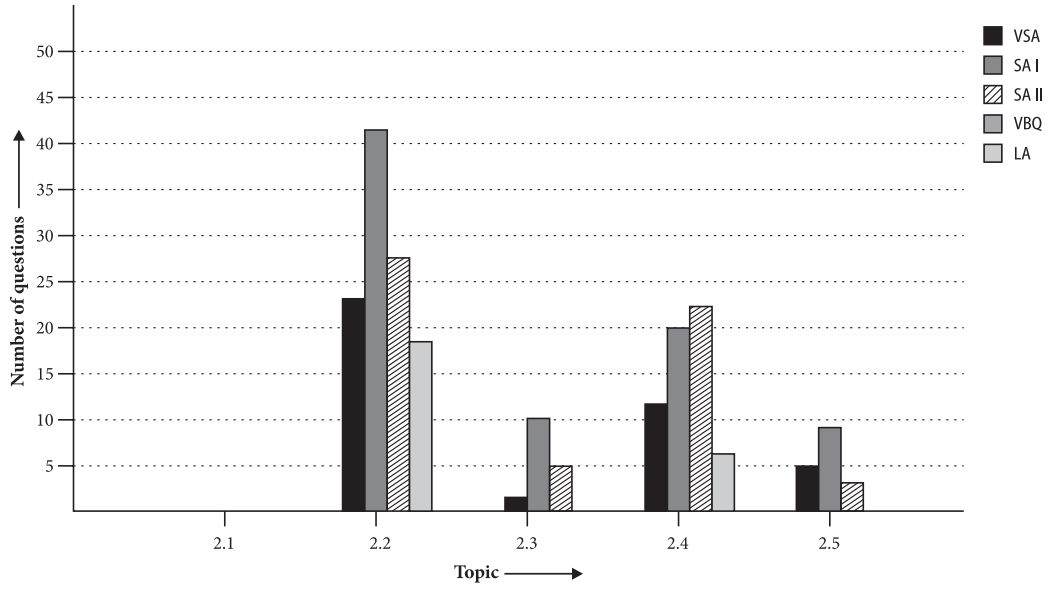
02 Sexual Reproduction in Flowering Plants

2.1 Flower-A fascinating Organ of Angiosperms
2.2 Pre-fertilisation : Structures and Events
2.3 Double Fertilisation
2.4 Post-fertilisation : Structures and Events
2.5 Apomixis and Polyembryony

Topicwise Analysis of Last 10 Years' CBSE Board Questions



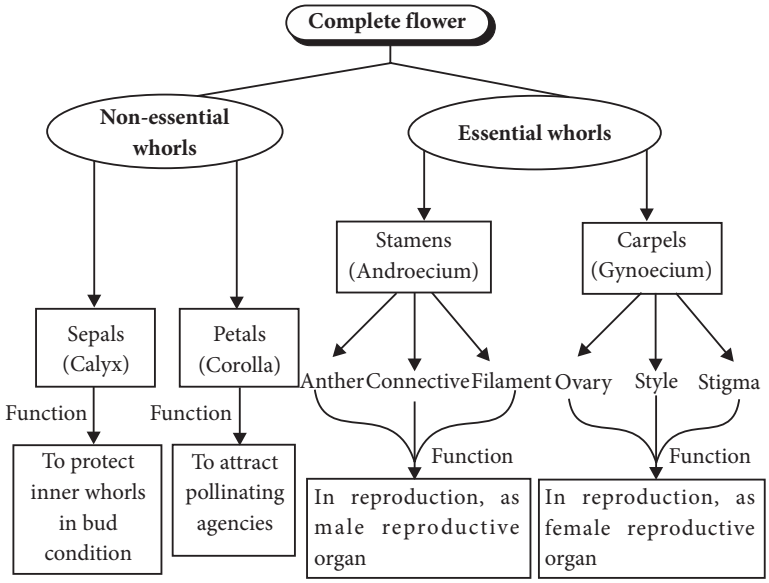
- Maximum weightage is of *Pre-fertilisation : Structures and Events.*
- Maximum VSA, SAI, SAII and LA type questions were asked from *Pre-fertilisation : Structures and Events.*

QUICK RECAP

- Sexual reproduction is the formation of new individuals through the meiotic gamete formation and their subsequent fusion during fertilisation. It is also called **amphimixis**.
- Flower is a **specialised condensed shoot** meant for carrying out the **sexual reproduction**. It bears floral leaves and gives rise to seeds and fruits.
- A typical flower has **4 whorls** of floral leaves *viz.*, **sepals** (calyx), **petals** (corolla), **stamens** (androecium) and **carpels** (gynoecium). Stamens and carpels respectively represent male and female reproductive organs of flowers.

MALE REPRODUCTIVE ORGAN

- Androecium consists of stamens as its units. The stamens or microsporophylls are regarded as the male reproductive organs of the flower.
- Each stamen consists of three parts - **filament**, **anther** and **connective**.
- The filament is the slender stalk of the stamen, and the anther is the expanded head, borne by the filament.



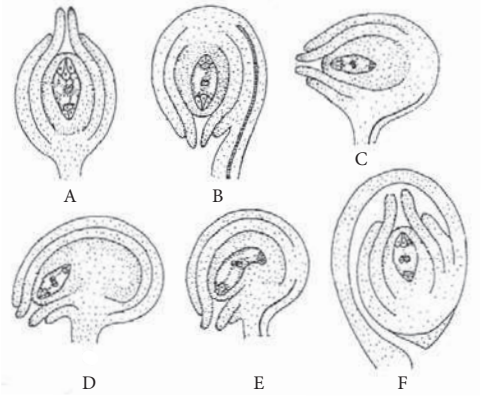
Flow chart : Parts of a typical flower

- Each anther consists usually of **two lobes** connected together by a sort of midrib known as the **connective**.
- Anther consists of 4 pollen sacs or **microsporangia** (two in each lobe). Microsporangial wall has four types of layers:
  - **Epidermis :** One cell thick and protective in function.
  - **Endothecium :** Single layered, cells have cellulose thickening with a little pectin and lignin in some cases. It helps in anther dehiscence.
  - **Middle layers :** 1-3 layers; they degenerate during maturity of the anther.
  - **Tapetum :** Tapetal cells are nutritive. By these cells, the **Ubisch bodies** are produced which help in the ornamentation of microspore wall.
- The process of formation of microspores from sporogenous tissue is known as **microsporogenesis.**
- The sporogenous cells may directly function as microspore mother cells (also called pollen mother cells or PMCs).
- As the anther matures and dehydrates, it dehisces by slits and pores to liberate the pollen grains.
- Pollen grain (microspore) is the first cell of the male gametophyte.
- Pollen grains are released from the anthers either at 2 - celled stage or at 3 - celled stage.
- Wall or covering of pollen grain is called **sporoderm**. It has two layers, outer exine and inner intine. The outer layer **exine** is thick and sculptured or smooth. It is made up of **sporopollenin** which is resistant to chemical and biological decomposition so pollen wall is preserved for long periods in fossil deposits. At certain places the exine remains thin. These thin areas are known as **germ pores**, when they are circular in outline and **germinal furrows** when they are elongated. The **intine** is thin and elastic. It emerges out as the pollen tube from the germ pores during germination.
- Development of male gametophyte is **precocious,** that is, it begins inside the microsporangium or pollen sac.

- The size of the nucleus increases and protoplast then divides mitotically to produce a **bigger vegetative** or **tube cell** and a **smaller generative cell**.
- The tube cell has a vacuolate cytoplasm which is rich in food reserve cell organelles and large and irregular nucleus.
- The generative cell is small, spindle shaped to spherical shaped, with thin dense cytoplasm and a prominent nucleus.
- Male gametes are formed by a mitotic division in a generative cell.

FEMALE REPRODUCTIVE ORGAN

- Gynoecium is female reproductive whorl of the flower. It is composed of one or more **carpels** or **pistils**.
- Each pistil consists of three parts, *i.e.*, **stigma**, **style** and **ovary**.
- A pistil has a terminal receptive disc-like **stigma**, a stalk-like **style** and a basal swollen ovule bearing part called **ovary.** Inside the ovary is the **ovarian cavity** (with one or more locules) and parenchymatous cushion called **placenta**, from which arise **ovules**.
- An ovule or integumented megasporangium develops from the base or the inner surface of the ovary. It is small, generally an oval structure and consists chiefly of a central body of tissue, the **nucellus** and one or two **integuments**.
- Each ovule is attached to the placenta by a small stalk called the **funiculus**.
- The place of attachment of the funiculus with the main body of the ovule is called the **hilum**.



Six different types of ovules in angiosperms. A, Orthotropous. B, Anatropous. C, Hemitropous. D, Campylotropous. E, Amphitropous. F, Circinotropous.

- In a typical (anatropous) ovule, the funiculus is fused with body of the ovule lengthwise beyond the hilum. It gives rise to a longitudinal ridge called **raphe**. Funiculus contains a vascular strand for the supply of nourishment to the ovule.
- The ovule contains a mass of thin walled parenchymatous cells called **nucellus**. The nucellus is protected by one or two multicellular coats called **integuments**. The basal portion of the nucellus from where the integuments appear is called **chalaza**. A small opening is left at the apex of integuments known as **micropyle**.
- **Embryo sac** or **female gametophyte** is embedded in the micropylar half of the nucellus. This makes the most important part of the mature ovule. It is the embryo sac, which bears the embryo later on.
- Formation of megaspore (n) from megaspore mother cell (2n) by meiosis inside the ovule is called **megasporogenesis**.
- Only one magaspore mother cell remains functional and other 3 degenerate. This functional megaspore develops into a female gametophyte. This method of embryo sac formation from a single megaspore is called monosporic development.
- The functional megaspore is the first cell of female gametophyte. The nucleus of magaspore divides mitotically to form 8 nuclei and give rise to embryo sac or female gametophyte. This process is called **megagametogenesis.**
- Out of 8 nuclei, 4 nuclei are arranged at each pole. One nucleus from each pole migrates to the centre to form two polar nuclei which further fuse to form a diploid or secondary nucleus.
- Three nuclei at the base of embryo sac form antipodal cells. The remaining 3 nuclei at the micropylar end get surrounded by cytoplasm and are called **egg apparatus.** The egg apparatus consists of one larger middle cell known as egg or oosphere and the remaining two cells are called as synergids or help cells.
- Thus a typical angiosperm embryo sac, at maturity, though 8-nucleate is 7 celled with 3 micropylar, 3 chalazal and one central cell.

POLLINATION

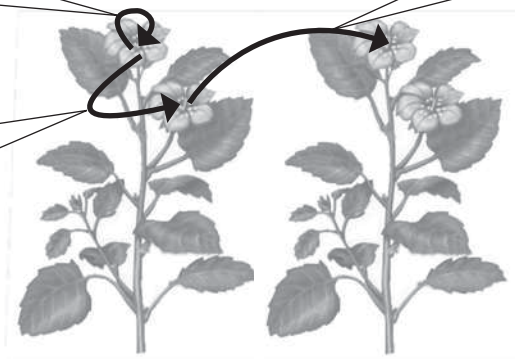
Pollination refers to transfer of pollen grains from anther to stigma of a flower. It is of two type: self pollination and cross pollination.

Self pollination

- It is the process where pollen grains are transferred from the anther of a flower to the stigma of either the same or genetically similar flower.
- Self pollination maintains the parental characters or purity of the race indefinitely.

Autogamy
Transfer of pollen grains from anther to stigma of same flower.

Geitonogamy
Transfer of pollen grains from anther of one flower to stigma of another flower present in the same inflorescence or in the same plant.



Xenogamy (Cross Pollination)

- Transfer of pollen grains from anther of one flower to the stigma of enetically different flower of same species.
- Also known as cross pollination or allogamy.
- Dichogamy, dicliny, herkogamy, heterostyly and self sterility ensure cross-pollination in bisexual flowers.

Fig.: Types of pollination

Agents of pollination

The transfer of pollen grains from plant to plant in cross pollination takes place through **biotic agencies** (living agencies) or through **abiotic agencies** (non-living agencies).

Agents of cross pollination

Abiotic

- **Anemophily** (by wind), *e.g.*, Palm, *Zea mays.*
- **Hydrophily** (by water), *e.g.*, *Vallisneria, Zostera.*

Biotic

- **Entomophily** (by insects), *e.g., Aristolochia, Salvia,* etc.
- **Ornithophily** (by birds), *e.g., Bombax, Bignonia* etc.
- **Chiropterophily** (by bats), *e.g., Kigelia, Adansonia* etc.
- **Malacophily** (by snails), *e.g., Arisaema.*
- **Myrmecophily** (by ants), *e.g.*, some members of Rubiaceae.

Pollen - Pistil Interaction

Pollen - pistil interaction is a safety measure to ensure that illegitimate crossing do not occur. It checks the promotion or inhibition of pollen growth. Pollen grains of a number of plants may settle over a stigma but only the right pollen belonging to same species would germinate while others fail to do so. **Compatibility and incompatibility of the pollen-pistil is determined by special proteins.** The compatible pollens are able to absorb water and nutrients from the surface of the stigma. They germinate and produce pollen tubes. Pollen tubes grow into the style. Their growth and path through the style are also determined by specific chemicals.

Significance of pollination

- Pollination is a means of taking the male gametophyte for its growth near the female gametophyte.
- Pollen-pistil interaction determines the suitability of pollen for carrying out the process of sexual reproduction.
- It has freed the seed plants from the dependence on external water during fertilisation.

- It can be manipulated to produce pure lines as well as desired varieties.

FERTILISATION

- The fusion of male and female gamete is called fertilisation.
- The fertilisation involving formation of pollen tube as in seed plants is called **siphonogamy**. On reaching the ovary, the pollen tube grows towards one of the ovules.
- The pollen tube enters the ovule either through its micropyle (porogamy *e.g.,* lily) or chalaza (chalazogamy *e.g.*, *Betula*) or integuments (mesogamy *e.g.*, *Cucurbita*). Irrespective of the place of entry into ovules, the pollen tube enters the embryo sac through the micropylar region.
- Inside the embryo sac, one male gamete fuses with the egg to form the zygote (2n), the process is known as **syngamy** or **generative fertilisation.** The second male gamete fuses with 2 polar nuclei or secondary nucleus to form triploid primary endosperm nucleus, the process is known as **triple fusion** or **vegetative fertilisation**.
- The zygote develops into **embryo** and primary endosperm nucleus develops into **endosperm**.
- The occurrence of syngamy and triple fusion simultaneously in angiosperms is called **double fertilisation**. Double fertilisation was first reported by **S.G. Nawaschin (1898)** in *Fritillaria* and *Lilium*.

POST-FERTILISATION : STRUCTURE AND EVENTS

- The events of endosperm and embryo development, maturation of ovule(s) into seeds and ovary into fruit, are collectively termed as **post-fertilisation events**.

Endosperm

- As a consequence of triple fusion in which a male gamete fuses with the secondary nucleus, a triploid structure called primary endosperm nucleus (PEN) is formed that divides by mitotic divisions and forms a mass of nutritive cells called the **endosperm**.
- Endosperm development precedes embryo development. Endosperm accumulates food reserves and functions as the nutritive tissue for the developing embryo.

Types of endosperm depending upon the mode of formation

Nuclear
Most common type of endosperm, the primary endosperm nucleus (PEN) divides repeatedly without wall formation and then multinucleate cytoplasm undergoes cleavage and forms multicellular tissue *e.g., Cocos nucifera*.

Cellular
Every division of PEN is followed by cytokinesis *e.g.,* Balsam, *Petunia*.

Helobial
The endosperm is of intermediate between cellular and nuclear type. The first division of PEN is followed by transverse cytokinesis but the subsequent divisions are free nuclear *e.g.*, Order helobiales and most monocots.

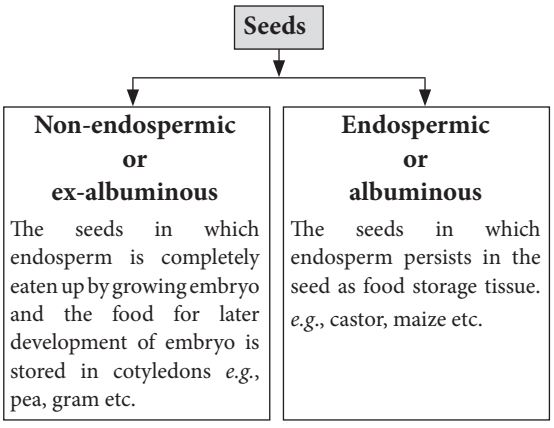
Embryo

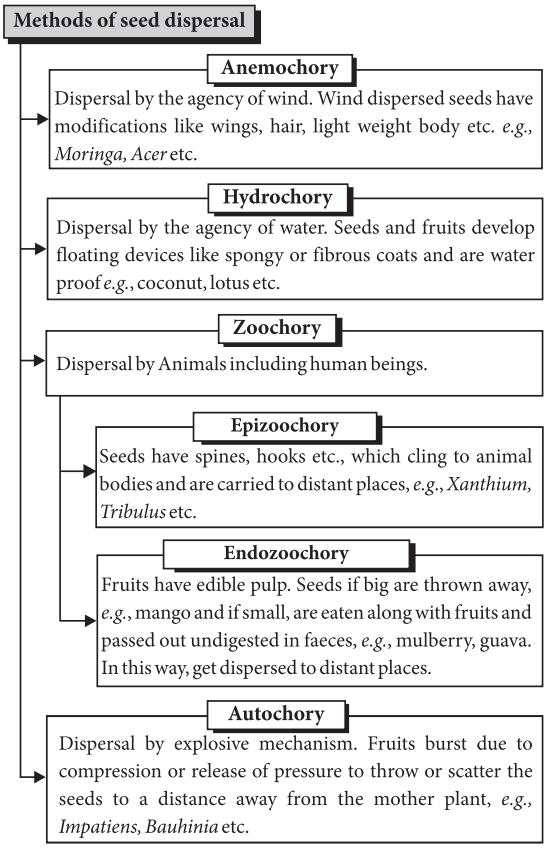
- After fertilisation, the fertilised egg is called **zygote** or **oospore** which develops into an **embryo**.
- This process of development of embryo is called **embryogenesis**.
- The oospore before entering the process of embryogenesis undergoes a period of rest which may vary from few hours to few months.
- 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.
- A typical dicotyledonous embryo consists of an embryonal axis and two cotyledons. The part of embryonal axis above the level of cotyledons is

called **epicotyl**. It terminates with the stem tip, called **plumule** (future shoot). The part below the level of cotyledons is called **hypocotyl** which terminates in the root tip called **radicle** (future root). The root tip is covered with a root cap **(calyptra).** In monocotyledons, there is only one terminal cotyledon situated towards lateral side of the embryonal axis called **scutellum** (shield shaped) *e.g.*, grass family. At its lower end, the embxyonal axis has radicle and root cap enclosed in an undifferentiated sheath called **coleorhiza**. The part of axis above scutellum attachment is called epicotyl. It has shoot apex and few leaf primordia enclosed in hollow foliar structure called **coleoptile**. The early development of dicot and monocot embryos is similar upto globular stage.

SEED

- Ripened ovules are known as seeds. A true seed is defined as a fertilised mature ovule that possesses an embryonic plant, stored food (sometimes absent) and a protective coat or coats.
- **Integuments** of ovule harden as tough protective **seed coat.** Outer integument forms **testa** and **tegmen** develops from the inner integument.
- **Funiculus** (stalk of ovule) forms stalk of the seed. Ultimately, stalk withers and leaves a minute scar called **hilum**. Antipodals, synergids disorganise and nucellus may disappear or persist as **perisperm**.





FRUITS

- A fruit is a seed containing part of a plant that develops from a **fertilised ovary** and often from other tissues that surround it.
- A **pseudocarp** or accessory fruit or **false fruit** is a fruit whose flesh is derived from the ovary, along with some other floral part like thalamus, *e.g.*, apple, strawberries.
- A **eucarp** or **true fruit** is a fruit which is developed only from the ovary after fertilisation, *e.g.*, mango.
- The wall covering the fruit is called **pericarp**. It consists of three parts :
  - **Epicarp,** called the skin of fruits.
  - **Mesocarp,** middle fleshy and pulpy part.
  - **Endocarp,** innermost portion that surrounds the seeds.
- Fruits can be simple fruit (develops from monocarpellary ovary), aggregate fruit (develops from multicarpellary apocarpous ovary) and composite fruits (develops from a complete inflorescence).

SPECIAL MODES OF REPRODUCTION

Polyembryony

The phenomenon of occurrence of more than one embryo in a seed is called polyembryony, *e.g.*, lemon, groundnut. Occurrence of polyembryony due to fertilisation of more than one egg is called **simple polyembryony**. Formation of extra embryos through sporophytic tissue is called **adventive polyembryony**.

Polyembryony was first reported by **Leeuwenhoek** (1719) in the seeds of orange. In angiosperms, it is generally present as unusual feature except few cases like *Citrus,* mango etc.

Apomixis

Apomixis may be defined as, "abnormal kind of sexualreproductionwhich does not involve meiosis and syngamy. The egg or other cells associated with egg (synergids, antipodals, etc) develop into embryo". Thus, there is development of seed without fertilisation.

Recurrent agamospermy and adventive embryony are two common methods of apomictic development in seeds.

Parthenocarpy

Parthenocarpy (Gk.*parthenos*-virgin, *karpos*-fruit) is the formation of fruit without fertilisation and pollination. However in some cases a pollination stimulus is required. The fruit produced due to parthenogenesis may or may not be seedless depending upon the occurrence of apomixis and subsequent development of embryo. When seeds are formed, they are abortive.

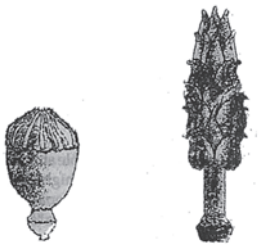
Parthenocarpic fruits are produced normally in many cultivated plants such as banana, grapes and pineapple. These fruits may be produced due to (i) absence of pollination, (ii) failure of fertilisation or (iii) lack of embryo development.

Previous Years' CBSE Board Questions

2.2 Pre-fertilisation: Structures and Events

VSA (1 mark)

1.



A B

These pictures show the gynoecium of (A) *Papaver* and (B) *Michelia* flowers. Write the difference in the structure of their ovaries. *(Delhi 2015C)*

2. Name the part of the flower which the tassels of the corn-cob represent. *(AI 2014)*

3. Give an example of a plant which came into India as a contaminant and is a cause of pollen allergy. *(AI 2014)*

4. What is pollen-pistil interaction and how is it mediated? *(Foreign 2014)*

5. State the function of filiform apparatus found in mature embryo sac of an angiosperm. *(Foreign 2014)*

6. Differentiate between xenogamy and geitonogamy. *(1/3, AI 2014C)*

7. An anther with malfunctioning tapetum often fails to produce viable male gametophytes. Give any one reason. *(1/3, Delhi 2013, 2010)*

8. How do the pollen grains of *Vallisneria* protect themselves? *(AI 2012)*

9. Write the function of tapetum in anthers. *(1/3, Delhi 2012)*

10. Explain the function of germ pores. *(AI 2012)*

11. Write the characteristic features of anemophilous flowers. *(AI 2012C)*

12. Give reason why anthers of angiosperm flowers are described as dithecous. *(1/5, Delhi 2011)*

13. Mention any one application of a pollen bank. *(1/3, Delhi 2011C)*

14. All papaya plants bear flowers but fruits are seen in some. Explain. *(AI 2011C)*

15. Write the characteristic features of anther, pollen and stigma of wind pollinated flowers. *(1/3, Delhi 2010)*

16. A bilobed, dithecous anther has 100 microspore mother cells per microsporangium. How many male gametophytes this anther can produce? *(Delhi 2010)*

17. Why do the pollen grains of *Vallisneria* have a mucilaginous covering? *(Delhi 2010C)*

18. The microscopic pollen grains of the past are obtained as fossils. Mention the characteristic of the pollen grains that makes it happen. *(Delhi 2009)*

19. Name the type of flower which favours cross pollination. *(AI 2009)*

20. Why is bagging of the emasculated flowers essential during hybridisation experiments? *(AI 2009)*

21. The following statements (a), (b) and (c) seem to describe the water-pollinated submerged plants. Which one of these statements is incorrect?

(a) The flowers do not produce nectar.

(b) The pollen grains have mucilaginous covering.

(c) The brightly coloured female flowers have long stalk to reach the surface. *(Foreign 2009)*

22. How can pollen grains of wheat and rice which tend to lose viability within 30 minutes of their release be made available months later for breeding programmes? *(Delhi 2009C)*

23. Mention one application of pollen bank. How are pollens stored in a bank ? *(Delhi 2008C)*

SA I (2 marks)

24. List the different types of pollination depending upon the source of pollen grain. *(2/5, Delhi 2016)*

25. Angiosperms bearing unisexual flowers are said to be either monoecious or dioecious. Explain with the help of one example of each. *(Delhi 2016)*

26. A single pea plant in your kitchen garden produces pods with viable seeds, but the individual papaya plant does not. Explain. *(AI 2016)*

27. Gynoecium of a flower may be apocarpous or syncarpous. Explain with the help of an example each. *(AI 2016)*

28. Why do hermaphrodite angiosperms develop outbreeding devices? Explain any two such devices with the help of examples. *(AI 2015C)*

29. Name the organic materials exine and intine of an angiosperm pollen grain are made up of. Explain the role of exine. *(Delhi 2014)*

30. Draw a diagram of a matured microspore of an angiosperm. Label its cellular components only. *(Foreign 2014)*

31. (a) How does cleistogamy ensure autogamy?
(b) State one advantage and one disadvantage of cleistogamy to the plant. *(Delhi 2013)*

32. Geitonogamous flowering plants are genetically autogamous but functionally cross-pollinated. Justify. *(Delhi 2013)*

33. Name all the haploid cells present in an unfertilised mature embryo-sac of a flowering plant. Write the total number of cells in it. *(AI 2013)*

34. Differentiate between the two cells enclosed in a mature male gametophyte of an angiosperm. *(AI 2013)*

35. Draw a labelled diagram of a mature pollen grain. *(2/5, Delhi 2013C)*

36. Explain the sequence of events in pollen-pistil interaction. *(Delhi 2013C)*

37. Draw labelled diagram of a mature ovule and embryo sac with its contents. *(2/5, Delhi 2013C)*

38. Draw the labelled structure of mature embryo sac. *(AI 2013C, 2/5, Delhi 2007)*

39. List the adaptive features of water pollinated flowers like *Vallisneria*. *(Delhi 2013C)*

40. State one advantage and one disadvantage of cleistogamy. *(2/5, Delhi, AI 2012)*

41. Where is sporopollenin present in plants? State its significance with reference to its chemical nature. *(Delhi 2012)*

42. How does the study of different parts of a flower help in identifying wind as its pollinating agent? *(AI 2012)*

43. Trace pollen grain development from sporogenous tissue in the anther. *(Delhi 2012C)*

44. What is the role of endothecium and tapetum in an anther? *(AI 2012C)*

45. Differentiate between autogamy, geitonogamy and xenogamy. *(2/5, AI 2012C)*

46. Why does a breeder need to emasculate a bisexual flower? Mention a condition in a flower where emasculation is not necessary. *(Delhi 2011C, 2009C)*

47. Explain why emasculation and bagging are practised during artificial hybridisation programme involving plants bearing bisexual flowers. *(Delhi 2011C)*

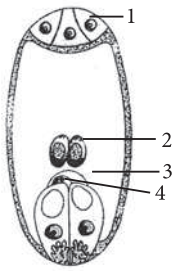
48. Mention an advantage and a disadvantage of a cleistogamous flower. *(AI 2011C)*

49. (a) Mention any four strategies adopted by flowering plants to prevent self-pollination.
(b) Why is geitonogamy also referred to as genetical autogamy? *(Delhi 2010)*

50. Explain the process of artificial hybridisation to get improved crop variety in (a) plants bearing bisexual flowers (b) female parent producing unisexual flowers. *(2/5, Delhi 2010)*

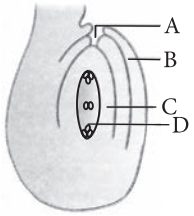
51. How many haploid cells are present in mature female gametophyte of a flowering plant? Name them. *(Delhi 2010)*

52. In the given figure of embryo sac label the parts (1), (2), (3) and (4).



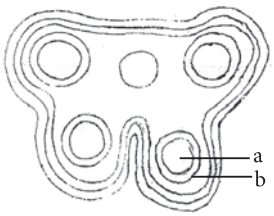
(AI 2010)

53. Identify and label the parts in the given anatropous ovule.



(AI 2010C)

54. In the T.S. of a mature anther given below identify 'a' and 'b' and mention their functions.



(Foreign 2009)

55. Explain how geitonogamy is functionally similar to cross pollination and genetically similar to autogamy. *(AI 2009C)*

56. Draw the longitudinal section of pistil showing pollen tube. *(AI 2009C)*

57. Cleistogamous flowers of *Commelina* are invariably autogamous. Mention its one advantage and one disadvantage to the plant. *(AI 2009C)*

58. (a) Draw a schematic diagram of T.S. of a mature anther. Label only the layers that help in dehiscence of the anther to release pollen grains.

(b) Why is exine of the pollen grain not a continuous layer? *(AI 2009C)*

59. The flower of brinjal is referred to as chasmogamous while that of beans is cleistogamous. How are they different from each other? *(Delhi 2008)*

60. Draw the structure of anatropous ovule. *(Delhi 2008)*

61. Draw a diagrammatic sketch of the sectional view of a typical anatropous ovule. *(2/5, Delhi 2008)*

62. What is geitonogamy? Give its one similarity to
(a) autogamy and
(b) xenogamy. *(Delhi 2008C)*

63. Draw a diagram of L.S. of an anatropous ovule of an angiosperm and label the following parts:
(a) Nucellus
(b) Integument
(c) Antipodal cell
(d) Secondary nucleus *(Delhi 2007)*

64. Draw a sectional view of a pollen grain and label the following parts:
(a) Intine (b) Exine
(c) Germ pore (d) Generative cell
(Delhi 2007)

SA II (3 marks)

65. (a) Name the organic material exine of the pollen grain is made up of. How is this material advantageous to pollen grain?
(b) Still it is observed that it does not form a continuous layer around the pollen grain. Give reason.
(c) How are 'pollen banks' useful? *(AI 2016)*

66. Draw a labelled diagram of a typical anatropous ovule. *(Delhi 2014)*

67. Make a list of any three outbreeding devices that flowering plants have developed and explain how they help to encourage cross-pollination.

OR

Why are angiosperm anthers called dithecous? Describe the structure of its microsporangium. *(AI 2014)*

68. Write the differences between wind-pollinated and insect-pollinated flowers. Give an example of each type. *(Foreign 2014)*

69. Describe the structure of a mature microsporangium of an angiosperm. *(3/5, AI 2014C)*

70. Describe the characteristic features of wind pollinated flowers. *(3/5, Delhi 2013)*

71. Draw a diagram of a mature embryo sac of an angiosperm and label the following parts in it.
(a) Filiform apparatus (b) Synergids
(c) Central cells (d) Egg cell
(e) Polar nuclei (f) Antipodals
(3/5, Delhi 2013)

72. Draw L.S. of a pistil showing pollen tube entering the embryo-sac in an angiosperm and label any six parts other than stigma, style and ovary. *(3/5, AI 2013)*

73. Explain the process of microsporogenesis in angiosperms. *(3/5, Delhi 2013C)*

74. Explain the process of megasporogenesis in angiosperms. *(3/5, Delhi 2013C)*

75. Write the mode of pollination in *Vallisneria* and water lily. Explain the mechanism of pollination in *Vallisneria*. *(AI 2013C)*

76. Describe the process of megasporogenesis in angiosperms until 8 nucleate stage.
(3/5, AI 2013C)

77. Describe the structure of a 3-celled pollen grain of an angiosperm.
(3/5, Delhi 2012C)

78. Explain the processes of emasculation and bagging of flowers. State their importance in breeding experiments. *(Delhi 2012C)*

79. Describe the development of a 7-celled female gametophyte from a megaspore mother cell in an angiosperm. *(3/5, AI 2012C)*

80. Explain any three outbreeding devices in flowering plants. *(AI 2012C)*

81. Draw a diagram of a male gametophyte of an angiosperm. Label any four parts. Why is sporopollenin considered the most resistant organic material? *(Delhi 2011)*

82. Differentiate between geitonogamy and xenogamy in plants. Which one between the two will lead to inbreeding depression and why? *(Delhi 2011)*

83. Draw a diagram of a vertical section of an anatropous ovule of an angiosperm. Label the following parts:
(a) Hilum (b) Micropyle
(c) Outer integument (d) Nucellus
(e) Embryo sac (f) Antipodals.
(AI 2011C)

84. (a) Mention the exact location or the site in a flowering plant where the following developments take place.
(i) Deposition of sporopollenin
(ii) Megasporogenesis
(b) Draw a labelled diagram of a male gametophyte of an angiosperm.
(AI 2011C)

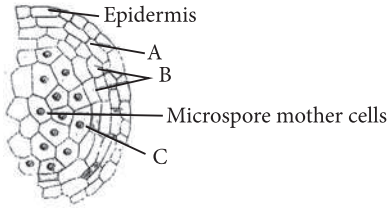
85. Draw a labelled L.S. of pistil showing path of pollen tube entering the embryo sac.
(AI 2011C)

86. Explain the characteristic features of flowers that facilitate wind-pollination. *(Delhi 2011C)*

87. Trace the development of megaspore mother cell up to the formation of a mature embryo-sac in a flowering plant. *(Delhi 2010)*

88. Draw a longitudinal section of a post-pollinated pistil showing entry of pollen tube into a mature embryo-sac. Label filiform apparatus, chalazal end, hilum, antipodals, male gametes and secondary nucleus. *(Delhi 2010)*

89. Given below is an enlarged view of one microsporangium of a mature anther.



(a) Name 'A', 'B' and 'C' wall layers.
(b) Mention the characteristics and function of the cells forming wall layer 'C'.

OR

State the significance of pollination. List any four differences between wind-pollinated and animal-pollinated flowers. *(Delhi 2008C)*

90. Enumerate any six adaptive floral characteristics of a wind pollinated plant. *(AI 2008C)*

91. Describe the *Polygonum* type of embryo sac. Why is it generally referred to as monosporic?
(Delhi 2007)

LA (5 marks)

92. (a) Draw a labelled diagram of the sectional view of microsporangium of an angiosperm.

(b) Explain the development of male gametophyte in the microsporangium. *(Delhi 2015C)*

93. (a) Describe the sequence of the process of microsporogenesis in angiosperms.

(b) Draw a labelled diagram of a two celled final structure formed. *(Delhi 2015C)*

94. Angiosperm flowers may be monoecious, cleistogamous or show self-incompatibility. Describe the characteristic features of each one of them and state which one of these flowers promotes inbreeding and outbreeding respectively. *(Delhi 2014C)*

95. (a) Describe the formation of mature female gametophyte within an ovule in angiosperms.

(b) Describe the structure of the cell(s) that guide(s) the pollen tube to enter the embryo sac. *(AI 2014C)*

96. (a) Draw a longitudinal section of a pistil of an angiosperm showing the growth of the pollen tube up to the micropyle of the ovule.

Label (i) stigma, (ii) embryo sac, (iii) pollen tube (iv) micropyle.

(b) Explain the events that occur, upto fertilisation, when the compatible pollen grain lands on the stigma. *(AI 2014C)*

97. (a) Draw a labelled schematic diagram of the transverse section of a mature anther of an angiosperm plant.

(b) Describe the characteristic features of an insect pollinated flower. *(Delhi 2013)*

98. (a) Describe the process of megasporogenesis in angiosperms until 8 nucleate stage.

(b) Draw the labelled structure of mature embryo sac. *(AI 2013C)*

99. How does the megaspore mother cell develop into 7-celled, 8 nucleate embryo sac in an angiosperm? Draw a labelled diagram of a mature embryo sac. *(Delhi 2012)*

100. (a) Draw a labelled diagram of a transverse section of a mature anther of an angiosperm showing different wall layers.

(b) Mention the function of each of these wall layers during pollen grain development. *(Delhi 2012C)*

101. (a) Draw a diagram of an enlarged view of T.S. of one microsporangium of an angiosperm and label the following parts:

(i) Tapetum
(ii) Middle layer
(iii) Endothecium
(iv) Microspore mother cells

(b) Mention the characteristic features and function of tapetum.

(c) Explain the following giving reasons:
(i) Pollen grains are well preserved as fossils.
(ii) Pollen tablets are in use by people these days. *(Foreign 2011)*

102. (a) Differentiate between autogamy, geitonogamy and xenogamy?

(b) Explain the events that occur during pollen-pistil interaction. *(AI 2011C)*

103. Describe in sequence the events that lead to the development of a 3-celled pollen grain from microspore mother cell in angiosperms. *(Delhi, AI 2010)*

104. (a) Describe in sequence the process of megasporogenesis in angiosperms.

(b) Draw the seven-celled structure formed and label all the different cells. *(Delhi 2010C)*

105. (a) Geitonogamy is functionally a cross pollination but genetically similar to autogamy. Explain.

(b) Why do flowering plants need to develop outbreeding devices. Explain any three such devices developed by flowering plants. *(AI 2010C)*

106. How does the pollen mother cell develop into a mature pollen grain? Illustrate the stages with labelled diagrams. *(Delhi 2009)*

107. Explain with the help of a diagram the development of a mature embryo sac from a megaspore mother cell in angiosperm. *(Delhi 2009)*

108. Draw a labelled diagram of an anther lobe at microspore-mother cell stage. Mention the role of different wall layers of anther.
(Delhi 2009C)

109. (a) Draw a labelled diagram of the sectional view of a mature pollen grain in angiosperms.
(b) Explain the functions of its different parts.
(Delhi 2008)

2.3 Double Fertilisation

VSA (1 mark)

110. Mention the exact location or the site in a flowering plant where the following developments take place.
(a) Triple fusion
(b) Release of male gametes. *(1/3, AI 2011C)*

111. What is double fertilisation? *(Delhi 2009C)*

SA I (2 marks)

112. Draw a diagram of a fertilised embryo sac of a dicot flower.Label all its cellular components.
(Delhi 2015C)

113. Write the fate of egg cell and polar nuclei after fertilisation. *(Delhi 2013)*

114. In angiosperms, zygote is diploid while primary endosperm cell is triploid. Explain. *(AI 2013)*

115. Explain triple fusion in angiosperm.
(Delhi 2013C)

116. Draw a labelled diagram of a male gametophyte of an angiosperm. Why does it possess two male gametes to fertilise one ovule?
(AI, Delhi 2013C)

117. Why is fertilisation in an angiosperm referred to as double fertilisation? Mention the ploidy of the cells involved. *(2/5, Delhi 2012C)*

118. Describe the process of syngamy and triple fusion in an angiosperm. *(2/5, Delhi 2011C)*

119. Mention the reasons for difference in ploidy of zygote and primary endosperm nucleus in an angiosperm. *(Delhi 2010)*

120. Draw a schematic labelled diagram of a fertilised embryo sac of an angiosperm. *(2/5, AI 2008)*

121. Explain the process of double fertilisation in angiosperms. *(2/5, Delhi 2008C)*

SA II (3 marks)

122. Explain the phenomenon of double fertilisation.
(3/5, AI 2014)

123. Why is fertilisation in angiosperms referred to as double fertilisation? Explain.
(3/5, AI 2013C)

124. In an angiosperm, the embryo sac is haploid, zygote is diploid and endosperm is triploid. Justify giving reasons for each stage. (*AI 2009C)*

125. List the components of the embryo sac and mention their fate on fertilisation.
(3/5, Delhi 2008)

126. Why does a pollen grain possess two male gametes? Explain. *(3/5, Delhi 2007)*

2.4 Post-fertilisation : Structures and Events

VSA (1 mark)

127. Mention the function of coleorhiza.
(Delhi 2015C)

128. Differentiate between parthenogenesis and parthenocarpy. *(1/3, AI 2014 C)*

129. Why is banana referred to as a parthenocarpic fruit? *(AI 2013 C)*

130. The meiocyte of rice has 24 chromosomes. Write the number of chromosomes in its endosperm.
(AI 2013C, Foreign 2009)

131. Write the function of scutellum.
(1/3, Delhi 2012)

132. Explain the function of coleorhiza.
(1/3, AI 2012)

133. Why is banana considered a good example of parthenocarpy? *(AI 2012)*

134. What is pericarp? Mention its function.
(AI 2011C)

135. Name the mechanism responsible for the formation of seed without fertilisation in angiosperms. Give an example of a species of flowering plants with such seed formation. *(Delhi 2010C)*

136. Name the part of flower that contributes to fruit formation in strawberry and guava respectively. *(AI 2009C)*

137. Strawberry is sweet and eaten raw just like any other fruit. Why do botanists call it a false fruit? *(AI 2008C)*

SA I (2 marks)

138. A non biology person is quite shocked to know that apple is a false fruit, mango is a true fruit and banana is a seedless fruit. As a biology student how would you satisfy this person? *(Delhi 2015)*

139. Banana fruit is said to be parthenocarpic whereas turkey is said to be parthenogenetic why? *(Delhi 2015C)*

140. Write the difference between the tender coconut water and the thick white kernel of a mature coconut and their ploidy. *(AI 2015C)*

141. Draw a labelled mature stage of a dicotyledonous embryo. *(2/5, AI 2014)*

142. Some angiosperm seeds are said to be 'albuminous', whereas few others are said to have a perisperm. Explain each with the help of an example. *(Foreign 2014)*

143. Banana crop is cultivated by farmers without sowing of seeds. Explain how the plant is propagated. *(Delhi 2014C)*

144. Draw a labelled diagram of a matured embryo of a dicotyledonous plant. *(AI 2014C)*

145. Write the changes a fertilised ovule undergoes within the ovary in an angiosperm plant. *(AI 2013)*

146. (a) Describe the endosperm development in coconut.

(b) Why is tender coconut considered healthy source of nutrition?

(c) How are pea seeds different from castor seeds with respect to endosperm? *(AI 2013)*

147. Write the fate of the products of triple fusion in the mature fruit of coconut. *(Delhi 2013C)*

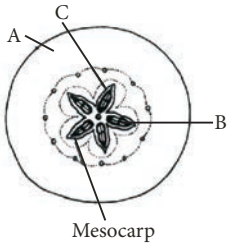
148. Draw a labelled diagram of the L.S. of a monocot seed (maize grain). *(2/5, AI 2013C)*

149. Draw a labelled diagram of a mature dicot embryo. *(AI 2012C, Delhi 2010C)*

150. Differentiate between albuminous and non-albuminous seeds, giving one example of each. *(Delhi 2011)*

151. Describe the development of endosperm in coconut. (*AI 2011C)*

152. (a) Given below is a T.S. of an apple. Identify A, B and C.



(b) Why is an apple categorised as a false fruit? *(Delhi 2010C)*

153. Name the cell from which the endosperm of coconut develops. Give the characteristics of endosperm of coconut. *(Delhi 2009)*

154. Banana is a parthenocarpic fruit whereas oranges show polyembryony. How are they different from each other with respect to seeds? *(Delhi 2009)*

155. Draw a vertical section of a maize grain and label (a) pericarp, (b) scutellum, (c) coleoptile and (d) radicle. *(AI 2009)*

156. Draw a labelled typical dicot emrbyo. *(AI 2009)*

157. What do you technically call the water that you drink and the kernel that you eat in a tender coconut? *(AI 2009C)*

SA II (3 marks)

158. Explain the post-pollination events leading to seed production in angiosperms. *(Delhi 2016)*

159. Double fertilisation is reported in plants of both castor and groundnut. However, the mature seeds of groundnut are non-albuminous and castor are albuminous. Explain the post fertilisation events that are responsible for it. *(Delhi 2015)*

160. Describe the development of endosperm after double fertilisation in an angiosperm. Why does endosperm development precedes that of zygote? *(Delhi 2015)*

161. Explain the development of a mature embryo from the embryo sac of dicot flower. *(Delhi 2015C)*

162. List the post-fertilisation events in angiosperms. *(Delhi 2014)*

163. Explain any three advantages the seeds offer to angiosperms. *(Delhi 2014)*

164. Name the two end products of double fertilisation in angiosperms. How are they formed? Write their fate during the development of seed. *(Delhi 2014C)*

165. Draw a diagrammatic sectional view of a mature anatropous ovule and label the following parts in it.

(a) that develops into seed coat

(b) that develops into an endosperm in an albuminous seed

(c) that develops into an embryo after fertilisation

(d) through which the pollen tube enters into the embryo sac

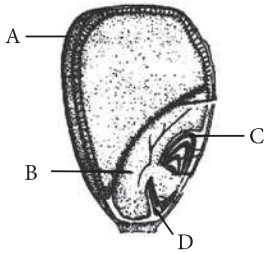
(e) that attaches the ovule to the placenta *(Delhi 2013)*

166. How is parthenocarpy different from parthenogenesis? Give an example of each. *(Delhi 2013C)*

167. Draw a neat labelled sketch of L.S. of an endospermous monocot seed. *(AI 2012)*

168. Differentiate between perisperm and endosperm giving one example of each. *(AI 2012)*

169. L.S. of a maize grain is given below. Label the parts A, B, C and D in it.



(AI 2012)

170. (a) Give one example each of albuminous and non-albuminous seeds.

(b) Name the parts of the ovule and the embryo sac of an angiosperm that develop into: (i) perisperm, (ii) seed coats, (iii) endosperm, (iv) embryonal axis. *(Delhi 2012C)*

171. Explain how false, true and parthenocarpic fruits are different from each other. Give one example of each. *(Delhi 2012C)*

172. Draw a neat labelled sketch of L.S. of an endospermous monocot seed. *(Delhi 2012C)*

173. Draw a labelled diagram of L.S. of an embryo of grass (any six labels). *(3/5, Delhi 2011)*

174. Differentiate between the following giving one example of each:

(a) Parthenogenesis and Parthenocarpy

(b) Perisperm and Pericarp *(Delhi 2011C)*

175. Explain the development of fertilised egg cell upto a mature embryo in a dicot plant. Draw a labelled diagram of a mature dicot embryo. *(3/5, Delhi 2011C)*

176. (a) Draw a labelled sectional view of an albuminous seed.

(b) How are seeds advantageous to flowering plants? (*Delhi 2010*)

177.

(a) Identify the figure.

(b) Name the initial cell from which this structure has developed.

(c) Draw the next mature stage and label the parts. *(Foreign 2009)*

178. Describe the stages in embryo development in a dicot plant. *(3/5, AI 2008)*

179. List the changes each part of the fertilised ovule undergoes to develop into a seed. *(Delhi 2008C)*

LA (5 marks)

180. A flower of tomato plant following the process of sexual reproduction produces 200 viable seeds.
Answer the following questions giving reasons.
(a) What would have been the minimum number of ovules present in per pollinated pistil?
(b) How many microspore mother cells would minimally be required to produce requisite number of pollen grains?
(c) How many pollen grains must have minimally pollinated the carpel?
(d) How many male gametes would have used to produce these 200 viable seeds?
(e) How many megaspore mother cells were required in this process?
(Delhi 2015)

181. A flower of brinjal plant following the process of sexual reproduction produces 360 viable seeds.
Answer the following questions giving reasons:
(a) How many ovules are minimally involved?
(b) How many megaspore mother cells are involved?
(c) What is the minimum number of pollen grains that must land on stigma for pollination?
(d) How many male gametes are involved in the above case?
(e) How many microspore mother cells must have undergone reduction division prior to dehiscence of anther in the above case?
(Delhi 2015)

182. (a) Explain the events after pollination leading to the formation of a seed in angiosperms.
(b) Mention the ploidy levels of the cells of different parts of an albuminous seed.
(Foreign 2015)

183. Give reasons why
(a) most zygotes in angiosperms divide only after certain amount of endosperm is formed?
(b) groundnut seeds are exalbuminous and castor seeds are albuminous?
(c) micropyle remains as a small pore in the seed coat of a seed?
(d) integuments of an ovule harden and the water content is highly reduced, as the seed matures?
(e) apple and cashew are not called true fruits?
(Delhi 2011)

184. Explain the development of the zygote into an embryo and of the primary endospermic nucleus into an endosperm in a fertilised embryo sac of a dicot plant. *(AI 2010C)*

185. (a) Trace the development of embryo after syngamy in a dicot plant.
(b) Endosperm development precedes embryo development. Explain.
(c) Draw a diagram of a mature dicot embryo and label cotyledons, plumule, radicle and hypocotyl in it. *(AI 2009)*

2.5 Apomixis and Polyembryony

VSA (1 mark)

186. Mention advantage of apomictic seeds to farmers. *(AI 2014)*

187. Hybrid seeds have to be produced year after year give reason. *(Delhi 2011)*

188. Normally one embryo develops in one seed but when an orange seed is squeezed many embryos of different shapes and sizes are seen. Mention how it has happened. *(Delhi 2011)*

189. What is apomixis? What is its importance? *(AI 2008C)*

190. Mention the scientific term used for modified form of reproduction in which seeds are formed without fusion of gametes. *(Delhi 2007)*

SA I (2 marks)

191. Suggest the advantage to a farmer for using apomictic seeds of hybrid varieties?
(Foreign 2015)

192. What is apomixis? How is the phenomenon useful to the farmer? *(Foreign 2015)*

193. Explain the different ways apomictic seed can develop. Give an example of each.
(2/5, AI 2014)

194. (a) Why are seeds of some grasses called apomictic? Explain.
(b) State two reasons to convince a farmer to use an apomictic crop. *(AI 2014C)*

195. How do plants produce seeds through apomixis? Explain with the help of an example. *(Delhi 2013C)*

196. Why are some seeds of *Citrus* referred to as polyembryonic? How are they formed? *(AI 2013C)*

197. What is apomixis? What is its importance? *(Delhi 2011C)*

198. If you squeeze a seed of orange you might observe many embryos of different sizes. How is it possible? Explain. *(Delhi, AI, 2010)*

199. Fertilisation is essential for production of seed, but in some angiosperms, seeds develop without fertilisation.
(a) Give an example of an angiosperm that produces seeds without fertilisation. Name the process.
(b) Explain the two ways by which seeds develop without fertilisation. *(AI 2009)*

SA II (3 marks)

200. State what is apomixis. Comment on its significance. How can it be commercially used? *(AI 2015)*

201. (a) How is apomixis different from parthenocarpy?
(b) Describe any two modes by which apomictic seeds can be produced. *(AI 2014C)*

202. With the help of an example of each explain the following : Apomixis, Polyembryony. *(AI 2012C)*

Detailed Solutions

1. The gynoecium of *Papaver* is multicarpellary and syncarpous (pistils fused together) whereas the gynoecium of *Michelia* is multicarpellary and apocarpous (pistils free). In *Papaver* ovary is unilocular to multilocular whereas in *Michelia* ovary is always unilocular.

2. Tassels of corn cob represent staminate inflorescence (cluster of male flowers), so they represent androecium (male reproductive part) of the flower.

3. *Parthenium* or carrot grass is an example of a plant which came to India as a contaminant and is a major contributor to pollen allergy.

4. Pollen-pistil interaction is the group of events that occur from the time of pollen deposition over the stigma to the time of pollen tube entry into ovule. The dialogue between pollen grain and the pistil is mediated by chemical components of the pollen interacting with those of the pistil.
The pistil has the ability to recognise the pollen, whether it is of the right type (compatible) or of the wrong type (incompatible). This is followed by its acceptance or rejection.

5. Filiform apparatus refers finger-like projections which arise from cell wall of the synergid and penetrate into the cytoplasm of the central cell. These are present at the micropylar tip of synergids. They play an important role in distribution of nutrients in the embryo sac, secretion of substances that attract pollen tube thereby guiding the pollen tube into synergid and also provide mechanical strength to synergids.

6. Differences between xenogamy and geitonogamy are as follows:

	Xenogamy	**Geitonogamy**
(i)	It is pollination between two flowers of different plants.	It is pollination between two flowers of the same plant.
(ii)	The flowers are genetically different.	The flowers are genetically similar.
(iii)	It is genetically cross pollination.	It is genetically self pollination.

7. Tapetum is the microsporangial layer that provides nourishment to the developing microspores. In an anther with malfunctioning tapetum, microspores do not get sufficient nutrition and hence viable male gametophytes are often not produced.

8. *Vallisneria* is a water pollinated plant. Pollen grains of *Vallisneria* have a protective mucilaginous coat that prevents the water from damaging the pollen grains.

9. (i) Tapetum nourishes the developing microspores.
(ii) It produces lipid rich ubisch granules containing sporopollenin, pollenkitt, compatibility recognising proteins etc.
(iii) It secretes enzyme callase for the separation of microspores.

10. Germ pores are prominent apertures of pollen grain where exine is thin or absent hence, sporopollenin is absent and intine is thickened. These are the regions where intine comes out to form a pollen tube after pollination.

11. The characteristic features of anemophilous flowers are well exposed stamens light, small, winged or dusty pollen grains and large, often-feathery and exposed stigma to trap air-borne pollen grains.

12. Anthers of most angiosperms (flowering plants) contain two anther lobes, hence are called dithecous.

13. Pollen banks are used to store pollen grains for long time, which can be used in plant breeding programmes. In pollen banks, pollens are stored in liquid nitrogen at a temperature of –196°C.

14. Papaya plant is dioecious plant and bears male and female flowers on different plants *i.e.*, male plant and female plant. Fruit is formed by the female part of the flower after fertilisation. Following double fertilisation, *i.e.*, fusion of one male gamete with egg cell and the other male gamete with secondary nucleus. Ovules turn into seeds and ovary turns into fruits.
As these female structures are found only on female papaya plants hence fruits are present only on

female papaya plant whereas male papaya plant only produces gametophytes, *i.e.*, pollen grains which bear male gametes.

15. In wind pollinated flowers, anthers are exserted and versatile. In some cases like *Urtica*, the anthers burst suddenly to throw the pollen grains (gun powder mechanism).
Pollens of wind pollinated flowers are light, small, winged, dry, smooth, non-sticky, unwettable and are produced in very large number.
Stigma of wind pollinated flower is exserted, hairy, feathery or branched to catch the wind borne pollen grains. The large thread-like stigmas and styles of cob of maize hang in air to catch wind borne pollens.

16. Dithecous anther has four microsporangia or pollen sacs. This anther will have 400 microspore mother cells. As each microspore mother cell forms 4 pollen grains, 400 microspore mother cells will form 1600 pollen grains (male gametophytes).

17. *Refer to answer 8.*

18. Sporopollenin is a major component of the hard outer layer called exine of pollen grains. It is chemically very stable and is usually well preserved in soils and sediments. Hence, pollen grains of the part are well preserved as fossils.

19. Unisexual flowers favour cross pollination.

20. Bagging of the emasculated flowers is essential to prevent the landing of unwanted pollen on the stigma of flowers during hybridisation experiments.

21. Statement (c) is incorrect. In submerged water-pollinated plants, the flowers are small, inconspicuous and generally dull coloured not brightly coloured.

22. In some cereals such as wheat and rice, pollen grains lose viability within 30 minutes of their release. They can be made available months later by means of cryopreservation *i.e.*, storing them in liquid nitrogen at a very low temperature (–196°C).

23. *Refer to answer 13.*

24. Based on the source of pollen grain, pollination can be of following three types:
(i) Autogamy : Autogamy (self pollination) is the transfer of pollen grains from anther to the stigma of the same flower.
(ii) Geitonogamy : It is the transfer of pollen grains from the anther of one flower to the stigma of another flower on the same plant. Geitonogamy is functionally cross-pollination involving a pollinating agent but genetically it is equivalent to autogamy since the pollen grains come from the same plant.
(iii) Xenogamy : It is the transfer of pollen grains from anther to the stigma of different plants of same species. It brings genetically different types of pollen grains to the stigma.

25. Unisexual flowers are flowers bearing either male or female reproductive structures. Male flower is staminate, *i.e.*, bearing stamens while female flower is pistillate *i.e.,* bearing pistils.
In some flowering plants, both male and female flowers are present on same plant. Such plants are referred to as monoecious *e.g.,* cucurbits. In some plants, unisexual male and female flowers are present on separate plants. Such plants are referred to as dioecious *e.g.,* papaya.

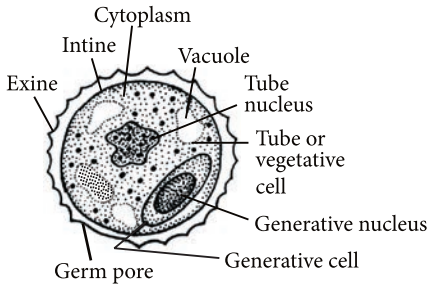
26. Pea plant is monoecious plant *i.e.*, bearing both male and female flowers on same plant. Thus, a single pea plant can produce viable seeds after pollination and fertilisation. However, a papaya plant is dioecious plant *i.e.*, bearing male and female flowers on different plants and requires cross pollination for production of viable seeds. Thus, in absence of either stamens or pistils, fertilisation will not take place and hence viable seeds will not be produced.

27. Gynoecium represents the female reproductive part of a flower. Gynoecium is called apocarpous if the carpels are free, *e.g., Michelia*. It is called syncarpous if the carpels are fused, *e.g., Papaver* (poppy).

28. Hermaphrodite angiosperms develop out breeding devices to avoid self pollination and encourage cross pollination. Two outbreeding devices which ensure cross pollination are as follows:
(i) Dichogamy : Anthers and stigmas mature at different times in a bisexual flower. It is of two types:
(a) Protandry : Anthers mature earlier than stigma of the same flower. Their pollen grains become available to stigmas of the older flowers, *e.g.*, Sunflower, *Salvia*.
(b) Protogyny : Stigmas mature earlier so that they get pollinated before the anthers of the same flower develop pollen grains, *e.g.*, *Mirabilis jalapa*, *Gloriosa, Plantago*.
(ii) Self sterility (Self incompatibility) : Pollen grains of a flower do not germinate on the stigma of the same flower due to presence of similar self sterile gene (S_1S_3 in pistil and S_1 or S_3 in pollen grain) *e.g.*, tobacco, potato, crucifers.

29. Exine is the outer tough and resistant layer of pollen grains made up of sporopollenin. Intine is thin continuous and inner wall of the pollen grain which is made up of cellulose and pectin.
Exine provides protection to pollen grain during its hazardous journey from anther of one flower to the stigma of another flower. Due to presence of sporopollenin in exine, pollens of past are will preserved as fossil in soil and sediments elabling the scientists to study pollen structure and pollination pattern of angiosperms of past.

30. Labelled diagram of mature microspore (or pollen grain) is as follows:



31. (a) Cleistogamy is the condition where pollination occurs in closed flowers that 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.

(b) One advantage of cleistogamy is that seed setting is assured even in the absence of pollinators as pollen on maturity will always reach the stigma due to their close placement.

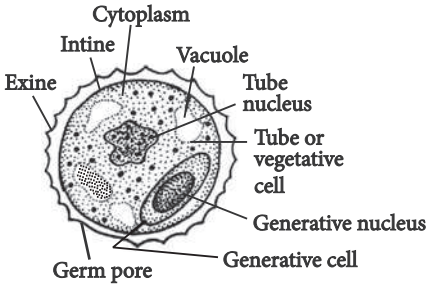
One disadvantage of cleistogamy is that it does not allow cross pollination, thereby restricting chances of genetic variability.

32. Geitonogamy is the transfer of pollen grains from the anther of one flower to the stigma of another flower of the same plant. It is functionally cross pollination involving pollinating agent but genetically it is similar to autogamy since the pollen grains come from the same plant.

33. In an unfertilised mature embryo sac of flowering plant, six haploid cells are present *i.e.*, two synergids, one egg, three antipodals. The total number of cells in an unfertilised mature embryo sac is seven *i.e.*, two haploid synergids, one haploid egg, three haploid antipodals and one central cell (containing two polar nuclei).

34. Two cells enclosed in a mature male gametophyte of an angiosperm are : a smaller generative cell and a much larger vegetative cell (or tube cell). Generative cell is spindle shaped to spherical in outline with thin dense cytoplasm surrounding a prominent nucleus. Vegetative cell has a lobed central nucleus that lies in vacuolated cytoplasm packed with, starch grains, lipids and proteins.

35. Labelled diagram of mature pollen grain is as follows:



36. Pollen pistil interaction is the group of events that occur from the time of pollen deposition over the stigma to the time of pollen tube entry into ovule.
As soon as a pollen grain lands on the stigma, it is hydrated. As a result of hydration, the exine and intine proteins are released on the stigmatic surface. The pollen wall proteins bind to the stigma surface pellicle (receptor site for the pollen wall proteins) within few minutes of the contact.
When pollen is compatible, erosion of the cuticle of the stigma papilla begins beneath the emerging pollen tube. This is the essential preliminary requirement for the penetration of the pollen tube.
In case of incompatible pollination, a callosic plug develops between the plasma membrane and pectocellulosic layer of the stigmatic papillae just below the point of contact with the pollen and the growth of pollen tube ceases.

37.

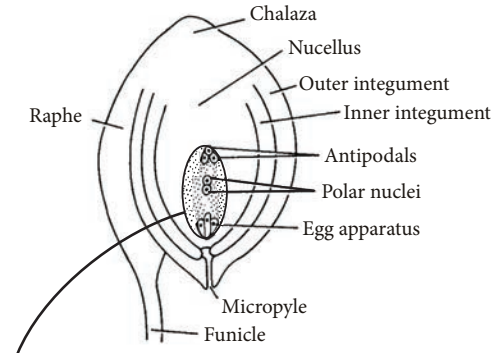


Fig. Mature anatropous ovule of an angiosperm.

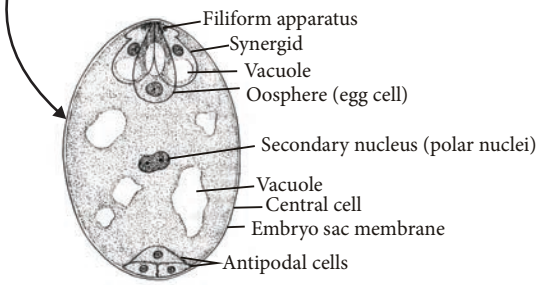


Fig.: Mature embryo sac *(Polygonum)* type of an angiosperm.

38. *Refer to answer 37.*

39. *Vallisneria* is a submerged dioecious aquatic plant in which pollination takes place by the agency of water. The adaptive features of water pollinated flowers of *Vallisneria* are as follows:

(i) The male plants produce a large number of male flowers. The male flowers abscise and rise to the surface where they float.

(ii) The male flowers have two fertile stamens. Two of their tepals form a boat-shaped structure while the third one functions as a sail.

(iii) The female plants bear long stalked solitary pistillate flowers. The mature female flowers are brought to the surface of water by the elongation of their stalks. They have large sticky trifid stigmas.

(iv) While floating, the male flowers are drawn in the depression surrounding each female flower. One anther of a male or staminate flower comes in contact with the stigma of the female flower. The anther bursts and pollination is performed.

(v) Pollen grains are covered by mucilage which helps them in sticking to stigma as well as protects them from wetting by water.

(vi) After pollination, the female flower is pulled inside water by the coiling of its stalk.

40. *Refer to answer 31 (b).*

41. Sporopollenin is present in exine layer of pollen grains. Sporopollenin is highly resistant fatty substance not degraded by any enzyme and not affected by high temperature, strong acid or strong alkali therefore pollen grains can be well preserved as microfossils.

42. In a wind pollinated flower, following characteristics are present which help to identify that wind is its pollinating agent:

(i) Flowers are small and inconspicuous.

(ii) Non-essential parts are either absent or reduced.

(iii) The flowers are colourless, odourless and nectarless.

(iv) In case of unisexual flowers, the male flowers are more abundant. In bisexual flowers, the stamens are generally numerous.

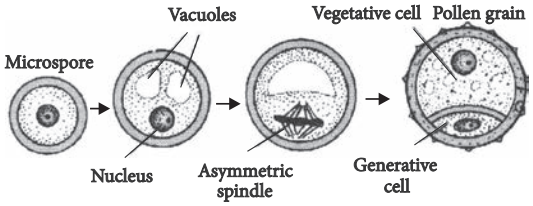
(v) Flowers are produced above the foliage, before the appearance of new foliage or placed in hanging position.

(vi) Both the stigmas and anthers are exserted. Anthers are versatile.

(vii) Pollen grains are light, small, dusty, dry and unwettable.

(viii) Stigma is hairy, feathery or branched to catch the wind borne pollen grains.

43. In an anther, each cell of the sporogenous tissue is a potential pollen or microspore mother cell (PMC). Each PMC divides by meiosis to form a microspore tetrad. This process is called microsporogenesis. As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains. The hard outer layer called the exine is made up of sporopollenin. The inner wall of the pollen grain is called the intine. When the pollen grain is mature it contains two cells, the vegetative cell and the generative cell. Different stages of microsporogenesis are shown below.



44. Endothecium performs the function of protection in the young anther and is involved in dehiscence of the mature anther.
Role of tapetum in an anther is as follows:

(i) Nourishment of the developing microspore mother cells and pollen grains.

(ii) It produces lipid rich ubisch granules containing sporopollenin for exine formation, pollenkitt in case of entomophilous plants, special proteins for the pollen grains to recognise compatibility and hormone IAA.

(iii) It secretes enzyme callase responsible for the degradation of callose wall around pollen tetrad.

45. Difference between autogamy, geitonogamy and xenogamy is as follows:

Autogamy	Geitonogamy	Xenogamy
Autogamy is transfer of pollen grains from anther to stigma of the same flower.	Geitonogamy is transfer of Pollen grains from anther of one flower to stigma of another flower of the same plant.	Xenogamy is transfer of pollen grains from the anther to the stigma of different plants.

46. Emasculation is removal of stamens from the floral buds of female parent. A breeder needs to emasculate a bisexual flower to eliminate the chances of self pollination. Emasculation is not required if the flowers are unisexual. However, flowers must be kept covered by bags to protect them from contamination by unwanted pollen grains.

47. *Refer to answer 46.*

48. *Refer to answer 31(b).*

49. (a) In self pollination, the pollen grains are transferred from the anther of a flower to the stigma of either the same or genetically similar flower. In this process the parental characters are sustained and new useful characters are seldom introduced in next generation. So, to prevent this, some strategies are adopted by the flowering plants. These are as follows:

- Dichogamy : Male and female sex organs of a bisexual flower mature at different times.
- Self sterility : The pollen of a flower has no fertilising effect on the stigma of the same flower.
- Pollen prepotency : In some plants when the stigma receives pollen from the same flower as well as from the other flower simultaneously the foreign pollen germinates quickly and fertilises the ovule.
- Herkogamy : It is the presence of natural and physical barriers between androecium and gynoecium which help in avoiding self pollination.

(b) In geitonogamy pollen grains of one flower are transferred to the stigma of another flower belonging to either the same plant or genetically similar plant. Thus, geitonogamy is also referred to as genetical autogamy.

50. Hybridisation is effective pollination between flowers of different species of the same genus, or even between flowers of different genera (as in the case of several orchids). It involves artificial pollination of the desired female parent with pollen from the desired male parent, taking all precautions to prevent contamination of the stigma with the pollen of any other type.

(a) In bisexual flowers, hybridisation involves emasculation *i.e.,* removal of male reproductive parts (stamens) followed by artificial pollination.

(b) In unisexual flowers the procedure is rather simple. Unopened floral buds are covered with cellophane bags. When the stigma attains receptivity pollens from the male parent are dusted on it, and the pollinated flowers are rebagged.

51. *Refer to answer 33.*

52. In the given figure, (1) - Antipodal cells, (2) - Polar nuclei, (3) - Central cell, (4) - Egg cell.

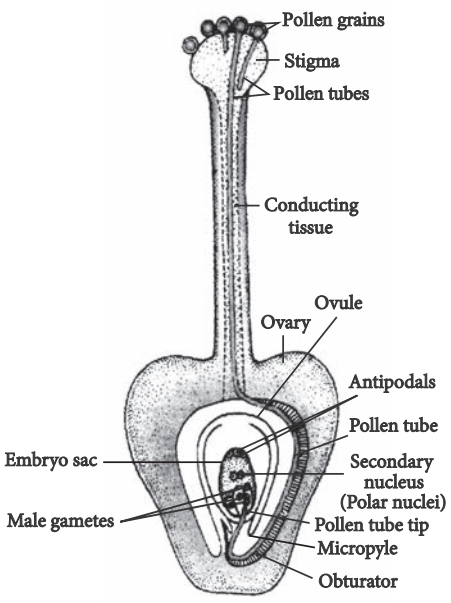
53. In the given figure, A - Micropyle, B - Outer integument, C - Nucellus, D - Antipodal cell.

54. In the given figure, 'a' represents sporogenous tissue and 'b' represents tapetum. Sporogenous tissue fills the whole interior of the microsporangium. Its cells divide with the growth of anther and increase their number. Ultimately they are transformed into microspore or pollen mother cells (PMC).

Microspore mother cells undergo meiosis to produce haploid microspores or pollen grains. *Also refer to answer 44.*

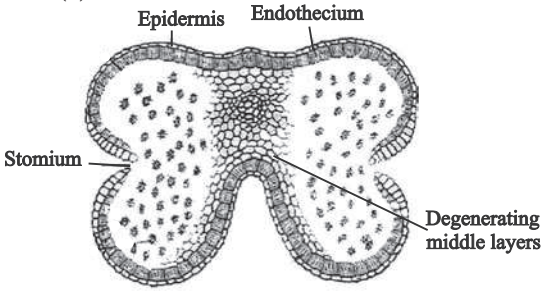
55. *Refer to answer 32.*

56. Longitudinal section of pistil showing growth of pollen tube is shown below.



57. *Refer to answer 31 (b).*

58. (a) T.S. of mature dehisced anther is as follows :

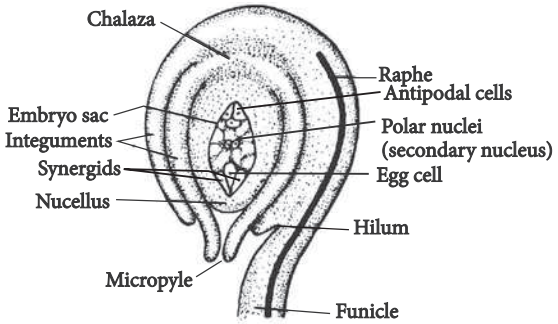


(b) Exine of pollen grain is not a continuous layer. It bears prominent apertures called germ pores. These are the places from where intine comes out as pollen tube, which carries male gametes required for fertilisation in angiosperms. If the exine is present as a continuous layer, it would render the pollen grain non-functional.

59. Differences between flowers of brinjal and beans are as follows :

	Flower of brinjal (Chasmogamous flower)	**Flower of beans** (Cleistogamous flower)
(i)	Open flowers with exposed anthers and stigma.	Closed flowers in which anthers and stigma lie close to each other and anthers dehisce within flower buds.
(ii)	Require pollinating agents.	Do not require pollinating agents.
(iii)	These flowers favour cross pollination.	These flowers ensure self pollination.

60. Sectional view of anatropous ovule is given below.



61. *Refer to answer 60.*

62. Geitonogamy is a type of pollination in which pollen grains of one flower are transferred to the stigma of another flower belonging to the same plant.

(a) Geitonogamy is genetically similar to autogamy since the pollen grains come from the same plant.

(b) Geitonogamy is functionally similar to xenogamy as it requires pollinating agent.

63. *Refer to answer 60.*

64. *Refer to answer 35.*

65. (a) Exine is made up of a highly resistant fatty substance called sporopollenin. Sporopollenin is highly protective layer not degraded by any enzyme. It is not affected by high temperature, strong acid or strong alkali. Because of sporopollenin, exine provides protection during the hazardous journey of pollen from anther to stigma. Also, pollen grains are well preserved as microfossils and protected from external adversities due to the presence of sporopollenin.

(b) *Refer to answer 58 (b).*

(c) *Refer to answer 13.*

66. *Refer to answer 60.*

67. The three outbreeding devices that flowering plants have developed are as follows:

(i) Dicliny (Unisexuality) : Flowers are unisexual so that self pollination is not possible. The plants may be monoecious (bearing both male and female flowers, *e.g.*, maize) or dioecious (bearing male and female flowers on different plants, *e.g.*, mulberry, papaya).

(ii) Dichogamy : Anthers and stigmas mature at different times in a bisexual flower so as to prevent self pollination. (a) Protandry : Anthers mature earlier than stigma of the same flower. Their pollen grains become available to stigmas of the older flowers, *e.g.*, sunflower, *Salvia*. (b) Protogyny : Stigmas mature earlier so that they get pollinated before the anthers of the same flower develop pollen grains, *e.g., Mirabilis jalapa*, *Gloriosa, Plantago*.

(iii) Heterostyly : There are 2 or 3 types of flowers with different heights of styles (and stamens), *e.g.*, In diheterostyly (dimorphic heterostyly), there are two types of flowers, pin eyed (long style and short stamens) and thrum eyed (short style and long stamens), *e.g., Primula* (primrose), jasmine. Pollination occurs between anthers and stigmas of the same height present in different flowers.

OR

Angiosperm anthers consist of two anther lobes therefore are called dithecous.

A typical angiospermic microsporangium appears near circular in outline. It consists of two parts, outer wall and central homogenous tissue. Microsporangial wall has four types of layers:

- Epidermis of single layer for protection.
- Endothecium of single layer for dehiscence of anther.
- Middle layers are 1-4 in number.
- Tapetum, the innermost parietal layer with cells having dense cytoplasm and large nuclei.

68. Differences between anemophilous (wind pollinated) and entomophilous (insect pollinated) flowers are as follows:

	Anemophilous flowers	**Entomophilous flowers**
(i)	Flowers are small.	Flowers are either large or if small they are grouped to form inflorescence.
(ii)	Flowers are inconspicuous due to the absence of bright colours.	Flowers are usually gaudy due to the presence of bright colours in corolla, sepals, bracts, etc.
(iii)	They are odourless.	Odour is commonly present.
(iv)	The flowers are devoid of nectar and edible pollen.	The flowers usually possess nectar and edible pollen.
(v)	Sepals and petals are either indistinguishable or absent.	Sepals and petals are commonly well developed.
(vi)	Anthers are usually exserted.	Anthers are usually inserted.
(vii)	Pollen grains are produced in very large number.	They are fewer.
(viii)	Pollen grains are light and unwettable.	Pollen grains are heavier and sticky.
(ix)	Pollination is non-directional.	Pollination is specific and directional.
(x)	Stigmas are exserted.	Stigmas are commonly inserted.
(xi)	Stigmas are branched or hairy to catch wind borne pollen grains. *E.g.*, maize, many grasses, etc.	Stigmas are usually unbranched and sticky. *E.g., Rafflesia, Mimosa*.

69. A microsporangium or pollen sac is a cylindrical sac which appears circular in transverse section. It consists of two parts, outer wall and central homogenous sporogenous tissue. Microsporangial wall has four types of layers - epidermis (common anther covering), endothecium, 1-3 middle layers and tapetum. The outer three perform the function of protection in the young anther and dehiscence

of the mature anther. Both endothecium and tapetum consist of larger cells. In a typical anther the endothecial cells develop fibrous thickenings of α-cellulose on the inner and radial walls. In the shallow groove present between the two microsporangia of an anther lobe, the hypodermal cells lying at the level of endothecium remain thin walled. They constitute the stomium or line of dehiscence. The sporogenous tissue gives rise to microspores.

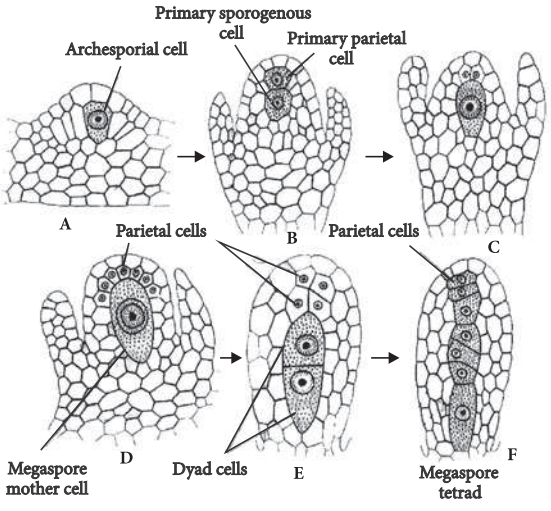
70. *Refer to answer 42.*

71. *Refer to answer 37.*

72. *Refer to answer 56.*

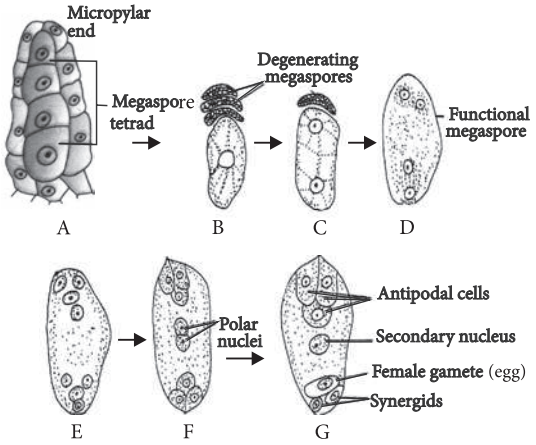
73. *Refer to answer 43.*

74. Megasporogenesis is the formation of megaspore (n) from megaspore mother cell (2n) inside the ovule by the process of meiosis. In the hypodermal region of nucellus towards the micropylar end develops a primary archesporial cell. The primary archesporial cell divides periclinally to form outer parietal cell and inner sporogenous cell. The sporogenous cell functions as megaspore mother cell (MMC),which undergoes reduction division to form four haploid megaspores. Only one megaspore (usually the chalazal one) remains functional and the other three degenerate. Different stages in the development of linear tetrad of megaspores are shown as follows :



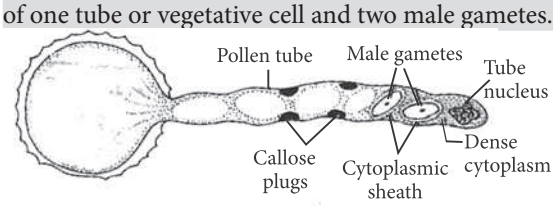
75. The mode of pollination in *Vallisneria* is water whereas mode of pollination in water lily is wind or insects. *Also refer to answer 39.*

76. Megasporogenesis is the formation of megaspore (n) from megaspore mother cell (2n) inside the ovule by the process of meiosis. In the hypodermal region of nucellus towards the micropylar end develops a primary archesporial cell. The primary archesporial cell divides periclinally to form outer parietal cell and inner sporogenous cell. The sporogenous cell functions as megaspore mother cell (MMC). The MMC undergoes meiotic division and produce four haploid megaspores. One of the megaspore is functional while other three degenerate. Different stages in the formation of embryo sac from functional megaspore are represented diagrammatically as follows :



The functional megaspore is the first cell of female gametophyte or embryo sac. The nucleus of megaspore divides by mitosis into eight daughter nuclei. Two polar nuclei are present in centre which further fuse to form a secondary nucleus. After fertilisation with a male gamete it produces triploid endosperm. Three nuclei at the base of embryo sac form antipodal cells. The remaining three nuclei at the micropylar end constitute egg apparatus, which consists of two cells known as synergids or help cells and an egg cell or oosphere. The egg cell on fusing with one male gamete (fertilisation) gives rise to zygote.

77. Pollen grain is the first cell of male gametophyte. The 3-celled pollen grain of an angiosperm consists of one tube or vegetative cell and two male gametes.



The tube cell has a vacuolated cytoplasm which is rich in the food reserves (starch, protein, fat with mostly unsaturated fatty acids) and cell organelles. Its nucleus is large and irregular. Male gametes are formed by division of generative cell. Each male gamete is lenticular to spherical in outline. It has a large nucleus which is surrounded by a thin sheath of cytoplasm.

78. Emasculation is the removal of the anthers of a bisexual flower in order to prevent self-pollination. Bagging involves covering of emasculated flowers by butter paper or polythene in order to protect them from contamination by foreign or undesirable pollen.
Emasculation and bagging are important steps of artificial hybridisation technique used in crop improvement programmes.

79. *Refer to answer 76.*

80. *Refer to answer 67.*

81. *For diagram, refer to answer 35.*
Sporopollenin is considered the most resistant organic material because it is not degraded by any enzyme, not affected by high temperature, strong acid or strong alkali.

82. *Refer to answer 6.*
Geitonogamy will lead to inbreeding depression because it is a type of pollination in which pollen grains are transferred from anther to stigma of different flowers belonging to the same plant.

83. *Refer to answer 60.*

84. (a) (i) Deposition of sporopollenin occurs in exine layer of pollen grains.
(ii) Megasporogenesis occurs inside the nucellus of developing ovule of angiosperms.
(b) *Refer to answer 35.*

85. *Refer to answer 56.*

86. The characteristic features of flowers that facilitate wind pollination are as follows:

(i) Both the stigmas and anthers are exserted.

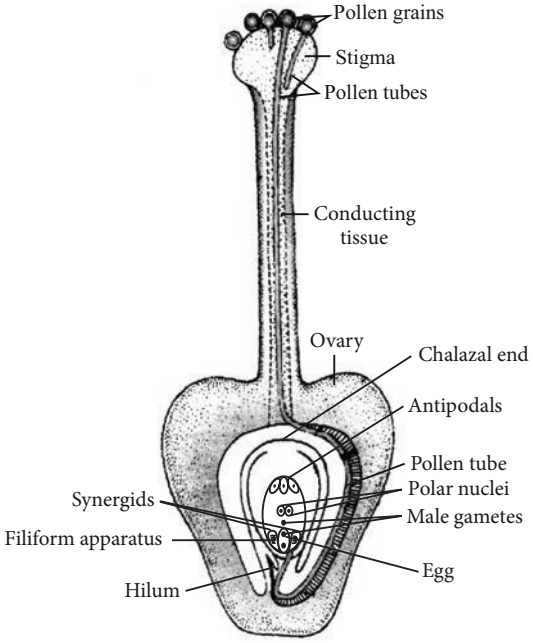
(ii) Pollen grains are light, small and winged or dusty. They can be blown by wind to distances of upto 1300 km.

(iii) Pollen grains are dry, smooth, non-sticky and unwettable.

(iv) Stigma is hairy, feathery or branched to catch the wind-borne pollen grains. The large thread-like stigmas and style of maize cob hang in air to catch wind borne pollens.
(v) Pollen grains are produced in very large number. For example, a single flower of *Cannabis* produces 5,00,000 pollen grains. Consequently, the pollen grains spread over large tracts so that even isolated plants get pollinated.
(vi) Calyx and corolla are either reduced or absent. Anthers are usually versatile.
(vii) Flowers are small and inconspicuous.
(viii) When flowers are unisexual, male flowers are more abundant than female flowers. In bisexual flowers, the stamens are generally numerous.

87. *Refer to answer 76.*

88. Longitudinal section of post pollinated pistil showing entry of pollen tube into a mature embryo sac is shown as follows:



89. (a) A - Endothecium
B - Middle layers
C - Tapetum
(b) The characteristics of labelled part C *i.e.*, tapetum are as follows:
(i) Tapetal cells are filled with protoplasmic contents as well as nutrients.
(ii) They are either multinucleate or their nucleus becomes polyploid due to endoploidy.
(iii) Tapetum is of two types – amoeboid and secretory.

(iv) In amoeboid type, the tapetal cells fuse to form a plasmodium or periplasmodium because it passes in between the sporogenous cells to nourish them.
(v) The cells of secretory tapetum pass out substances over the sporogenous cells for their growth and differentiation. Also *refer to answer* 44.

OR

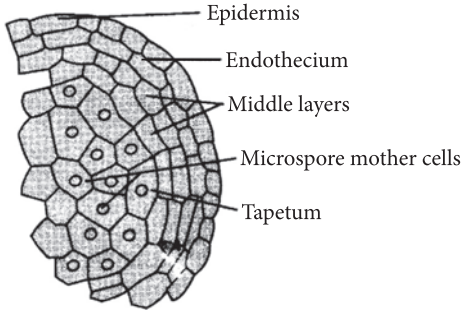
Significance of pollination :
(i) Pollination leads to fertilisation and production of seeds and fruits, which ensures continuity of plant life.
(ii) The pollination, especially cross pollination results in the production of plants with a combination of characters from two plants. So it introduces genetic recombinations and hence variations in the progeny.
Differences between wind pollinated and animal pollinated flowers are as follows :

	Wind pollinated flowers	**Animal pollinated flowers**
(i)	The flowers are small.	The flowers are either large or if small they are grouped to form a large mass.
(ii)	The flowers are inconspicuous due to the absence of bright colours.	The flowers are usually gaudy due to the presence of bright colours in corolla, sepals, bracts, etc.
(iii)	Flowers are odourless.	Odour is commonly present in flowers.
(iv)	The flowers are devoid of nectar and edible pollen.	The flowers usually possess nectar or edible pollen.

90. *Refer to answer 86.*

91. The most common type of embryo sac, found in 80% flowering plants is called *Polygonum* type of embryo sac. It contains 8 nuclei and 7 cells – 3 micropylar, 3 chalazal and one central. It is formed by one meiosis and three mitosis. The three micropylar cells are collectively known as egg apparatus. One middle cell is larger and is called egg or oosphere. The remaining two cells are called synergids or cooperative cells or help cells. The three chalazal cells of the embryo sac are called antipodal cells. The central cell contains two polar nuclei which often fuse to from a single diploid secondary nucleus or definitive nucleus.
Polygonum type of embryo sac is developed from a single megaspore (rest three degenerate) and so it is called monosporic type of embryo sac.

92. (a) Sectional view of microsporangium of an angiosperm is as follows:



(b) Pollen grain or microspore is the first cell of male gametophyte and represents immature male gametophyte. Development of male gametophyte is precocious, *i.e.*, it begins inside the microsporangium or pollen sac.
Young pollen grain has a centrally placed nucleus embedded in dense cytoplasm covered by plasma membrane. It grows in size with the inflow of nutrients. The protoplast of the pollen grain divides mitotically to form two unequal cells - smaller generative cell and larger tube or vegetative cell. A layer of callose develops around the generative cell which separates the cell from the pollen wall. Later on, callose dissolves and the naked generative cell comes to lie freely in the cytoplasm of the tube cell. The tube cell has vacuolated cytoplasm which is rich in the food reserve and cell organelles. Its nucleus becomes large and irregular. The generative cell is spindle shaped to spherical in outline with thin dense cytoplasm surrounding a prominent nucleus. In some species the generative cell divides into two nonmotile male gametes prior to the dehiscence of anther and release of the pollen grains. Therefore, at the time of pollination, the pollen grain is either 2-celled or 3-celled.

93. (a) *Refer to answer 43.*

(b) *Refer to answer 35.*

94. Monoecious flowers are bisexual *i.e.*, they bear both male and female reproductive organs, *e.g.*, pea. Cleistogamous flowers are those flowers which

do not open at all. These flowers are intersexual and remain closed causing self pollination. In cleistogamous flowers, the anthers dehisce inside closed flowers. Growth of style brings the pollen grains in contact with stigma. Pollination and seed setting are assured. Pollinators are not required. *E.g. Commelina benghalensis,* balsam.

Self incompatibility is inability of pollen of a plant to fertilise the pistil of the same plant, *e.g.*, *Primula.*

Monoecious and cleistogamous flowers promote inbreeding whereas self incompatibility in plants promotes outbreeding.

95. (a) *Refer to answer 76.*

(b) Synergids are the part of egg apparatus which occur at micropylar end of embryo sac. They have special cellular thickenings or finger-like projections called filiform apparatus, which play an important role in guiding the pollen tube towards embryo sac. Each of the synergids contains filiform apparatus in the micropylar region, a lateral hook, chalazal vacuole and a central nucleus.

96. (a) *Refer to answer 56.*

(b) The compatible pollen grain germinates on the stigma; the intine grows out through one of the germ pores as a pollen tube.

- The contents of the pollen grain move into the pollen tube.
- The generative cell divides into two male gametes.
- The pollen tube grows through the stigma and style and reaches the ovary; it enters the ovule through micropyle and then enters the embryo sac guided by the filiform apparatus and discharges the male gametes into one of the synergids.
- One of the male gametes fuses with the egg cell (syngamy) to form the zygote and the other male gamete fuses with the two polar nuclei (triple fusion) to form the primary endosperm nucleus (PEN).

97. (a) *Refer to answer 58 (a).*

(b) Characteristic features of insect pollinated flowers are :

(i) Nectar is produced by nectariferous glands of flower which attracts the pollinators for feeding.

(ii) Some flowers produce edible pollen grains which attract the pollinators to visit the flowers *e.g.*, rose, *Papaver*, *Clematis*.

(iii) Flowers are fragrant and emit scent and odour *e.g.*, *Jasminum*, *Cestrum* etc.

(iv) Flowers are showy and brightly coloured. They usually have coloured leaves, petals, sepals, stamens or sometimes stigma, *e.g.*, leaves in *Euphorbia pulcherrima*, bract in *Bougainvillea*.

(v) Small flowers occur in groups and thus, become more conspicuous.

(vi) Stigma also secretes some exudates which make stigma sticky. This sticky stigma can get pollens easily.

(vii) The pollen grains become sticky or develop spines around their body. This feature help in their attachment with the body of pollinators.

98. (a) *Refer to answer 76.*

(b) *Refer to answer 37.*

99. *Refer to answers 76 and 37.*

100. (a) *Refer to answer 58 (a).*

(b) The different wall layers of an anther and their functions are as follows:

(i) Epidermis – One cell thick and protective in function.

(ii) Endothecium – Second wall layer. Usually single layered. Cells have a cellulose thickening with a little pectin and lignin in some cases. It helps in anther dehiscence.

(iii) Middle layers – The number of middle layers ranges from 2-3. The middle layers degenerate at the time of maturity of the anther to provide nourishment to the growing microspore mother cells.

(iv) Tapetum – This is the innermost layer of anther wall which surrounds the sporogenous tissue.

Tapetum has a number of functions :

- Nourishment of the developing microspore mother cells and pollen grains.
- It produces lipid rich ubisch granules containing sporopollenin for exine formation, pollenkitt special proteins for the pollen grains which recognise compatibility and hormone IAA.
- It secretes enzyme callase responsible for the degradation of callose wall around pollen tetrad.

101. (a) **:** *Refer to answer 92 (a).*

(b) *Refer to answers 89 (b) and 100 (b).*

(c) (i) *Refer to answer 41.*

(ii) Pollen tablets are used as food supplement by people to improve health.

102. (a) *Refer to answer 45.*

(b) *Refer to answer 36.*

103. *Refer to answer 43.*

104. (a) *Refer to answer 74*

(b) *Refer to answer 37.*

105. (a) *Refer to answer 32.*

(b) *Refer to answers 49 and 67.*

106. *Refer to answer 43.*

107. *Refer to answer 76.*

108. *Refer to answers 92 (a) and 100 (b).*

109. (a) *Refer to answer 35.*

(b) A mature pollen grain has two layered wall-the outer exine and the inner intine. The wall encloses a large vegetative cell containing vegetative nucleus and a lenticular generative cell. Their functions are as follows:

Exine : The outer thick exine layer is made up of sporopollenin which is resistant to physical and biological decomposition. It provides protection during the hazardous journey of pollen from anther to the stigma. There are one or many germpores on the pollen surface which are associated with its germination.

Intine : The intine is pectocellulosic in nature. It is associated with the formation of pollen tube.

Vegetative cell : The vegetative cell is large and contains abundant food reserve. It has a large vegetative nucleus. The function of vegetative cell is to provide the medium for the movement of male gametes in pollen tube.

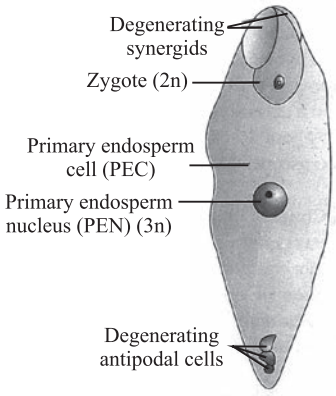
Generative cell : The generative cell cytoplasm is highly reduced but it contains the usual cell organelles. It divides mitotically to produce two functional male gametes.

110. (a) In angiosperms, triple fusion takes place in central part of embryo sac.

(b) In angiosperms, release of male gametes by pollen tube takes place into the cytoplasm of the synergid.

111. Double fertilisation is the fusion of two male gametes brought by a pollen tube to two different cells (egg and secondary nucleus) of central cell of the same female gametophyte in order to produce two different structures (zygote and primary endosperm nucleus).

112. The labelled diagram of a fertilised embryo sac of a dicot flower is as follows:



113. Egg cell after getting fertilised with one of the two male nuclei forms zygote which further develops into embryo. Polar nuclei fuse with other male nuclei to form primary endosperm nucleus which further develops into endosperm.

114. In angiosperms, pollen tube releases the two haploid male gametes into the cytoplasm of the synergid. One of the male gametes moves towards the egg cell (haploid) 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 polar nuclei located in the central cell and fuses with them to produce a triploid primary endosperm nucleus.

115. In angiosperms, one of the male gametes (n) fuses with diploid secondary nucleus to form a triploid (3n) primary endosperm cell. This process is referred to as triple fusion.

116. *For diagram refer to answer 35.*

The male gametophyte of angiosperms possesses two male gametes so as to carry out the process of double fertilisation. Double fertilisation is the process of fusion of two male gametes brought by a pollen tube to two different cells of the same female gametophyte present in an ovule.

117. In angiosperms, one of the male gametes fuses with the egg cell to form the zygote (syngamy). The other male gamete fuses with the two polar nuclei to produce a triploid primary endosperm nucleus (triple fusion). Since two types of fusions, syngamy and triple fusion take place in the same embryo sac, the phenomenon is termed as double fertilisation.

The ploidy of the cells involved in double fertilisation are as follows:
(i) Male gamete - Haploid (n)
(ii) Egg cell - Haploid (n)
(iii) Central cell - Diploid (2n)

118. *Refer to answer 117.*

119. Zygote is formed due to fusion of two haploid (n) cells, hence it is diploid (2n). Endosperms develops from triploid (3n) primary endosperm nucleus formed due to fusion of male gamete (n) and two polar nuclei (n), hence it is triploid.

120. *Refer to answer 112.*

121. *Refer to answer 117.*

122. *Refer to answer 117.*

123. *Refer to answer* 117.

124. Embryo sac is female gametophyte formed by haploid megaspores (produced by meiotic division in diploid megaspore mother cells). Therefore, it is haploid in nature.
Zygote is formed by the fusion of one of two male gametes (haploid) with egg (haploid) therefore, it is dipoid (2n).
Endosperm is produced by fusion of one of two male gametes (n) with two polar nuclei (2n) therefore, it is triploid in nature.

125. The components of the embryo sac are antipodals, polar nuclei (central cell), egg, synergids and filiform apparatus. Filiform apparatus, antipodals and synergids degenerate after fertilisation, egg after fertilisation with male gamete forms zygote whereas the polar nuclei fuse with other male gamete to form primary endosperm nucleus which gives rise to endosperm.

126. In angiosperms, there is a unique phenomenon, called double fertilisation, in which there are two fusions involved in the fertilisation of an ovule. A pollen has two male gametes, one of which fuses with the female gamete (egg) to form the zygote, while the other fuses with the polar nuclei (secondary nucleus) to form the primary endosperm nucleus.

127. Coleorhiza is a protective sheath that covers the young root of the embryo in plants of the grass family.

128. Differences between parthenocarpy and parthenogenesis are as follows:

	Parthenocarpy	**Parthenogenesis**
(i)	It is the production and development of seedless fruits without pollination and fertilisation.	It is the development of unfertilised egg into a complete individual without fertilisation.
(ii)	It occurs in plants only.	It occurs in both plants and animals.
(iii)	Examples: Banana, pineapple, guava, grapes, apple, tomato, papaya, etc.	Examples: Plants such as *Solanum nigrum, Nicotiana, Datura, Oenothera* etc. and animals like, Drones of honey bees, *Lacerta saxicola armaniaca, Typhlina brahmina*, etc.

129. Banana is a fruit obtained from an unfertilised ovary. It is seedless and produced without pollination and fertilisation, therefore, it is referred to as parthenocarpic fruit.

130. If the meiocyte (2n) of rice has 24 chromosomes, then the gametes (n) of rice will have 12 chromosomes. Therefore, the number of chromosome in its endosperm will be = $12 \times 3 = 36$.

131. Scutellum is the tissue in a monocot seed that lies between the embryonic axis and the endosperm. It is the modified cotyledon of grasses. It is very thin with high surface area and serves to absorb nutrients from the endosperm during germination.

132. *Refer to answer 127.*

133. *Refer to answer 129.*

134. Pericarp is the covering of fruit that develops from ovary wall. It protects the fruit and also helps in its dispersal.

135. Parthenocarpy is the mechanism which is responsible for the formation of seed without fertilisation in angiosperms. Examples of plants in which parthenocarpic seed formation takes place are banana, pineapple, tomato, papaya etc.

136. Thalamus along with ovary takes part in fruit formation in strawberry and guava.

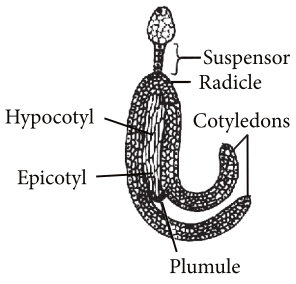
137. True fruits are the fruits in which only ovary participates in the formation of fruit whereas false fruits are the fruits in which along with ovary some other parts also participate in the formation of fruit. In strawberry, along with ovary thalamus also contributes to fruit formation, therefore, botanists call it a false fruit even though it is sweet and eaten raw just like any other fruit.

138. A fruit is a seed containing part of a plant that develops from a fertilised ovary. Apple is a false fruit because in apple apart from the ovary, thalamus also contributes to fruit formation.
Mango is a true fruit as it develops only from the ovary after fertilisation.
Banana is a seedless fruit or parthenocarpic fruit because it develops without fertilisation.

139. Banana fruit is a seedless fruit which is developed without pollination and fertilisation hence is referred to as parthenocarpic fruit, whereas in turkey the unfertilised egg develops into complete individual after fertilisation hence turkey is referred to as parthenogenetic.

140. The tender coconut water is free nuclear endosperm *i.e.,* during development the primary endosperm nucleus divides by repeated mitotic free nuclear division without formation of wall. White kernel of coconut is cellular endosperm *i.e.*, during development first nuclear division of the primary endosperm nucleus is followed by the formation of either a longitudinal or transverse cell wall in the central cell. Both tender coconut water and white kernel of coconut are triploid (3n) but coconut water is multinucleated structure whereas in kernel of coconut each cell is uninucleated.

141. Labelled diagram of dicot embryo is as follows:



142. The seeds in which endosperm persists as food storage tissue are called endospermic or albuminous, seeds, *e.g.*, castor, maize, wheat, barley, rubber, coconut.

In some seeds remains of nucellus persist. The residual nucellus which persists in the seed is called perisperm, *e.g.*, black pepper, coffee, castor, cardamum, *Nymphaea.*

143. Banana crop is cultivated by vegetative propagation without sowing seeds. It has subaerial stem structures called suckers which are slender branches that develop from base of aerial shoot, grow for some distance and form new aerial shoots or crowns. Breaking of suckers forms new plant. Rhizomes of banana also forms new plant.

144. *Refer to answer 141.*

145. Double fertilisation in angiosperms triggers the transformation of ovule into a seed. Following changes usually occur in the ovule during the development of seed:

(i) The zygote develops into an embryo.

(ii) The triploid primary endosperm nucleus gives rise to a nutritive tissue called endosperm. The endosperm may persist or gets completely digested during embryogenesis.

(iii) The nucellus is generally used up during the development of embryo but in some cases it remains outside the endosperm in the form of a thin layer, called perisperm.

(iv) The outer integument becomes hard and forms leathery testa or outer seed coat which ensures survival of seeds.

(v) The inner integument, if persists, forms the tegmen.

(vi) The micropyle remains in the form of a fine pore on the surface of seed. Funicle is transformed into stalk of the seed. The hilum marks the point of attachment to the stalk.

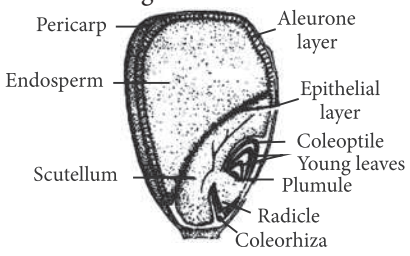
146. (a) In the most common type of endosperm development of coconut the PEN undergoes successive nuclear divisions to give rise to free nuclei. This stage of endosperm development is called free-nuclear endosperm. Subsequently cell wall formation occurs and the endosperm becomes cellular. The number of free nuclei formed before cellularisation varies greatly. The coconut water from tender coconut is free-nuclear endosperm (made up of thousands of nuclei) and the surrounding white kernel is the cellular endosperm.

(b) Tender coconut is rich in minerals, vitamins, proteins and is isotonic with our body fluids therefore it is considered healthy source of nutrition.

(c) Pea seeds are exalbuminous seeds *i.e.*, the endosperm is completely eaten up by growing embyro and food for later development of embryo is stored in cotyledon which becomes massive whereas castor seeds are albuminous seeds *i.e.*, the endosperm persists in the seed as food storage tissue.

147. In coconut, the product of triple fusion is primary endosperm cell which develops into endosperm. Coconut has cellular endosperm (called coconut meal) in the outer part and free nuclear endosperm (called coconut milk) in the centre. This endosperm persists in the seed hence the seed is known as albuminous seed.

148. L.S. of a maize grain is as follows:



149. *Refer to answer 141.*

150. Albuminous seeds are those seeds in which endosperm is present and serves as the reserve food material for the developing embryo. Most monocot and some dicot seeds are albuminous seeds, *e.g.*, cereal, coconut, castor etc.
Non-albuminous seeds are those seeds in which endosperm is consumed during seed development and food is stored in cotyledons. Most dicot and some monocot seeds are non-albuminous seeds, *e.g.*, pea, gram, bean, orchids etc.

151. In *Cocos nucifera* (coconut), the coconut water represents free-nuclear endosperm and the surrounding kernel represents the cellular endosperm. The primary endosperm nucleus (PEN) first undergoes a number of free nuclear divisions without wall formation to form a large number of free nuclei (free nuclear endosperm). When the fruit is about 50 mm long, the embryo sac gets filled with a clear fluid in which float numerous nuclei of various sizes. At a later stage (about 100 mm long fruit), the suspension shows, in addition to free nuclei, several cells each enclosing a variable number of nuclei. Gradually these cells and free nuclei start settling at the periphery of the cavity, and layers of cellular endosperm start appearing. This forms the coconut meal. The quantity of the cellular endosperm increases further by divisions of the cells.

152. (a) In the given figure of T.S. of an apple,
A – Thalamus
B – Seed
C – Endocarp

(b) In apple, along with ovary thalamus also contributes to fruit formation therefore apple is categorised as a false fruit.

153. *Refer to answer 147.*

154. Banana shows parthenocarpy. Its fruit is formed without fertilisation and is therefore seedless. Polyembryony refers to presence more than one embryo in a seed *e.g.,* orange. Some of the nucellar cells surrounding the embryo sac start dividing and protrude into the embryo sac and develop into the embryos. Thus each ovule contains many embryos. With respect to seeds, bananas and oranges differ as bananas are seedless whereas oranges contain many seeds.

155. *Refer to answer 148.*

156. *Refer to answer 141.*

157. Coconut water that we drink is free nuclear endosperm. Kernel that we eat is cellular endosperm of coconut.

158. Post-pollination events leading to seed formation in angiosperms are as follows :

(i) After pollination, the pistil recognises the pollen whether it is of the right type (compatible) or of the wrong type (incompatible). Compatible pollens are accepted and germinate on the stigma to produce a pollen tube. Pollen tube grows and reaches the ovary and enters the ovule either through micropyle or chalaza or integuments.

(ii) The pollen tube bursts open in one of the two synergids to release the two male gametes. One male gamete fuses with the egg to form a diploid zygote or oospore (syngamy). The second male gamete fuses with the diploid secondary nucleus of the central cell to form a primary triploid endosperm nucleus (triple fusion). The whole process is termed as double fertilisation.

(iii) The primary endosperm nucleus gives rise to endosperm while the zygote develops into embryo.
(iv) The integuments of fertilised ovule harden to form the seed coat.
(v) The outer integument becomes hard and forms leathery testa or outer seed coat which ensures survival of seeds.
(vi) The inner integument, if persists, forms the tegmen.
(vii) The micropyle remains in the form of a fine pore on the surface of seed. Funicle is transformed into stalk of the seed. The hilum marks the point of attachment to the stalk. Micropyle facilitates the entry of oxygen and water into the seed.

159. In angiosperms double fertilisation produces two structures - a diploid zygote and a triploid primary endosperm cell. The latter gives rise to tissue called endosperm. Zygote forms the embryo and endosperm provides nourishment to the growing embryo. With the growth of embryo the central part of the endosperm is utilised. In some seeds, the endosperm persists in the seed as food storage tissue. Such seeds are called endospermic or albuminous seeds, *e.g.,* castor, cereals, etc. In others the endosperm is completely eaten up by growing embryo. The food for later development of embryo is then stored in cotyledons which become massive. Such seeds are called nonendospermic or exalbuminous, seeds *e.g.*, groundnut, pea etc.

160. Endosperm is the food laden tissue formed after double fertilisation. It provides essential nutrients to the growing embryo and also the young seedling at the time of seed germination. In angiosperms, the endosperm develops from triploid (3n) primary endosperm nucleus which is formed as a result of vegetative fertilisation or triple fusion *i.e.*, fusion of a male gemete with secondary nucleus of the central cell. Based on the first and subsequent divisions of primary endosperm nucleus, the development of endosperm takes place in different ways and accordingly endosperm is of three types – nuclear, cellular and helobial.

Nuclear type : In the nuclear type of endosperm the first division of primary endosperm nucleus and few subsequent nuclear divisions are not accompanied by wall formation. The nuclei produced are free in the cytoplasm of the embryo sac and they may remain free indefinitely or wall formation takes place later. The multinucleate cytoplasm undergoes cleavage, and gives rise to multicellular tissue, maize, wheat, rice.

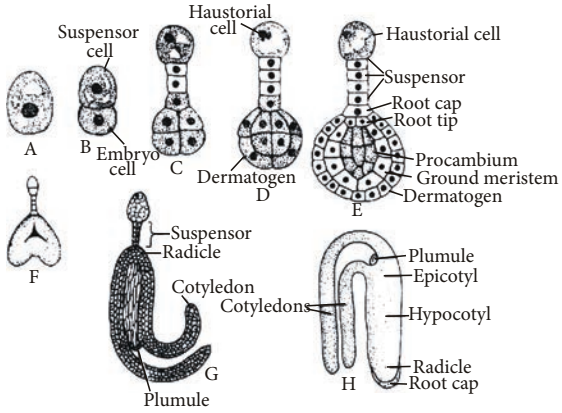
Cellular type : In this case, there is cytokinesis after each nuclear division of endosperm nucleus. The endosperm, thus, has a cellular form, from the very beginning because first and subsequent divisions are all accompanied by wall formation. *e.g.*, *Petunia*, *Datura*, *Adoxa* etc.

Helobial type: It is an intermediate type between the nuclear and cellular types. The first division is accompanied by cytokinesis but the subsequent ones are free nuclear. The chamber towards micropylar end of embryo sac is usually much larger than the chamber towards chalazal end. A large number of nuclei are formed in the micropylar chamber by free nuclear divisions while the nucleus of the chamber towards chalazal end divides to form a fewer free nuclei or may not divide at all, *e.g.*, Order Helobiales and most monocots.

Endosperm provides nourishment to the zygote. So, endosperm development precedes that of zygote.

161. In a typical dicot flower, after double fertilisation, the zygote elongates and then divides by a transverse wall into two unequal cells. The larger basal cell is called suspensor cell. The other towards the antipodal end is termed as terminal cell or embryo cell. The suspensor cell divides transversely a few times to produce a filamentous suspensor of 6–10 cells. The suspensor helps in pushing the embryo in the endosperm. The first cell of the suspensor towards the micropylar end becomes swollen and functions as a haustorium. The last cell of the suspensor is known as hypophysis. Hypophysis later gives rise to the radicle and root cap. The embryo cell undergoes two vertical divisions and one transverse division to form eight cells arranged in two tiers– epibasal (terminal) and hypobasal (near the suspensor). The epibasal cells eventually form the two cotyledons and the plumule. The hypobasal cells produce the hypocotyl except its tip.

Stages in the development of a dicot embryo are represented diagrammatically as follows:



Initially the embryo is globular and undifferentiated. Early embryo with radial symmetry is called proembryo. It is transformed into embryo with the development of radicle, plumule and cotyledons. At this time the embryo becomes heart-shaped. The rate of growth of the cotyledons is very high so that they elongate tremendously while the plumule remains as a small mound of undifferentiated tissue.

162. Soon after the act of double fertilisation, the flower begins to lose its shine. The petals, stamens and style either fall or wither away. The calyx, however, may persist in some cases (*e.g.*, tomato, brinjal). The major events include –

(i) Development of endosperm from triploid primary endosperm nucleus in the central cell of embryo sac.

(ii) Development of embryo from diploid zygote.

(iii) Development of seed from ovule.

(iv) Development of fruit from ovary.

163. The three advantages that seeds offer to angiosperms are as follows:

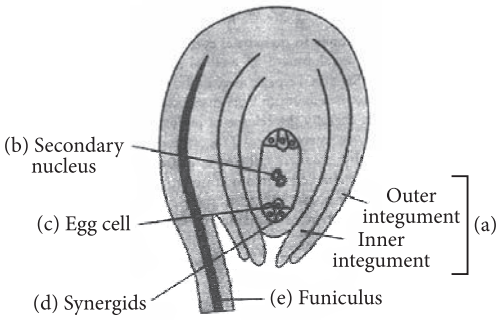
(i) Seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas.

(ii) They have sufficient food reserves, young seedlings are nourished until they are capable to photosynthesise on their own and hard seed coat provides protection to the young embryo.

(iii) Seeds are product of sexual reproduction, they generate new genetic combinations leading to variations.

164. *Refer to answer 159.*

165. Diagrammatic sectional view of anatropous ovule is as follows:



166. *Refer to answer 128.*

167. *Refer to answer 148.*

168. Differences between perisperm and endosperm are as follows:

	Perisperm	**Endosperm**
(i)	Perisperm is the residual persistent nucellus. It encloses the embryo and provides nourishment to it in certain seeds.	Endosperm is the tissue formed after double fertilisation. It surrounds, stores food and provides nourishment to the embryo in an angiosperm seed.
(ii)	It is diploid in nature.	It is triploid in nature because it is formed as a result of triple fusion.
(iii)	Example : Black pepper	Example : Wheat

169. A - Pericarp
B - Scutellum
C - Coleoptile
D - Coleorhiza

170. (a) *Refer to answer 150.*

(b) (i) Persistent nucellus of the ovule is called perisperm.

(ii) Integuments of the ovule develop into seed coats.

(iii) Polar nuclei of the embryo sac on fusion with male nuclei for triploid endosperm nucleus that develops endosperm.

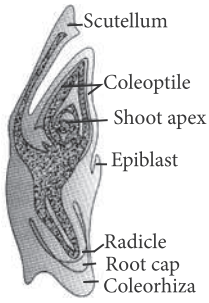
(iv) Zygote forms embryo or embryonal axis.

171. False fruit is the fruit which is derived from the fertilised ovary and accessory floral parts *e.g.*,

thalamus also contribute to the fruit formation. Examples : apple, strawberry, guava etc. True fruit is the fruit which is derived only from the ovary of a flower and is not associated with any non-carpellary part , for example : mango, tomato, etc.
Parthenocarpic fruit is the fruit that is formed without fertilisation and does not bear seeds, *e.g.*, pineappale, banana, etc.

172. *Refer to answer* 148.

173. L.S. of embryo of grass is as follows:



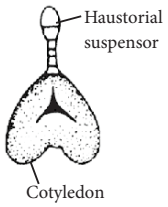
174. (a) *Refer to answer 128.*
(b) Differences between perisperm and pericarp are as follows :

	Perisperm	**Pericarp**
(i)	It is persistent nucellus in the seed.	It is the covering of fruit that develops from ovary wall.
(ii)	It is a part of seed.	It is a part of fruit.
(iii)	It is usually dry.	It may be dry or fleshy.
(iv)	It is often nonfunctional for seed.	It is protective covering and also helps in dispersal.
(v)	Perisperm is present in few seeds, *e.g.*, black pepper, coffee.	It is found in almost all the fruits, *e.g.*, mango.

175. *Refer to answer 161.*

176. (a) *Refer to answer 148.*
(b) *Refer to answer 163.*

177. (a) The given figure represents globular embryo which is the developmental stage of dicot embryo.
(b) Zygote or oospore is the initial cell from which the given structure has developed.
(c) The next mature stage is heart shaped embryo, as shown below:



178. *Refer to answer 161.*

179. The following changes take place in fertilised ovule to develop into a seed :

	Parts before fertilisation	**Parts after fertilisation**
(i)	Ovule	Seed
(ii)	Outer integument	Testa (tough)
(iii)	Inner integument	Tegmen (delicate)
(iv)	Nucellus	Perisperm
(v)	Primary endosperm nucleus	Endosperm
(vi)	Egg cell or zygote	Embryo
(vii)	Funiculus	Stalk
(viii)	Antipodals	Degenerate
(ix)	Synergids	Degenerate

180. A flower of tomato plant contains 200 viable seeds.
(a) Minimum number of ovules involved = 200 because following fertilisation one ovule matures into one seed.
Each microspore mother cell undergoes meiosis and gives rise to tetrad of four haploid microspores or pollen grains.
(b) Number of microspore mother cells required to produce 200 pollen grains is $\frac{\cancel{200}}{\cancel{4}} = 50$

(c) 200 pollen grains must have pollinated 200 carpels for production of 200 viable seeds.
(d) Male gametes involved are $200 \times 2 = 400$
Each pollen grain releases two male gametes, one fuses with the egg to form zygote and second male gametes fuses with polar nuclei to form endosperm nucleus.
(e) Megaspore mother cell undergoes reduction division to form four haploid megaspores. Only one megaspore remains functional and other

three degenerate. Only the functional megaspore develops into female gametophyte. Hence, number of megaspore mother cell = 200.

181. A flower of brinjal plant contains 360 viable seeds.

(a) Number of minimally involved ovules = 360. This is because following sexual reproduction, one ovule matures into one seed.

(b) Megaspore mother cell undergoes reduction division to forms four haploid megaspores. Only one megaspore remains functional and other three degenerate. Only the functional megaspore develops into female gametophyte. Hence, number of megaspore mother cell = 360.

(c) Compatible pollen grain after landing on stigma forms pollen tube which traverses through style of carpel and enters the ovule to release male gamete. Here, minimum number of pollen grains involved is = 360.

(d) Each pollen grain releases two male gametes in an embryo sac. One male gamete fuses with the egg to form zygote and second male gamete fuses with polar nuclei to form endosperm nucleus. Hence, number of male gametes involved is = 360 × 2 = 720.

(e) Each microspore mother cell undergoes meiosis and gives rise to tetrad of four haploid microspores or pollen grains.

Number of microspore mother cell that have undergone reduction division prior to dehiscence of anther $= \frac{360}{4} = 90$

182. (a) *Refer to answer 158.*

(b) The ploidy levels of the cell of different parts of an albuminous seed are:

Zygote – diploid (2n)	Coleoptile – diploid (2n)
Pericarp – diploid (2n)	Plumule – diploid (2n)
Endosperm – triploid (3n)	Radicle – diploid (2n)
Scutellum – diploid (2n)	Coleorhiza– diploid (2n)

183. (a) Endosperm is food storing tissue formed during the development of angiospermous seed which provides essential nutrients to the growing embryo and also young seedling at the time of seed germination.

(b) Groundnut seeds are exalbuminous as the seeds usually store food materials in cotyledons and the endosperm is used up by the developing embryo. Castor seeds are albuminous as they, have copious amounts of endosperm tissue to provide nutrition to the developing embryo.

(c) Micropyle remains as a small pore in the seed coat to facilitate entry of O_2 and water into the seed during germination.

(d) Integuments of an ovule harden and the water content is highly reduced, as the seed matures to enable the seed to remain viable for a long time during the period of dormancy. The seed may enter a state of inactivity called dormancy and germinates only when the favourable conditions are available.

(e) Apple and cashew are not called true fruits as in these fruits, along with the ovary, thalamus also forms a part of fruit.

184. *Refer to answers 160 and 161.*

185. (a) *Refer to answer 161.*

(b) Endosperm is the food laden tissue formed after double fertilisation. It provides nourishment to the developing embryo. So endosperm development precedes that of zygote.

(c) *Refer to answer 141.*

186. In hybrid apomicts, there is no segregation of characters in hybrid progeny. So, farmers can keep on using the hybrid seeds to raise new crop year after year and they do not have to buy new hybrid seeds every year.

187. Hybrid seeds have to be produced year after year because seeds collected from hybrid plants, if sown subsequently, do not maintain hybrid characters due to segregation of traits.

188. In orange seed, embryos originate by adventive embryony from diploid cells of nucellus or integuments and thus, if orange seed is squeezed many embryos of different sizes can be observed.

189. Apomixis is a mode of reproduction which does not involve formation of zygote through gametic fusion. It is a form of asexual reproduction that mimics sexual reproduction, in which seeds are produced without fertilisation. It is common in grasses and species of Family Asteraceae.

Apomicts have advantages in horticulture and agriculture, particularly hybrid seed industry.

(i) The hybrid varieties are more productive but production of these seeds is very costly and time consuming and such seeds do not maintain hybrid

vigour in progeny due to segregation of characters / genes during meiosis. If the hybrids are made into apomicts, there will be no segregation of genes due to no meiosis. Thus, apomictic hybrid seeds can be used year after year which will reduce the cost on purchasing hybrid seeds every year.

(ii) Adventive embryos are better clones than cuttings.

(iii) Apomictic embryos are generally free from infections.

190. Apomixis is a mode of reproduction that produces seeds without fertilisation.

191. Advantages of apomictic seeds of hybrid varieties to farmer are as follows:
(i) It will reduce the cost on purchasing hybrid seeds every year.
(ii) Apomixis is genetically controlled so genes of apomixis can be introduced in hybrid varieties.

192. *Refer to answer 189.*

193. There are several methods of apomictic development in seeds. The two common ones are recurrent agamospermy and adventive embryony.

(i) Recurrent agamospermy : Agamospermy is the formation of seed that has an embryo formed without meiosis and syngamy. It is of two types, nonrecurrent and recurrent. In nonrecurrent agamospermy, the embryo is haploid. Therefore, the seed having it is non-viable. In recurrent agamospermy all the cells of embryo sac are diploid as it is formed directly either from a nucellar cell (apospory) or diploid megaspore mother cell (diplospory), *e.g.*, *Rubus*, apple.

(ii) Adventive embryony : An embryo develops directly from a diploid cell other than egg like that of nucellus and integument, *e.g., Citrus, Opuntia*.

194. (a) Seeds of some grasses are called apomictic because they are produced without fertilisation and do not involve formation of zygote through gametic fusion.

(b) Two reasons to convince a farmer to use an apomictic crop are as follows:
(i) Production of infection free embryo for development of plant.
(ii) Production of better clones as adventive embryos are better clones than cuttings.

195. *Refer to answer 193.*

196. Polyembryony is the occurrence of more than one embryo in a seed. In *Citrus*, some of the nucellar cells surrounding the embryo sac start dividing, protrude into the embryo sac and develop into the embryos. So, their seed contains many embryos and are referred as polyembryonic seed.

197. *Refer to answers 189 and 191.*

198. *Refer to answer 188.*

199. (a) In the members of Family Asteraceae, seeds develop without fertilisation. This process is called apomixis.
(b) Two ways by which seeds develop without fertilisation are as follows:
(i) In some species, the diploid (2n) egg cell is formed without reduction division and develops into embryo without fertilisation.
(ii) In many varieties of *Citrus* and mango some of the nucellar cells surrounding the embryo sac start dividing, protrude into the embryo sac and develop into embryos.

200. *Refer to answer 189.*
The commercial use of apomixis is as follows:
(i) Production of infection free embryos for development of plant.
(ii) Production of better clone as adventive embryos are better clones than cuttings.

201. (a) Apomixis is a mode of reproduction which does not involve formation of zygote through gametic fusion whereas parthenocarpy involves formation of zygote through gametic fusion but produces seedless fruits. Asomixis produces seeds without fertilisation *e.g.*, some species of Asteraceae and grasses parthenocarpy is production and development of seedless fruits *e.g.*, banana, grapes.
(b) *Refer to answer 193.*

202. *Refer to answers 189 and 196.*