CHAPTER **02**

Sexual Reproduction in Flowering Plants

1. Sexual Reproduction

It is a process of development of new organisms due to the fusion of male and female gametes.

It occurs through flowers in plants. Such plants are called **angiospermic** or **flowering plants**.

2. Flower

It is the site of sexual reproduction in flowering plants. A typical flower consists of four whorls of floral appendages, attached on the receptacle, *i.e.*

A. **Calyx** is the outermost protective whorl of flower, which is usually green in colour.

B. **Corolla** is the second whorl of flower. It contains petals which are brightly coloured and are fragrant. This makes flowers attractive which helps in pollination.

C. **Androecium** is the male whorl which consists of stamens. Each stamen consists of anther, filament and a connective.

D. **Gynoecium** is the female whorl which consists of carpel or pistil. It contains three parts, *i.e*. stigma, style and ovary.

3. Pre-Fertilisation Events

These include the development of male and female gametophyte.

A. **Male Reproductive Part** It consists of a stamen, microsporangium and a pollen grain.

(i) A typical stamen has two main parts, *i.e.* an anther and a long slender structure called filament. Anther is a bilobed structure with each lobe having two theca. Thus, it has four microsporangia which develop and become pollen sacs that contain pollen grains. Ploidy level of pollen mother cell is diploid.

(ii) **Structure of Microsporangium** Transversely, a microsporangium appears circular in outline. It is generally surrounded by four layers, *i.e.* the **epidermis**, **endothecium**, **middle layer** and **tapetum** (nourishing tissue).

(iii) **Pollen grains** are known as **male gametophytes**. Each pollen grain has a two-layered wall, *i.e.* **sporoderm**. The outer layer is hard and known as **exine**. It is made up of sporopollenin. The inner layer is thin, called as **intine**. It is composed of cellulose and pectin.

- **Microsporogenesis** The formation of microspores from a pollen mother cell through the meiosis is called **microsporogenesis**. Pollen grains are released by dehiscence of an anther.
- These microspores later develop into microgametophytes or matured pollen grains. This process is known as microgametogenesis. Each pollen grain has two cells, *i.e.* generative cell and vegetative cell. The vegetative cell is large and irregular in shape. It has abundant reserve food. The generative cell is small, spindle-shaped and floats in cytoplasm of the vegetative cell.

B. **Female Reproductive Part** It consists of pistil, megasporangium (ovule) and embryo sac.

(i) **Pistil** is the female reproductive unit of a flower. The main parts of a pistil are stigma, style and ovary.

Stigma is meant to receive pollen grains, **style** is the slender part below the stigma and the basal swollen part of style is called **ovary**.

(ii) **Ovule** (megasporangium) is attached to the placenta by a stalk called **funicle**. **Hilum** is the junction between ovule and funicle. Each ovule contains two protective envelops, called **integuments**.

Micropyle is present at the tip while chalaza lies opposite to the micropylar end representing the basal part of the nucellus. Nucellus has food reserves.

(iii) **Megasporogenesis** It is the process of formation of megaspores (4) from megaspore mother cell by meiotic division.

- Only one of the 4 megaspores is functional which develops into female gametophyte or embryo sac. This is called **monosporic development**, while the other three degenerate in most of the angiosperms.
- **Embryo sac or female gametophyte** is formed when the nucleus of functional megaspore divides mitotically to form two nuclei, which move to the opposite poles and form 2-nucleate embryo sac, which then results into the formation of 4-nucleate and later 8-nucleate stage. This event is known as **megagametogenesis**.
- The mature embryo sac contains 7- cells and 8-nuclei (polygonum type). The 6 out of 8-nuclei get surrounded by cell wall and are organised into cells. Three cells present towards the micropylar end, grouped together constitute the egg apparatus, *i.e.* two **synergids** and one **egg cell**. The 3-cells of the chalazal end are called **antipodals**.

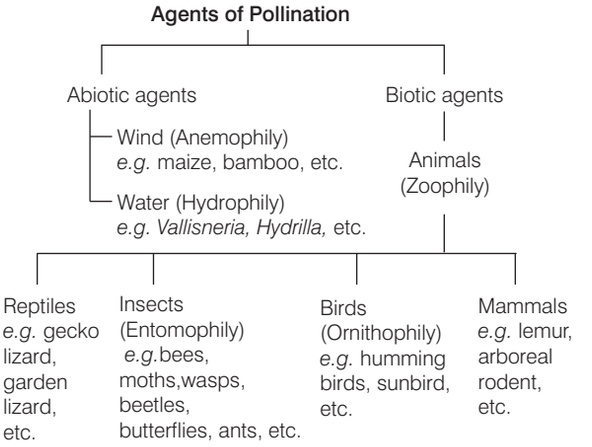
4. Pollination

Transfer of pollen grains from anther to stigma is called pollination. Stamen and other whorls fall down after pollination. Pollination is of two types

A. **Self-Pollination** When pollen grains reach to the stigma of the same flower (autogamy) or to the stigma of the another flower of the same plant, (geitonogamy), it is known as self-pollination. It is found in both unisexual and bisexual flowers. Adaptations for self-pollination are homogamy and cleistogamy.

B. **Cross-Pollination** or **Allogamy** (Xenogamy) In this pollination, pollen grains of one plant reach to the stigma of flower of another plant of the same species. It involves two plants of the same species to produce seeds. **Unisexuality**, **dichogamy**, **self-sterility**, **heterostyly**, **dioecy** and **herkogamy** are the specific adaptations in flowering parts to prevent self-pollination. These are also known as **outbreeding devices**. Pollen grains require some agencies to reach to the stigma.

These agencies are grouped as follows



5. Pollen-Pistil Interaction

It is an essential step in fertilisation of angiosperms because it determines the compatability and incompatability of pollen and pistil. It generally includes the events from the deposition of pollen on the stigma till the pollen tube enters ovule. This pollen-pistil interaction comprises of three stages

(i) Recognition of compatible pollen

(ii) Growth of a pollen tube

(iii) Entry of pollen tube into the ovule.

6. Artificial Hybridisation

It is the crossing of different species to generate a progeny by combining desirable characters which are present in commercially superior varieties. It is used for crop improvement programmes. This process involves

(i) **Emasculation** It refers to anther removal before its dehiscence.

(ii) **Bagging** and covering emasculated flower in a bag to prevent its contamination by unwanted pollen grains.

7. Fertilisation

It occurs just after pollination. Fusion of male and female gametes is called fertilisation. Pollen tube enters in ovary and after fertilisation embryo is formed.

8. Double-Fertilisation

It was discovered by **SG Nawaschin** in ***Fritillaria*** and ***Lilium*** plants in 1898. In this, one of the male gametes fuses with egg cell and forms diploid zygote.

This is called **syngamy**. The other male gamete fuses with polar nuclei and forms **3*n*** (triploid) Primary Endosperm Nucleus (PEN), so this is called triple fusion. This is the specific feature of angiosperms.

9. Post-Fertilisation Events

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

Endosperm development is of three types, *i.e.* **nuclear type**, **cellular type** and **helobial type**. Out of these, nuclear type is the most common one in which the PEN undergoes repeated mitotic divisions without cytokinesis. At this stage, endosperm is called **free endosperm nucleus**.

Development of an embryo takes place at the micropylar end of the embryo sac. The zygote development gives rise to proembryo and later globular, heart-shaped and mature embryo.

Embryos are of two types, i.e. dicot embryo which consists of two cotyledons and monocot embryo which consists of only one cotyledon (called scutellum) *e.g.* rice, maize, etc.

10. Development of Seed and Fruit Formation

After fertilisation, ovary converts into fruit. The wall of ovary develops into **pericarp**, a fleshy part of fruits. It has three layers, *i.e.* **epicarp**, **mesocarp** and **endocarp**. Ovule converts into **seed** which consists of **seed coat**, **cotyledon** and **embryonal** axis. The seed coat contains two layers, *i.e.* outer called **testa** (hard) and inner called **tegmen**.

Types of fruits are as follows

A. **False fruits** are derived from ovary along with thalamus or other accessory floral parts, *e.g.* apple, cashewnut, strawberry, etc.

B. **True fruits** are derived from ovary of flower, *e.g.* mango and tomato.

C. **Parthenocarpic Fruit** When development of fruit in plants occurs without pollination and fertilisation, it is called parthenocarpy. As a result of this process, seedless fruits are developed like grapes, banana, pineapple, papaya, lemon, etc.

11. Significance of Seed and Fruit Formation

Seeds are basis of agriculture and can be stored for long period of time. Fruits protect seed from mechanical injury. They provide food to animals who act as pollinating agents.

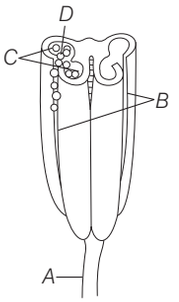
12. Methods of Specific Types of Seed Development

A. **Apomixis** Sometimes embryo and sporophyte develop without fusion of male and female gametes or without gametophyte. This is called apomixis.

B. **Polyembryony** The process of developing more than one embryo in one seed is called polyembryony. It occurs as a result of presence of more than one embryo sac in the ovule or due to fusion with cell other than egg cell.

Practice Questions

1. Identify *A* to *D* in the following diagram.



(a) A – Filament (stalk) , B – Pollen sac, C – Pollen grain, D – Line of dehiscence
(b) A – Filament (stalk), B – Pollen sac, C – Line of dehiscence, D – Pollen grain
(c) A – Line of dehiscence, B – Filament (stalk) , C – Pollen sac, D – Pollen grains
(d) A – Filament (stalk), B – Line of dehiscence, C – Pollen sac, D – Pollen grains

2. The lengthwise running groove on anther which separate theca is called
(a) rupture line (b) line of dehiscence
(c) suture of anther (d) None of the above

3. Number of microsporangia in an angiospermic anther is
(a) 1 (b) 2 (c) 3 (d) 4

4. Microsporangium develops into
(a) pollens (b) microgametes
(c) megagametes (d) pollen sac

5. The innermost layer of microsporangium is
(a) tapetum (b) endothecium
(c) middle layer (d) epidermis

6. Centre of each microsporangium is occupied by
(a) sporogenous tissue (b) tapetum
(c) central tissue (d) microspore mother cell

7. The outermost wall layer of microsporangium in anther is
(a) endothecium (b) tapetum
(c) middle layer (d) epidermis

8. Which of the following perform microsporogenesis?
(a) Microspore mother cell (b) Pollen mother cell
(c) Both (a) and (b) (d) None of these

9. Microspore tetrad (pollen grains) is the result of
(a) mitotic cell division (b) meiotic cell division
(c) Both (a) and (b) (d) None of these

10. Dehiscence of anther in mesophytes is caused by
(a) hydration of anthers (b) dehydration of anthers
(c) mechanical injury (d) None of these

11. Pollens have two prominant walls which are …*A*… and …*B*… . Here *A* and *B* refers to
(a) A–intine, B–protein coat
(b) A–exine, B–intine
(c) A–sporopollenin, B–intine
(d) A–sporopollenin, B–exine

12. Intine is made up of
(a) cellulose
(b) pectin
(c) Both (a) and (b)
(d) protein

13. Exine of pollen is made up of
(a) sporopollenin
(b) sporogenous tissue
(c) spongiform tissue
(d) inorganic material

14. The sporopollenin is non-degradable because
(a) it can withstand strong acids
(b) it is resistant at very high temperature
(c) no enzyme degrade it
(d) All of the above

15. The functions of germ pore is/are
(a) emergence of radicle
(b) absorption of water for seed germination
(c) initiation of pollen tube
(d) All of the above

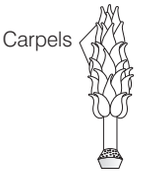
16. When the pollen grain is mature, it contains two cells, the … *A* … and … *B* ….
(a) A–generative cell, B–spore mother cell
(b) A–vegetative cell, B–spore mother cell
(c) A–spore mother cell, B–male gamete
(d) A–vegetative cell, B–generative cell

17. 60% of the angiosperms shed their pollens at the
(a) 2-celled stage (b) 3-celled stage
(c) 4-celled stage (d) 1-celled stage

18. Identify the type of pistil in the diagram.

(a) Multicarpellary, apocarpous
(b) Multicarpellary, syncarpous
(c) Multicarpellary, pistillate
(d) Monocarpellary, apocarpous

19. Identify the type of pistil in the diagram alongside.



(a) Monocarpellary, syncarpous
(b) Monocarpellary, apocarpous
(c) Multicarpellary, syncarpous
(d) Multicarpellary, apocarpous

20. An ovule is a
(a) differentiated megasporangium
(b) dedifferentiated megasporangium
(c) integumented megasporangium
(d) redifferentiated megasporangium

21. Chalazal pole is present
(a) opposite to micropyle
(b) at the origin of integuments
(c) opposite to nucellus
(d) near the embryo sac

22. Mass of cells enclosed by integuments is called
(a) nucellus (b) embryo
(c) ova (d) pollen

23. Embryo sac is also called
(a) female gamete
(b) synergids
(c) female gametophyte
(d) egg of angiosperm

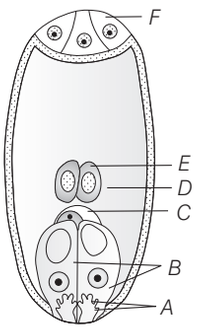
24. Megasporogenesis is
(a) formation of fruits
(b) formation of seeds
(c) formation of megaspores
(d) Both (b) and (c)

25. Megaspore mother cell is found near the region of
(a) micropyle (b) chalaza
(c) nucellus (d) integuments

26. Single megasporic development is called
(a) single sporic (b) unisporic
(c) monosporic (d) disporic

27. In embryo sac, the number of synergid → egg cell → central cell → antipodal cell follows the order
(a) 1–1–2–3 (b) 2–1–3–2
(c) 2–1–1–3 (d) 3–2–1–2

28. Identify *A* to *F* in the diagram given below.



(a) A–Egg, B–Filiform apparatus, C–Synergid, D–Antipodals, E–Polar nuclei, F–Central cell
(b) A–Egg, B–Synergid, C–Filiform apparatus, D–Antipodals, E–Central cell, F–Polar nuclei
(c) A–Central cell, B–Egg, C–Synergid, D–Antipodals, E–Filiform apparatus, F–Polar nuclei
(d) A–Filiform apparatus, B–Synergid, C–Egg, D–Central cell, E–Polar nuclei, F–Antipodals

29. Filiform apparatus are
(a) special cellular thickenings at antipodal cell
(b) special cellular thickenings at the micropylar end
(c) special cellular thickenings at synergid cells
(d) special cellular thickenings at nuclear end

30. Autogamy stands for
(a) pollination in same flower
(b) pollination between different plants
(c) pollination in two flowers of same plant
(d) division in embryo

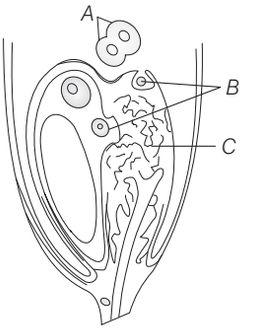
31. Cleistogamous flowers are strictly autogamous because they remain
(a) always open (b) always close
(c) always fragrance (d) are brighty coloured

32. In chasmogamy pollination takes place in
(a) open flower (b) closed flower
(c) large flower (d) geitonogamy flower

33. The most common abiotic pollinating agency in flowering plant is/ are
(a) water (b) wind
(c) Both (a) and (b) (d) None of these

34. Characteristic of wind pollinated pollens is, they are
(a) non-sticky
(b) light
(c) produced in large number
(d) All of the above

35. Diagram showing discharge of gametes in the egg apparatus. Identify *A, B* and *C*.



(a) A–Polar nuclei, B–Female gametes, C–Synergid cell
(b) A–Male gametes, B–Synergid cell, C–Polar nuclei
(c) A–Synergid cell, B–Male gametes, C–Polar nuclei
(d) A–Polar nuclei, B–Male gametes, C–Synergid cell

36. Double fertilisation is
(a) fusion of two male gametes with one egg
(b) fusion of one male gamete with two polar nuclei
(c) fusion of two male gametes of pollen tube with two different eggs
(d) syngamy and triple fusion

ANSWERS

1.	(d)	**2.**	(b)	**3.**	(d)	**4.**	(d)	**5.**	(a)	**6.**	(a)	**7.**	(d)	**8.**	(c)	**9.**	(b)	**10.**	(b)
11.	(b)	**12.**	(c)	**13.**	(a)	**14.**	(d)	**15.**	(c)	**16.**	(d)	**17.**	(a)	**18.**	(b)	**19.**	(d)	**20.**	(c)
21.	(a)	**22.**	(a)	**23.**	(c)	**24.**	(c)	**25.**	(a)	**26.**	(c)	**27.**	(c)	**28.**	(d)	**29.**	(c)	**30.**	(a)
31.	(b)	**32.**	(a)	**33.**	(b)	**34.**	(d)	**35.**	(d)	**36.**	(d)								

Hints & Explanations

2. (***b***) The dehiscence (release of pollen grain) of anther occurs through the line of dehiscence which is the running groove on anther longitudinally. It separates the theca of anther.

3. (***d***) A typical angiosperm anther is bilobed with each lobe having two theca. The anther is a four-sided (tetragonal) structure consisting of four microsporangia located at the corner with two in each theca.

4. (***d***) Microsporangium develops further and becomes pollen sac. It is like a sac in which pollen develops. It is called pollen sac at the time of maturity.

6. (***a***) Sporogenous tissue occupies the centre of each microsporangium. Each cell of this tissue is a potential pollen mother cell and can give rise to microspore tetrad.

7. (***d***) Microsporangium is surrounded by four wall layers. The outermost layer is epidermis which is followed by endothecium, the middle layer and the innermost layer called tapetum. The three outer layers of microsporangium perform the function of protection and help in dehiscence of anther to release pollen.

8. (***c***) Microspore mother cell and pollen mother cell are the same terms and form male gametes (pollens) by the process called microsporogenesis.

10. (***b***) As the anthers of angiospermic mesophytic plants mature and dehydrate, the line of dehiscence ruptures releasing the microspores in atmosphere. These microspores dissociate from each other and develop into pollen grains.

12. (***c***) The inner layer of pollen grain is called intine. It is a continuous and thin layer made up of cellulose and pectin.

15. (***c***) The germ pores are apertures in the exine layer of a pollen grain which help in the initiation of pollen tube and the release of the male gametes during fertilisation. There are usually three germ pores in dicots (tricolpate) and one in monocots (monocolpate).

16. (***d***) When a pollen grain is mature it contains two cells, a 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.

17. (***a***) 60% of angiosperms shed their pollens at 2-celled stage and in rest 40%, the pollens are shed at 3-celled stage.

18. (***b***) The diagram represents the multicarpellary, syncarpous pistil of *Papaver*. The gynoecium of this plant consists of more than one pistil, showing multicarpellary condition. These pistils are fused together and hence are called syncarpous.

19. (***d***) The diagram shows the multicarpellary, apocarpous pistil of *Michelia*. The gynoecium of this ovary consists of more than one pistil (multicarpellary) which are free (apocarpous).

20. (***c***) An ovule is an integumented megasporangium found in angiosperms, which develops into seeds after fertilisation.

21. (***a***) Chalazal pole is present just opposite to the micropylar end and represents the basal part of the ovule.

22. (***a***) Integuments enclose a mass of cells called the nucellus. Cells of the nucellus have abundant reserve food materials.

23. (***c***) Embryo sac is also called the female gametophyte. In flowering plants, it is formed by the division of the haploid megaspore nucleus and acts as the site of fertilisation and development of the embryo.

25. (***a***) Megaspore Mother Cell (MMC) is found in the micropylar region of the nucellus. It is a large cell containing dense cytoplasm and prominent nucleus.

27. (***c***) The functional megaspore develops into the embryo sac containing 2 synergids, l egg cell, 1 central cell and 3 antipodal cells. Thus, option (c) gives the correct number of different cells in an embryo sac.

31. (***b***) Cleistogamous flowers are strictly autogamous because they always remain close for ensuring self-pollination. In these flowers, there is no chance of cross-pollination.

34 (***d***) Wind pollinated pollens are non-sticky and light so that they can go far away in wind currents. These are produced in large numbers, because there is a lot of wastage of pollens.

36. (***d***) Double fertilisation is the fusion of two male gametes to two different cells of the same female gametophyte.

It consists of the following two events

- **Syngamy** is the fusion of the egg nucleus with one male gamete.
- **Triple fusion** is the fusion of second male gamete and polar nuclei of central cell.