DAY TWENTY SIX

Reproduction in Plants

Learning & Revision for the Day

- Asexual Reproduction
- Sexual Reproduction
- Sexual Reproduction in Flowering Plants
- Development of male and female gametophyte
- Post-Fertilisation Events

Reproduction is a biological process by which an organism produces another organism (offspring) similar to itself. It is meant for perpetuation of species.

Plants exhibit several modes of reproduction, i.e. asexual and sexual reproduction.

Asexual Reproduction

It is uniparental mode that involves formation of new individuals from specialised or non-specialised parts of the parent without the meiotic formation gametes and their fusion. Only mitotic divisions are involved in asexual reproduction.

The various modes of asexual reproduction in various organisms are as follows

(i) **Binary fission** is the process of division of parent cell into two daughter cells of equal size.
- During binary fission, the cell elongates and its nucleus divides into two daughter nuclei.
- A transverse wall is formed in the centre of parent cell, dividing it into two daughter cells, which later on separate and lead independent lives.
- It is the characteristic feature of some yeasts, algae and bacteria.

(ii) **Sporulation** is the process of formation of spores. It is found in algae, fungi, bryophytes and pteridophytes.

(iii) **Budding** occurs when the parent cell produces one or more bud-like protuberances, which detach from parent cell and grow into new individual. Such type of reproduction is very common in yeast (*Saccharomyces*), where chain of buds may produce pseudomycelium.

(iv) **Gemmule** is a single cell or a mass of cell, or a modified bud of tissue that germinate into new plant on detachment from the parent, e.g. *Marchantia*.

(v) **Fragmentation** is the process of breaking down of parent individual into small pieces or fragments accidently or through external force. Each piece or fragment develops into a new individual.

This type of reproduction is very common in lower forms like algae, fungi and lichens.

(vi) **Vegetative propagation** is the ability of plants to reproduce *via* its vegetative structures like root, stem and bud, etc. It takes place by following methods

(a) **Cutting** In this method a small part of any plant organ (stem/root/leaf) is used for its propagation, e.g. stem cutting in sugarcane, grapes, cocoa, rose, *Bougainvillea*, etc.

(b) **Layering** is a process in which a ring of the bark is removed from lower branch and bent down and is covered by soft soil.

After 2-3 months, root develops and the branch is cut off to grow independently, e.g. lemon, grapes, strawberry, etc.

(c) **Air layering** is a process in which a ring of bark is removed from an aerial shoot. It is covered by grafting clay (water, clay, cow, dung, etc.).

After 1-2 months, roots appear and the shoot is removed to be used for planting, e.g. litchi, pomegranate.

(d) **Grafting** is a process in which the upper part (scion) of one plant is joined to the root system (stock) of another plant, so that they conjugate to grow as a single plant.

Grafting is especially successful in dicotyledonous plants, where stem has cambium layer, e.g. citrus, mango, rose, apple, etc.

(e) **By leaves** It occurs when plantlets develop along the margins of intact leaves, e.g. *Begonia, Saintpaulia, Bryophyllum,* etc.

(f) **Tissue culture** is a man-made process in which new plants are grown by culturing tissue or cells from the growing tip of a plant. They are cultured in an artificial medium, where they divide and form a small group of cells called **callus**.

- After this the callus is transferred to another medium for growth and differentiation and the plantlets are placed in the soil, so that plantlets can grow into mature plant.
- Raising a new plant by this method is called **micropropagation**.

NOTE **Vegetative propagation** also takes place by runners, e.g. *Cynodon* (doob grass), *Oxalis,* etc., bulbs, e.g. *Allium cepa, Tulipa,* etc., rhizomes, e.g. *Zingiber, Marsilea,* etc., offset, e.g. *Eichhornia, Pistia* and by roots, e.g. *Murraya* sp., *Albizzia lebbek* and *Dalbergia sissoo.*

Ordinary roots of ***Dalbergia sissoo***, guava, etc., can develop adventitious buds which grow to form new plants.

Sexual Reproduction

It involves the formation of an offspring through the fusion of egg and sperm (gametes) by the process of fertilisation. Gametes formed as a result of meiosis. It brings about new genetic recombinations.

In flowering plants, male gametes, are produced inside the pollen grains of anthers whereas female gamete is produced inside the embryo sac in an ovule.

1. **Sexual reproduction in algae and fungi** involves plasmogamy (fusion of protoplasts of male and female cells), karyogamy (fusion of male and female nuclei forming zygotic nucleus) and subsequently meiosis to convert diploid zygote into haploid spores.
2. **Sexual reproduction in bryophytes and pteridophytes** involves multicellular sex organs which are covered by multicellular sterile jacket.
   - The male sex organ is the antheridium which produces antherozoids.
   - The female sex organ is the flask-shaped archegonium (that encloses the egg or oosphere).
   - On maturity, the egg fuses with the antherozoid and forms a diploid zygote.
   - The zygote by repeated cell divisions gives rise to embryo which forms a sporophytic plant.
3. **Sexual reproduction in gymnosperms** involves two types of spores, i.e. microspores (pollen grains) produced in microsporangia (borne on microsporophylls) and megaspore (embryo sac) in megasporangia produced on megasporophylls that constitute the female cone. They may be monoecious (*Pinus*) or dioecious (*Cycas* and *Ginkgo*).

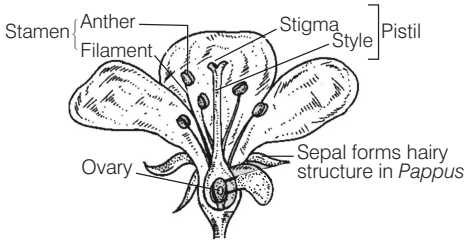
Sexual Reproduction in Flowering Plants

Sexual reproduction is the process of fusion of male and female gamete (n), resulting in the production of zygote ($2n$), which ultimately develops into a new organism.

All flowering plants show sexual reproduction and flowers are the reproductive part of a plant, where sexual reproduction takes place.

Structure of Flower

Structure of a typical flower is as follows



Structure of a flower

- The whole process of sexual reproduction in flowering plants involves the following steps, i.e. pollen grain formation, embryo sac formation, pollination, fertilisation, fruit and seed formation.

1. Pollen Grain Formation

It involves two processes microsporogenesis and microgametogenesis, which occurs in anther.

Anther (Microsporangium)

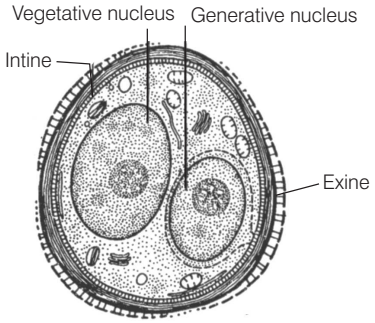
- The formation of microspores or pollen grains from microsporangia is called **microsporogenesis** which takes place in fertile portion of anther called **pollen sacs**.
- Each anther lobe has two chambers or pollen sacs called microsporangia. Since an anther is a bilobed structure. Thus, each anther consists of four microsporangia (dithecous).
- Anther develops from a group of cells (eusporangiate development). A young anther is made up of homogenous mass of meristematic cells surrounded by an epidermis.
- On maturation, each microsporangium consists of 3-5 layered anther wall surrounding the sporogenous tissue.
- Tapetum which is the innermost layer surrounding the microsporangia, consists of cells with large nuclei and dense cytoplasm. Its function include production and transport of enzymes, hormones and food materials to developing microspores/pollen grains.
- Callase enzyme is secreted by tapetum, which dissolves callose. Ubisch bodies are also secreted by tapetum. These are lipid in nature and get covered with sporopollenin, which increases the thickness of exine (i.e. outer layer of pollen grain).

Microsporogenesis

- During microsporogenesis, the primary sporogenous cells undergo mitosis and form diploid microspore mother cells or pollen mother cells or microsporocytes. Each microspore mother cell (diploid) further divides by meiosis to form a tetrad of haploid pollen grains.
- In polyspory, more than four pollen grains are produced from one microspore mother cell.
- Pollen grain is spherical and 25-50 micrometer in diameter having two layers, i.e. exine and intine.
- Sporopollenin present in the exine of pollen grains is resistant to microbial and chemical decomposition.
- Exine of pollen grain has prominent apertures called germ pores, where sporopollenin is absent.
- Pollen kit is an oily layer present on the outside of the mature pollen grains of many insect pollinated species, and consists of lipids and carotenoids.
- Pollen kit attracts insects and protects the pollen grains from UV-radiation.
- A pollen grain is partly germinated microspore representing the male gametophyte.

Development of Pollen Grain (Microgametogenesis)

- Development of male gametes begins inside the microspore. Where the first mitotic division of cell produce two unequal cells, i.e. a larger vegetative cell and a small generative cell.
- Microgametogenesis involves formation of two male gametes from the generative cell nucleus, mean while the vegetative cell forms pollen tube after pollination.



A mature pollen grain

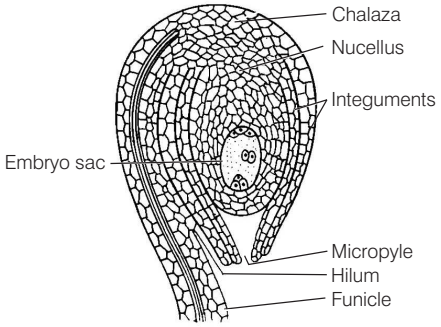
- Pollen grain at the time of pollination may be 2-celled or 3-celled.
- In over 60% of angiosperms, pollen grains are shed at 2-celled stage (i.e. vegetative cell and generative cell).
- In the remaining species, the generative cell divides mitotically to give rise to the two male gametes, thus shed at 3-celled stage.
- Pollen grains of many species (e.g. *Parthenium* or carrot grass) cause severe allergies and bronchial infections in some people often leading to chronic respiratory disorders such as asthma, bronchitis, etc.
- Once the pollen grains are shed, they have to land on the stigma before they lose viability if they have to bring about fertilisation.
- In rice and wheat, pollen grains lose viability within 30 minutes of their release. In some members of Rosaceae, Leguminoseae and Solanaceae, pollen grains remain viable for months. It is also possible to store pollen grains of a large number of species for years in liquid nitrogen (– 196°C), i.e. cryopreservation.

2. Embryo Sac Formation

It includes two processes megasporogenesis and megagametogenesis. These processes occurs in ovule.

Ovule (Megasporangium)

- Ovule arises from placenta and is attached to the placenta by a stalk called funicle. Hilum is a junction between ovule and funicle. Each ovule has one or two protective envelope called **integuments**. They encircle the ovule.
- Micropyle is an opening present at the tip, where integument is absent. Chalaza is opposite to the micropylar end representing the basal part of the ovule. The integument encloses a mass of cells called the nucellus. Nucellus have food reserves.

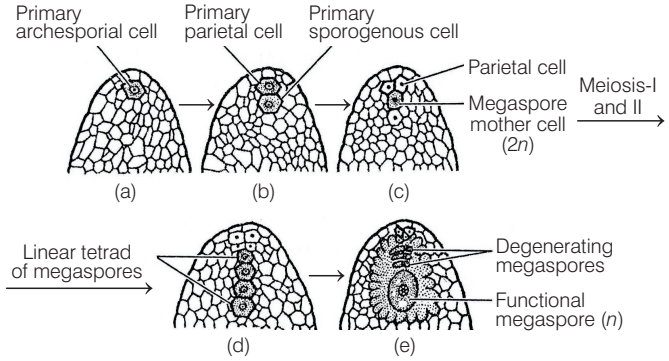


Structure of a typical ovule of angiosperm

- On the basis of the relative position of micropyle, body of the ovule and funicle, i.e. the degree of curvature, there are six types of ovules.
  - **Orthotropous or Atropous** The micropyle, chalaza, and funicle are in a vertical plane. This is the most primitive type of ovule, e.g. *Piper*, *Polygonum* and *Cycas*.
  - **Anatropous or Inverted** The ovule turns at 180° angle. Thus, it is an inverted ovule. Micropyle lies close to funicle or at side of hilum, e.g. found in 82% of angiospermic families.
  - **Hemianatropous** The ovule turns at 90° angle such that the funicle and body of ovule are at right angle to each other, e.g. *Ranunculus*.
  - **Campylotropous** The ovule is curved more or less at right angle to funicle. Micropylar end is bend down slightly, e.g. on members of Leguminosae and Cruciferae.
  - **Amphitropous** The ovule as well as embryo sac is curved like horseshoe, e.g. *Lemna*, *Poppy* and *Alisma*.
  - **Circinotropous** The ovule turns at more than 360° angle, so funicle covers the entire ovule, e.g. *Opuntia* (Cactaceae), Plumbaginaceae.

Megasporogenesis

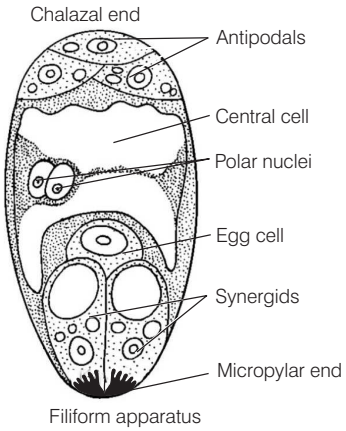
- Megasporogenesis is the process when Megaspore Mother Cell (MMC) undergoes meiosis to produce four haploid cells called 'megaspores'.
- Depending upon the pattern of cell plate and haploid cell formation it can be monosporic, bisporic or tetrasporic, 70% of angiospermic plants are monosporic (also called polygonum type), where out of four uninucleate megaspore, three degenerates resulting to a single functional megaspore.
- It is well established that the functional megaspore then undergoes further process of development to form female gametophyte (embryo sac) as shown in the figure.



Megasporogenesis (meiosis-I and II)

Development of Embryo Sac (Megagametogenesis)

- The process of megagametogenesis forms female gametophyte, i.e. embryo sac. The functional megaspore is the first cell of female gametophyte. It involves mitotic divisions (3 times) of functional megaspore to produce eight haploid nuclei that are enclosed within a 7-celled embryo sac. Three nuclei at the base of embryo sac form antipodal cells.
- At the opposite end there are two synergids and an egg cell. This egg cell fuses with a male gamete to form zygote during fertilisation.



Embryo sac

- At the centre there are two polar nuclei fused to form a diploid secondary nucleus.
- The filiform apparatus is a cellular thickening that form finger-like projections at the micropylar tip around synergids, it is present in the embryo sac to guide the pollen tubes into the synergids.

3. Pollination

The transfer of pollen grains from anther of a flower to the stigma of same or other flower is known as **pollination**.
It is mainly of two kinds

(i) Self-pollination or Autogamy

- It is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or from one flower to another on the same plant.
- Self-pollination produces homozygous characters in the progeny and good characters can be as such retained.
- Self-pollination is disadvantageous in the sense that no variations are produced and the progeny becomes genetically weak.
- Adaptations for self-pollination includes
  - **Homogamy** is a condition in which the anthers and stigma mature at the same time and the stigma is receptive at the time, when the pollens are shed, e.g. *Mirabilis* and *Vinca rosea*.
  - **Cleistogamy** is a condition which occurs when the flowers do not open and remain closed throughout their life in bud form. The pollination occurs in the bud itself. Most of the plants with cleistogamous flowers, also bear chasmogamous flowers, i.e. the flowers, which open normally. Thus, cleistogamy is a facultative character. Example of exclusively, cleistogamous flowers are very few and include *Sibularia aquatica* and *Polycarpon tetraphyllum*.

(ii) Cross-pollination or Allogamy

- It is the transfer of pollen from anther of a flower to stigma of another flower, borne on separate plants of the same species. While **xenogamy** is a type of allogamy between two genetically different plants.
- **Geitonogamy** is another type of cross-pollination in which pollen grains of one flower is transferred to stigma of another flower belonging to same plant or genetically similar plant.
- Cross-pollination results in combination or mixing up of characters thus, improving the quality or vigour of the species.
- Various agencies helpful in cross-pollination are broadly categorised into two types, i.e. **biotic** and **abiotic** agencies or agents.
- Abiotic agents involved in cross-pollination are wind and water.
- Pollination with the help of air or wind is called as **anemophily**, e.g. maize and pollination taking place with the help of water is called as **hydrophily**, e.g. *Hydrilla*.
- When biotic agents are involved in cross-pollination, the process is collectively, called as **zoophily.**
  Most common types of zoophily are
  - **Entomopily**, i.e. pollination with the help of various insects. This is the most common type of zoophily, e.g. rose, jasmine.
  - **Ornithophily**, i.e. pollination through birds, e.g. *Bignonia*, bottle brush.
  - **Cheiropterophily**, i.e. pollination acquired through bats, e.g. *Agave*.
  - **Malacophily**, i.e. pollination by snails, e.g. *Lemna*.
  - **Myrmecophily** i.e. pollination by ants when they feed on their juicy secretions. It is beneficial association between the ants and flowers.

Outbreeding Devices

These are adaptations developed by flowering plants to discourage self-pollination and encourage cross-pollination.

These are as follows

(i) **Self-sterility** or **Self-incompatibility** is an adaptation, in which either the pollens of a flower are unable to grow on the stigma of same flower or if they do, so they grow very slowly, e.g. *Malva* and *Abutilon*.

(ii) **Dichogamy** is an adaptation in which the maturation time of stigma and anthers is such that either stigma becomes receptive before anthers mature (protogyny), e.g. in *Aristolochia* and *Scrophularia* or the anthers are ready for dehiscence before stigma becomes receptive (protandry), e.g. rose, sunflower, *Impatiens*.

(iii) **Heterostyly** is a type of adaptation that occurs in some members of Oxalidaceae, Rubiaceae, Polygonaceae, etc., where the flowers are **dimorphic,** i.e. of two different forms.
- One form has long stamens and styles are very small. The anthers are well above stigma thus minimising the chances of self-pollination.
- The other form has long styles and the stamens are having small filaments. Thus, anthers lie below the receptive part of the stigma, e.g. primrose. This condition is termed as **dimorphic heterostyly**.

(iv) **Unisexuality** (Dicliny) is the presence of only one kind of reproductive whorl in a flower.
- A plant may be **monoecious,** i.e. carrying two different flowers as male and female flowers on the same plant. In this case, both cross or self-pollination can occur.

- However in **dioecious** plants, i.e. plants in which male and female flowers are borne on different plants, cross-pollination is the only way of pollination.

(v) **Herkogamy** occurs in bisexual flowers in which a mechanical barrier exists between compatible pollen and stigma, so that self-pollination is not possible.

For example, in *Iris* and *Calotropis* a hood-like covering covers the stigma and the pollens are grouped in pollinia which stick to surface till they are carried away by insects.

Pollen-Pistil Interaction

- It refers to all the events from pollen deposition on the stigma until pollen tube enters the ovule.
- The pistil has the ability to recognise the suitable pollen type. If it is of right type, the pistil accepts pollen and promotes the post-pollination events that lead to fertilisation.
- The acceptance or rejection of pollen by the pistil is mediated by chemical components of the pollen interacting with those of the pistil.
- Following compatible pollination, the pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores.
- The content of pollen grain moves into the pollen tube which grows through the tissues of the stigma and style and reaches the ovary.
- The pollen tube enters the ovule in majority of cases through micropyle by a process termed **porogamy** or it may enter through chalaza (**chalazogamy**) as first reported in *Casuarina* and *Juglans*. In rare cases, the pollen tube may pierce through integuments (**mesogamy**) as in *Pistacia* and *Cucurbita*.
- The filliform apparatus of synergids secrete some chemical substances which direct the pollen tube towards micropyle of ovule.
- In artificial hybridisation, emasculation enables the pollination with desired pollen grains and after which the stigma is protected from contamination (with unwanted pollen) by bagging.

4. Fertilisation or Double Fertilisation

- Fusion of male and female gametes is known as **fertilisation**.
- The phenomenon of fertilisation was first reported by **Strasburger** (1884) in *Monotrapa*.
- In angiosperms, the pollen tube having the two male gametes enter the ovule through the micropylar or the chalazal end.
- Once entered, the male gametes are discharged in one of the synergids, which bursts open and later degenerates.
- Out of the two male gametes one fuses with egg cell (syngamy) forming a diploid zygote ($2n$) and the other fuses with two polar nuclei (or secondary nucleus) to form a triploid primary endosperm nucleus ($3n$).
- The process of fusion of two male gametes in a single embryo sac is called as **double fertilisation** and the formation of triploid nucleus by fusion of one male gamete with secondary nucleus is called **triple fusion**.
- Double fertilisation was discovered by **Nawaschin** in 1898 in *Lilium* and *Fritillaria*.
- Total five nuclei take part in double fertilisation.

Post-Fertilisation Events

The major events that take place soon after the double fertilisation are called post-fertilisation events. These include, development of endosperm and embryo, maturation of ovules into seeds and ovary into fruit.

1. Development of Endosperm

- As the consequence of triple fusion, a male gamete fuses with the secondary nucleus and a triploid structure called Primary Endospesm Cell (PEC) is formed, that divides by mitotic division to form a mass of nutritive cells called as **endosperm**. It provides nutrition to the developing embryo.
- Endosperm is of three kinds based on its development in a single seed. In case of coconut (*Cocos nucifera*), it is called free **nuclear endosperm**, in plants like *Petunia*, it is called **cellular endosperm**, while in plants like *Eremurus*, it is called **helobial endosperm**.
- Endosperm is hard and stony in *Areca* nut and datepalm.
- Endosperm sometimes has irregular or uneven surface due to surface layer or due to endosperm itself. Such endosperm is called **ruminate endosperm**.

2. Development of Embryo

- The entire series of events that occurs between fertilisation and maturity of a plant is called **embryogenesis**.
- During development, the cells become progressively more specialised or differentiated.
- The first stage in the development of a plant, the zygote have a pre-determined mode of development. It gives rise to an organised mass of cells called the **embryo**.
- Generally, a zygote divides transversely resulting in a small **apical cell** and large **basal cell**, from the 2-celled stage until the initiation of organs.
- The embryo is commonly called **proembryo.** It subsequently develops in globular, heart-shaped and later into mature embryo.

- In **dicot embryo**, an embryonal axis and two cotyledons are present.
- 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 the lower end in the radicle or root tip which is covered with root cap.
- In **monocots,** embryo possesses only one cotyledon. In the grass family, the cotyledon is called **scutellum** that is situated towards one side of the embryonal axis.
- At lower end, the embryonal axis has the radicle and root cap enclosed in an undifferentiated sheath called **coleorhiza**.
- The portion of the embryonal axis above the level of attachment of scutellum is the **epicotyl**.
- Epicotyl has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure the **coleoptile**.

3. Development of Seed

- A seed is a fertilised mature ovule.
- An ovule is changed into seed after some changes. Seeds are formed inside the fruits.
- A seed typically consists of seed coat(s), cotyledon(s) and an embryo axis.
- The two integuments develop into seed coats.
- The outer one is called **testa** and inner one is **tegmen.**
- The cotyledons (seed leaves) are simple structures, generally thick due to the storage of food reserves.
- Mature seeds may be non-albuminous or non-endospermic (e.g. pea, groundnut and albuminous or endosperimic (e.g. wheat, maize).

4. Formation of Fruit

A fruit is a seed containing part that forms from a fertilised ovary.

- Most fruits develop only from the ovary and are called **true fruits**.
- In some species such as apple, strawberry, cashew, etc., the thalamus also contributes to fruit formation. Such fruits are called **false fruits**.

Fruits are classified into three kinds

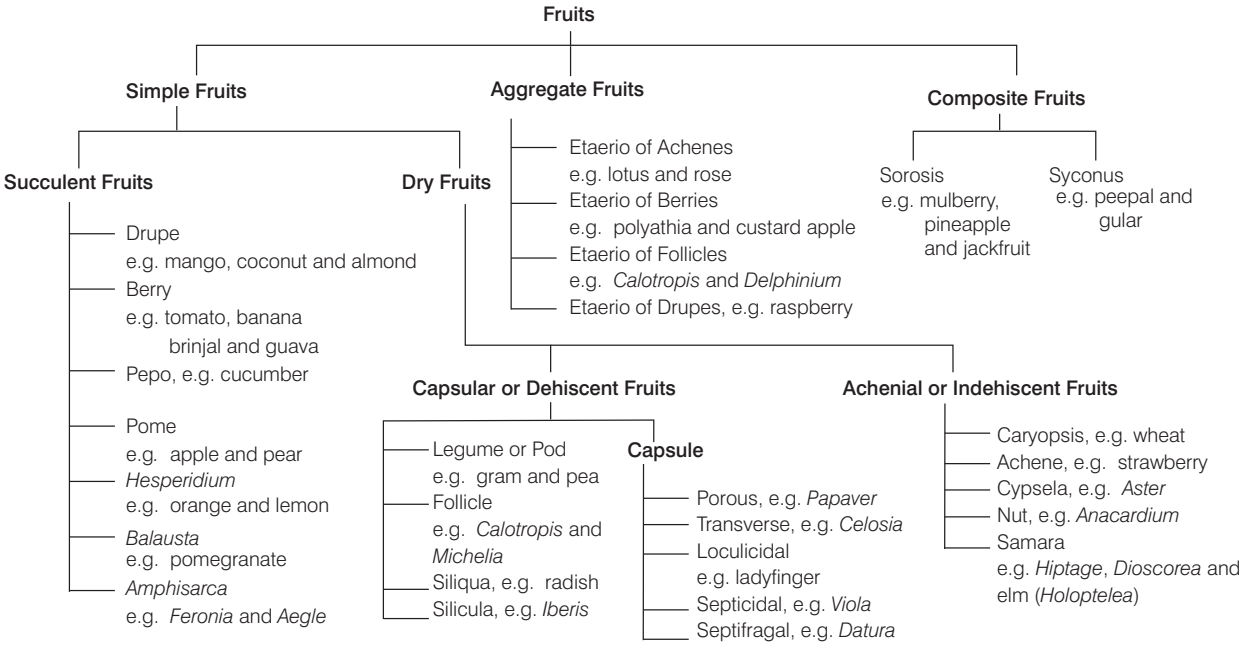
(i) **Simple fruits** are those, which develop from single ovary of a single flower.

(ii) **Aggregate fruits** are formed from polycarpellary, apocarpous flowers. Each carpel forms a fruitlet and all fruitlets together form an aggregate fruit.

(iii) **Composite or multiple fruits** are those, which develop from inflorescence, where flowers are crowded together.

- Besides, there are schizocarpic fruits, they have many seeds and break into many pieces on maturity. These are **lomentum** as in *Acacia* and *Mimosa*; **cremocarp** as in coriander and carrort; **carcerulus** as in *Ocimum*; **samara** as in *Hiptage, Acer* and **regma** as in *Geranium*.

Detailed classification of the fruits



Significance of Seed and Fruit Formation

Seeds and fruits offer several advantages to angiosperms as follows

- Seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas.
- They have sufficient food reserves, young seedlings are nourished until they are capable of photosynthesising on their own.
- The hard seed coat provides protection to the young embryo.
- Being the products of sexual reproduction they generate new genetic varieties leading to variations.
- Dehydration and dormancy of mature seeds is crucial for their storage, which can be used as food throughout the year and also to raise crops for the next season.

Special Modes of Reproduction

Seeds, normally develop by the process of fertilisation. However, in some plants there are some special modes for their development. These are as follows

1. **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.
2. **Polyembryony** occurs in many citrus and mango varieties, where 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 which is referred to as polyembryony.
3. **Amphimixis** is actually the process of sexual reproduction, which involves meiosis and syngamy.
   - By meiosis, the diploid cells of the sporophyte give rise to haploid gametophytes, which produce male and female gametes.
   - Syngamy, i.e. fusion of haploid gametes, results in the restoration of the diploid sporophytic generation.
4. **Parthenocarpy** is defined as the formation of fruits without fertilisation, e.g. banana. Parthenocarpy have great practical uses in plant breeding and genetics. The useful characteristics of plants can be preserved for many generations.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1. Vegetative propagation in *Cynodon* (doob grass) occurs by

(a) offset (b) rhizome
(c) runner (d) sucker

2. Ring of a bark is removed from the shoot for the vegetative propagation in which of the following methods?

(a) Air layering
(b) Tissue culture
(c) Grafting
(d) Fragmentation

3. Which of the following pairs is not correctly match?

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	Mode of reproduction	Example
(a)	Offset	Water hyacinth
(b)	Rhizome	Banana
(c)	Binary fission	*Sargassum*
(d)	Conidia	*Penicillium*

4. Meiosis in *Spirogyra*, *Ulothrix*, *Chlamydomonas* and most of the algae/thallophytes is

(a) sporic
(b) zygotic
(c) gametic
(d) unequal

5. Plasmogamy followed by karyogamy and subsequently meiosis to produce spores occurs in

(a) algae (b) bryophytes
(c) gymnosperm (d) pteridophytes

6. In bryophytes, the multicellular flask-shaped structure is the

(a) archegonium (b) biflagellate spores
(c) gemmules (d) androcytes

7. Sexual reproduction brings about variations because

(a) it generates new genetic combinations
(b) new individuals are formed by callus
(c) new plants are produced from existing plants
(d) parent cells are divided into two equal sized daughter cells.

8. 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

9. Callase enzyme which dissolves callose of pollen tetrads to separate four pollens is provided by
(a) pollens (b) tapetum
(c) middle layers (d) endothecium

10. The outer wall of a pollen grain is made up of
(a) cellulose (b) pectocellulose
(c) lignin (d) sporopollenin

11. Which one of the following is surrounded by a callose wall?
(a) Microspore mother cell (b) Male gamete
(c) Egg (d) Pollen grain

12. Which function of tapetum is correct?
(a) Helps in pollen wall formation
(b) Transportation of nutrients to inner side of anther
(c) Synthesis of callase enzyme for separation of microspore tetrads
(d) All of the above

13. One of the most resistant biological material present in the exine of pollen grain is
(a) pectocellulose (b) sporopollenin
(c) suberin (d) cellulose

14. Pollen kit is generally found in
(a) anemophilous flowers (b) entomophilous flowers
(c) ornithophilous flowers (d) malacophilous flowers

15. In over 60% angiospermic species, the pollen grains are shed at……stage.
(a) 2-celled (b) 3-celled
(c) 4-celled (d) 6-celled

16. ……cell of the pollen grain divides to from two male gametes.
(a) Vegetative cell (b) Generative cell
(c) Microspore mother cell (d) None of these

17. Male gametophyte in angiosperms produces → CBSE-AIPMT 2015
(a) two sperms and a vegetative cell
(b) single sperm and a vegetative cell
(c) single sperm and two vegetative cells
(d) three sperms

18. Severe allergy can be caused by pollens of
(a) carrot grass (b) doob grass
(c) lemon grass (d) tiger lily

19. Megasporangium is equivalent to → NEET 2013
(a) fruit (b) nucellus
(c) ovule (d) embryo sac

20. In higher monocots nucellus is
(a) unitegmic (b) bitegmic
(c) polytegmic (d) polygonum

21. Monosporic development in which only one megaspore develops into embryo sac is also called
(a) polygonum (b) polyandrous
(c) totipotency (d) monoecious

22. Collar-like outgrowth that arises from the base of the ovule and forms a sort of third integument is called
(a) coma (b) caruncle
(c) aril (d) operculum

23. The most primitive and simplest type of ovule is
(a) anatropous (b) hemitropous
(c) orthotropous (d) campylotropous

24. Which of the following nuclei is unlike other nuclei in the female gametophyte of angiosperms?
(a) Egg nucleus
(b) Nucleus of synergids
(c) Secondary nucleus
(d) Nuclei of antipodals

25. In a fertilised embryo sac, the haploid, diploid and triploid structures are
(a) synergids, zygote and primary endosperm nucleus
(b) synergids, antipodals and polar nuclei
(c) antipodals, synergids and primary endosperm nucleus
(d) synergids, polar nuclei and zygote

26. During the formation of embryo sac, the functional megaspore undergoes
(a) two mitotic divisions (b) two meiotic divisions
(c) three meiotic divisions (d) three mitotic divisions

27. 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

28. Advantage of autogamy is
(a) more hybrid plants can be produced
(b) genetically advanced offsprings are produced
(c) no dependence on pollinating agents
(d) parthenogenesis can be induced

29. In some plants, anthers and stigma grow and mature at same time. This phenomenon is called
(a) homogamy (b) syngamy
(c) allogamy (d) fusion

30. In *Mirabilis*, there is close association between anther and stigma. It exhibits
(a) homogamy (b) chasmogamy
(c) xenogamy (d) dichogamy

31. Both chasmogamous and cleistogamous flowers are present in

(a) *Helianthus* (b) *Commelina*
(c) *Rosa* (d) *Gossypium*

32. 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 length

33. Name the kind of pollination in maize

(a) entomophily (b) anemophily
(c) ornithophily (d) hydrophily

34. Characteristics of flowers which exhibit anemophily are

(a) large, producing nectar and pollen grains
(b) small, producing nectar and pollen grains
(c) small, producing large number of dry pollen grains
(d) small, brightly coloured

35. Pollination acquired through bats is called

(a) entomophily (b) ornithophily
(c) cheiropterophily (d) myrmecophily

36. Malacophily is pollination acquired by

(a) ants (b) wasps
(c) snails (d) reptiles

37. Fragrant flowers with well-developed nectaries are an adaptation for

(a) hydrophily (b) anemophily
(c) entomophily (d) malacophily

38. Spiny or sticky pollen grains large attractively coloured flowers are associated with

(a) hydrophily (b) entomophily
(c) ornithophily (d) anemophily

39. Flowers exhibiting myrmecophily

(a) have dry and hairy stigma
(b) produce juicy secretions
(c) are colourless, odourless and nectarless
(d) None of the above

40. Select the incorrect pair of type of pollination and the corresponding pollinating agency.

(a) Anemophily–Wind (b) Hydrophily–Water
(c) Ornithophily–Birds (d) Chiropterophily–Insects

41. Plants of which one of the following groups of genera are pollinated by the same agency?

(a) *Triticum*, *Mussanda* and *Zea mays*
(b) *Kadam* and *Cannabis*
(c) *Salvia* and *Calotropis*
(d) *Salvia*, *Pinus* and *Ophrys*

42. Both autogamy and geitonogamy are prevented in

→ CBSE-AIPMT 2012

(a) papaya (b) cucumber (c) castor (d) maize

43. Which adaptation is shown in *Malva*?

(a) Autogamy (b) Cleistogamy
(c) Dichogamy (d) Self-incompatibility

44. The outbreeding device in which the anthers are ready for dehiscence before stigma becomes receptive is

(a) protogyny (b) protandry
(c) heterostyly (d) self-sterility

45. Protandry and protogyny are type of

(a) dichogamy (b) heterophyly
(c) herkogamy (d) homogamy

46. Hood-like covering that covers the stigma is present in

(a) *Calotropis* (b) *Casuarina*
(c) *Areca* (d) Malva

47. Entry of pollen tube through micropyle is

(a) chalazogamy (b) mesogamy
(c) porogamy (d) pseudogamy

48. The filiform apparatus is present in

(a) synergids (b) egg cell
(c) antipodals (d) secondary nucleus

49. Germination of pollen grain on the stigma is

(a) autogamy
(b) *in vivo* germination
(c) *in vitro* germination
(d) *in situ* germination

50. The pollen tube usually enters the embryo sac

(a) between the egg cell and synergid
(b) by directly penetrating the egg
(c) between one synergid and antipodal cell
(d) by knocking off the antipodal cells

51. Double fertilisation was discovered by

(a) Hofmeister (b) Leeuwenhoek
(c) Nawaschin (d) Strasburger

52. Double fertilisation is fusion of

(a) two eggs
(b) two eggs and polar nuclei with pollen nuclei
(c) one male gamete with egg and other with synergid
(d) one male gamete with egg other with secondary nucleus

53. Triple fusion in angiosperm is the fusion of second sperm with

(a) antipodal cell and one synergid cell
(b) two antipodal cells
(c) two synergid cells
(d) two polar nuclei

54. 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

55. Which one of the following events takes place after double fertilisation?

(a) The pollen grain germinates on the stigma
(b) The pollen tubes enter the embryo sac
(c) Two male gametes are discharged into the embryo sac
(d) The PEN (Primary Endosperm Nucleus) develops into endosperm

56. The structure, which can show the effect of traits brought by the male gamete immediately after its formation is

(a) embryo (b) cotyledons
(c) endosperm (d) plumule

57. The coconut water from tender coconut represents → NEET-I 2016

(a) fleshy mesocarp (b) free-nuclear proembryo
(c) free-nuclear endosperm (d) endocarp

58. In grass family, cotyledon is also called

(a) coleorhiza (b) coleoptile (c) scutellum (d) plumule

59. The scutellum of grass embryo is a

(a) vestigial organ
(b) photosynthetic organ
(c) absorptive organ
(d) reserve food storage organ

60. In dicot embryo, the portion of embryonal axis above the cotyledon is

(a) hypocotyl (b) epicotyl (c) hypogeal (d) epigeal

61. In monocot plants, the epicotyl is inclosed in hollow foliar structure

(a) coleoptile (b) coleorhiza
(c) scutellum (d) ovule

62. ..... is not an endospermic seed.

(a) Pea (b) Castor (c) Maize (d) Wheat

63. Endosperm is consumed by developing embryo in the seed of → CBSE-AIPMT 2008

(a) coconut (b) castor (c) pea (d) maize

64. Endospermic seeds are found in

(a) castor (b) barley (c) coconut (d) All of these

65. In albuminous seeds, food is stored in ..... and in non-albuminous seeds, it is stored in ..... .

(a) endosperm, cotyledons (b) cotyledons, endosperm
(c) nucellus, cotyledons (d) endosperm, radicle

66. Sorosis and syconus are types of

(a) simple fruits (b) aggregate fruits
(c) composite fruits (d) dry fruits

67. The condition in which diploid egg cell is formed without reductional division is called

(a) amphimixis (b) apomixis
(c) parthenogenesis (d) polyembryony

68. Polyembryony is displayed in

(a) lemon (b) *Triticum* (c) papaya (d) maize

69. Process of sexual reproduction involving meiosis and syngamy is also called

(a) polyembryony (b) amphimixis
(c) apomixis (d) parthenogenesis

70. Fruits that develop without ferlilsation are

(a) false fruit (b) true Fruit
(c) parthenocarpic fruit (d) composite fruit

71. In a type of apomixis known as adventive embryony, embryos develop directly from the

(a) nucellus or integuments
(b) zygote
(c) synergids or antipodals in an embryo sac
(d) accessory embryo sac in the ovule

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1. The direction of micropyle in anatropous ovule is

(a) upward (b) downward
(c) right (d) left

2. Even in the absence of pollinating agents seed setting is assured in

(a) *Commelina* (b) *Zostera*
(c) *Slavia* (d) fig

3. Ruminate endosperm is found in the seed of family

(a) Compositae (b) Cruciferae
(c) Euphorbiaceae (d) Annonaceae

4. In which of the following plants, pollen is released before the stigma becomes receptive in the same flower?

(a) *Allium* (b) *Colchicum*
(c) *Datura* (d) *Solanum*

5. In the embryos of a typical dicot and a monocot, true homologous structures are

(a) coleorhiza coleoptile
(b) coleoptile and scutellum
(c) cotyledons and scutellum
(d) hypocotyl and radicle

6. Persistent nucellus is called as ……and is found in …….

(a) perisperm, black pepper (b) perisperm, ground nut
(c) endosperm, black pepper (d) endosperm, groundnut

7. If stock contains 58 chromosomes and scion contains 30 chromosomes, then how many chromosomes are present in root and egg cell of resultant plant, respectively?

(a) 30 and 29 (b) 15 and 58
(c) 58 and 15 (d) 29 and 30

8. This is an example of a very old viable seed excavated from Arctic Tundra. The seed germinated and flowered after an estimated record of 10,000 years of dormancy. It is

(a) Victoria
(b) *Lupinus arcticus*
(c) *Phoenix dactylifera*
(d) *Strobilanthus kunthiana*

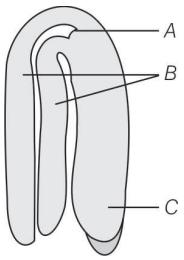
9. If an endosperm cell of an angiosperm contains 24 chromosomes, the number of chromosomes in each cell of the root will be

(a) 8 (b) 4
(c) 16 (d) 24

10. What would be the chromosome number in the aleurone cells of a plant with 14 chromosomes the root tip cells

(a) 21 (b) 63
(c) 42 (d) 7

11. Identify the different parts of a typical dicot embryo labelled as *A*, *B* and *C* and select the correct option.

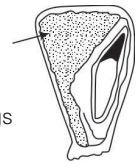


	A	*B*	*C*
(a)	Plumule	Cotyledons	Radicle
(b)	Radicle	Cotyledons	Plumule
(c)	Cotyledons	Plumule	Radicle
(d)	Cotyledons	Radicle	Plumule

12. In a case of polyembryony, if an embryo develops from the synergid and another form the nucellus, then the synergid embryo is …*A*… and nucellar embryo is …*B*….

	…A…	*…B…*
(a)	haploid	haploid
(b)	diploid	diploid
(c)	haploid	diploid
(d)	diploid	haploid

13. Which of the following applies to the tissue indicated with the arrow in figure?



(a) It may store fat
(b) It is an endosperm
(c) It provides nutrients for the young seedlings
(d) All of the above

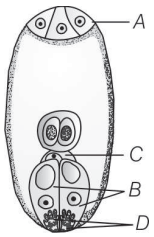
14. Consider the following statements and choose the ones that represents tapetum.

I. It is the single innermost layer.
II. It provides nutrition to the pollen grains.
III. It helps in the dispersal of microspores.
IV. It stores reserve food during early stages of microspore development.

Choose the correct option.

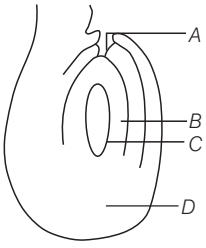
(a) I, II and III (b) III and IV
(c) I and III (d) IV and II

15. Identify the parts labelled *A*, *B*, *C* and *D* in the given figure and select the correct option.



	A	*B*	*C*	*D*
(a)	Synergids	Antipodals	Egg	Filiform apparatus
(b)	Antipodals	Synergids	Egg	Filiform apparatus
(c)	Antipodals	Synergids	Filiform apparatus	Egg
(d)	Polar nuclei	Antipodals	Filiform apparatus	Egg

16. Identity the parts labelled *A*, *B*, *C* and *D* in the given figure and select the correct option.



	A	*B*	*C*	*D*
(a)	Chalaza	Female gametophyte	Embryo sac	Micropyle
(b)	Chalaza	Nucellus	Embryo sac	Micropyle
(c)	Micropyle	Egg	Embryo sac	Chalaza
(d)	Micropyle	Nucellus	Embryo sac	Chalaza

17. In angiosperms, normally after fertilisation

(a) the zygote divides earlier than the primary endosperm nucleus
(b) the primary endosperm nucleus divides earlier than the zygote
(c) both the zygote and primary endosperm nuclei divide simultaneously
(d) both the zygote and primary endosperm nuclei undergo a resting period

18. Select the plants pollinated by water.

I. Water hyacinth II. *Zostera*
III. *Amorphophallus* IV. *Vallisneria*
V. *Yucca*

(a) I, IV and V (b) II and V
(c) II and IV (d) II, III and IV

19. Which of the given statements are true?

I. During the development of a dicot embryo, heart-shaped embryo is followed by globular embryo.
II. The part of embryonal axis above the level of cotyledons is epicotyl, while the part below the level of cotyledons is hypocotyl.
III. Monocot seeds possess a single cotyledon represented by scutellum.

(a) I and II (b) II and III
(c) I and III (d) I, II and III

20. Refer the given statements.

I. Both wind and water pollinated flowers are not very colourful and do not produce nectar.
II. Entomophilous flowers are large, colourful, fragrant and rich in nectar.
III. *Kigelia pinnata* is an insect pollinated flower.

Which of the above statements is/are incorrect?

(a) Only I (b) Only II
(c) Only III (d) All of these

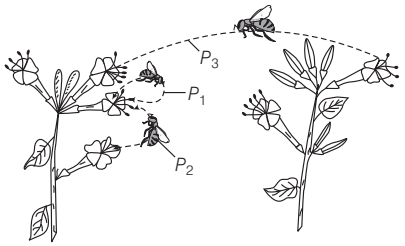
21. Match the following columns.

	Column I		Column II
A.	Monoecious	1.	*Primula*
B.	Dioecious	2.	Maize
C.	Cleistogamous	3.	Datepalm
D.	Heterostyly	4.	*Commelina*

Codes

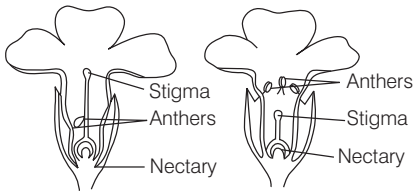
	A	B	C	D
(a)	3	2	4	1
(b)	2	3	4	1
(c)	2	3	1	4
(d)	1	2	3	4

22. The given diagram shows two plants of the same species. Identify the types of pollination indicated at P_1, P_2 and P_3.



	P_1	P_2	P_3
(a)	Allogamy	Chasmogamy	Cleistogamy
(b)	Autogamy	Xenogamy	Geitonogamy
(c)	Autogamy	Geitonogamy	Xenogamy
(d)	Geitonogamy	Allogamy	Autogamy

23. Given figure shows two types of primrose flowers. They occur naturally in the roughly equal numbers and differ in length of style and position of anthers. What is the advantage of such a system?



(a) It encourages inbreeding (b) It encourages outbreeding
(c) Both (a) and (b) (d) None of these

24. Refer the given statements.

I. Outer exine is made up of sporopollenin.
II. Inner intine is pectocellulosic in nature.
III. Generative cell is bigger and contains abundant food reserve.
IV. Vegetative cell is small and floats in the cytoplasm of the generative cell.

Which of the given statements are not true regarding structure of pollen grain?

(a) I and II (b) II and III
(c) III and IV (d) I and IV

25. Select the correct option regarding the ploidy level of different structures of an angiospermous ovule.

	Nucellus	MMC	Functional megaspore
(a)	*n*	2*n*	2*n*
(b)	2*n*	*n*	*n*
(c)	2*n*	2*n*	*n*
(d)	*n*	2*n*	*n*

26. Which of the following statements is/are correct?

I. Endothecium lies behind epidermis.
II. Fusion of egg with male gamete is called apogamy.
III. Synergids are haploid.
IV. The point at which funicle touch the ovule is raphe.

(a) I and IV (b) I and II
(c) I and III (d) II and III

27. Match the following columms.

	Column I		Column II
A.	Funicle	1.	Mass of parencymatous cells
B.	Hilum	2.	Basal part of ovule
C.	Integument	3.	One or two protective layers of ovule
D.	Chalaza	4.	Region where body of ovule fuses with funicle
E.	Nucellus	5.	Stalk of ovule

Codes

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

28. The angiospermic endosperm, except in special cases, is a triploid (3*n*) tissue as it is a product of triple fusion involving double fertilisation. It is thus, distinct from the endosperm of gymnosperms and heterosporous pteridophytes, where the endosperm is a

(a) diploid before fertilisation
(b) simple haploid (*n*) tissue of the gametophyte not involving any complication like polar fusion or fertilisation
(c) polyploid formed after simple fertilisation
(d) haploid formed after fertilisation

29. Match the following columns.

	Column I		Column II
A.	Place where pollen grains land	1.	Spores
B.	The site, where the seeds develop	2.	Stigma
C.	Reproductive cells that have exactly the same number of chromosomes as the parent plant	3.	Microspore mother cells
D.	Meiotically dividing cells is the male reproductive tissues that make four microspores	4.	Ovary

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

30. 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 and 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

Directions (Q. Nos. 31-33) *In each of the following questions a statement of Assertion is given followed by a corresponding statement of Reason just below it . Of the statements , mark the correct answer as*

(a) If both Assertion and Reason are true, but Reason is the correct explanation of Assertion
(b) If both Assertion and Reason are true, but Reason is not the correct explanation of Assertion
(c) If Assertion is true, but Reason is false
(d) If both Assertion and Reason are false

31. **Assrtion** Insects visit flowers to gather pollen.
Rason Attraction to flowers prevents the insects from damaging other parts of the plant.

32. **Assertion** Synergids are elongated cell that occur at the micropylar pole.
Reason Synergids help in chemotropic movement of pollen tube.

33. **Assertion** Coconut tree is distributed in coastal areas over a large part of the world.
Reason Coconut fruit can float and get dispersed over thousands of kilometres before losing viability.

ANSWERS

SESSION 1

1. (c)	**2.** (a)	**3.** (c)	**4.** (b)	**5.** (a)	**6.** (a)	**7.** (a)	**8.** (d)	**9.** (b)	**10.** (d)
11. (a)	**12.** (d)	**13.** (b)	**14.** (b)	**15.** (a)	**16.** (b)	**17.** (a)	**18.** (a)	**19.** (c)	**20.** (b)
21. (a)	**22.** (c)	**23.** (c)	**24.** (c)	**25.** (a)	**26.** (d)	**27.** (b)	**28.** (c)	**29.** (a)	**30.** (a)
31. (b)	**32.** (c)	**33.** (b)	**34.** (c)	**35.** (c)	**36.** (c)	**37.** (c)	**38.** (b)	**39.** (b)	**40.** (d)
41. (c)	**42.** (a)	**43.** (d)	**44.** (b)	**45.** (a)	**46.** (a)	**47.** (c)	**48.** (a)	**49.** (b)	**50.** (a)
51. (c)	**52.** (d)	**53.** (d)	**54.** (b)	**55.** (d)	**56.** (c)	**57.** (c)	**58.** (c)	**59.** (d)	**60.** (b)
61. (a)	**62.** (a)	**63.** (c)	**64.** (d)	**65.** (a)	**66.** (c)	**67.** (b)	**68.** (a)	**69.** (b)	**70.** (c)
71. (a)									

SESSION 2

1. (b)	**2.** (a)	**3.** (d)	**4.** (a)	**5.** (c)	**6.** (a)	**7.** (c)	**8.** (b)	**9.** (c)	**10.** (a)
11. (a)	**12.** (c)	**13.** (d)	**14.** (a)	**15.** (b)	**16.** (d)	**17.** (b)	**18.** (c)	**19.** (b)	**20.** (c)
21. (b)	**22.** (c)	**23.** (b)	**24.** (c)	**25.** (c)	**26.** (d)	**27.** (b)	**28.** (b)	**29.** (b)	**30.** (b)
31. (c)	**32.** (b)	**33.** (a)							