D – I

23. **(b)**

24. **(b)** Aquatic plants such as water hyacinth & Lily, the flower semerge above the level of water & are pollinated by insects & wind.

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

26. **(a)** Crossing leads to hybrid vigour or superiority.

27. **(a)** Honey is produced by worker bees using nectar (fructose) of flowering plants.

28. **(c)** Embryo sac is 7-celled structure. There is a large central cell with two polar nuclei, egg apparatus with egg cell and 2 synergids present at micropylar end and its chalazal end, 3 antipodal cells are present.

29. **(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).

31. **(a)**

32. **(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.

34. **(c)** False fruit are those fruits in which addition to ovary other floral parts (like thalamus) also contribute for its development is called false fruits.
Examples– apple, pear, strawberry and cashewnut. In the given figure of false fruit (apple), the structure marked as A, B, C and D are respectively thalamus, seed, endocarp and mesocarp.

Thalamus is a receptacle of a flower in which the embryo fruits and later the seeds are held. Seed is a fertilized and ripened ovule and the characteristics of gymnosperms and angiosperms. Endocarp is the innermost layer of the pericarp which surrounds a seed in a fruit. It may be membranous (as in apples) or woody (as in the stone of a peach or cherry). Mesocarp is the middle layer of the pericarp of a fruit, between the endocarp and the exocarp.

36. **(b)** Stigma is protected from contamination. While anther is extract by the help of forceps through emasculation process

37. **(d)** 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 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.

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

39. **(b)** Sporopollenin is fatty substance present in pollen wall and provides resistance against extremes conditions like high temperature, acid, bases.

40. **(b)** Pollination by wind is called anemophily. Wind pollinated flowers are small in size, producing large number of dry pollen grains. Pollens are small, dry and light in weight. Grasses are anemophilous plants.

41. **(b)**

43. **(a)** In a dicot plant general arrangement of nuclei in the embryosac is that 3 nuclei in 3 cells of egg apparatus (one egg cell & 2 synergids) at micropylar end and 2 polar nuclei in almost middle region and 3 nuclei in the form of antipodals at the distal end from micropyle, towards nucellus. So total nuclei 3 + 2 + 3.

44. **(d)** Antipodal cells occur at the chalazal end of the ovule. Synergids are the helping cells.

45. **(a)**

46. **(b)** In a fertilized ovule n, 2n and 3n conditions occur respectively in egg, nucellus and endosperm.

47. **(b)** Endosperm of angiosperms is triploid in nature. As, one of the male gamete moves towards the egg cell & fuses with its nucleus results in the formation of a diploid zygote where as the other male gamete moves towards the two polar nuclei located in the central cell & fuses with the polar nuclei results in the formation of a triploid primary endosperm nucleus.

48. **(c)** Double fertilization is a unique phenomenon that occurs in angiosperms only.

Double fertilization = Syngamy + Triple fusion

49. **(d)** In the cytoplasm of the synergid, pollen tube releases the two male gametes. One of two male gametes fuses with egg to form diploid zygote (2n) while the other uses with two polar nucles of the central cell to produce triploid primary endosperm nucleus (3n).

50. **(a)** Diploid female plant will have 2 polar nuclei (each haploid) with which one male gamete form tetraploid male plant (male gamete of tetraploid plant will be diploid) fuses, to form endosperm. So endosperm will be tetraploid.

Male gamete + 2 polar nuclei → Endosperm
($2n$) (n) (n) ($4n$)
(Male) (Female)

53. **(a)** The synergids have special cellular thickenings at the micropylar tip called filiform apparatus, which play an important role in guiding the pollen tube into the synergid.

54. **(c)** Figs are pollinated by wasps that belong to Hymenoptera, family Agaonidae.

55. **(d)** Cucumber plants mostly disperse their seeds **through the help of animals**. Animals eat the fruit and then move along to a new area.

56. **(c)** The fruit of *Siliqua* is a characteristic found in many species of the family of **Brassicaceae (Brassica)** while in case of some species, there are silicles present.

57. **(c)** True fruit is the one that developed from mature ripened ovary and is also known as eucarp whereas the fruit developed from floral parts other than ovary is known as false fruit. Therefore , fruit developed from only from ovary is called true fruit. Hence, option C is correct.

58. **(d*)** Endosperm is a tissue produced inside the seeds of most flowering plants around the time of fertilization. It surrounds the embryo and provides nutrition in the form of starch, though it can also contain oils and protein. These are typically triploid but can vary widely from diploid. Perisperm develops from the nucellus of the seed and the endosperm develops when the sperm cell fuses with two haploid polar nuclei (contained in the central cell) in the centre of the embryo sac (or ovule). The resulting cell is triploid (3n). Perisperm is remnants of nucellus which is diploid (2n). But both endosperm and Perisperm store food. So, option D is having some mistake as only difference in the ploidy is correct.

59. **(c)** **Androecium and gynoecium** are the two most important parts of sexual reproduction in plants as they produce the male and female gametes respectively. The most important units in androecium and gynoecium are the anther and ovary as they produce gametes necessary for sexual reproduction in plants.
Hence, option C is correct.

60. **(d)** The tapetum is a specialised layer of nutritive cells found within the anther, of flowering plants, where it is located between the sporangenous tissue and the anther wall. Tapetum is important for the nutrition and development of pollen grains, as well as a source of precursors for the pollen coat. Hence, option D is correct.

61. **(d)** In a majority of aquatic plants like water hyacinth and water lily, the flowers emerge above the water level and are pollinated by insects or wind as in most of the land plants.

62. **(a)** **63.** **(c)**

64. **(b)** Pollen tubes are produced by the male gametophytes of seed bearing plants. They act as conduits to transport the male gamete cells from the pollen grain or from the stigma (in flowering plants) to the ovules at the base of the pistil.

65. **(b)** Formation of endosperm from primary endosperm cell.

- Formation of embryo from zygote
- Formation of seed from ovule
- During seed formation, integuments develops into seed coats. Outer integument forms testa (outer seed coat) while inner integument forms tegmen (inner seed coat).
- Formation of pericarp from ovary wall.

66. **(c)** Egg apparatus is a group of three cells found at the micropylar end of a common angiosperm embryo sac. The three cells are – an egg cell and two synergids. The egg apparatus is formed because of the mitotic division of the megaspore.