CHAPTER

2 SEXUAL REPRODUCTION IN FLOWERING PLANTS

Syllabus

➢ ***Sexual Reproduction in Flowering Plants :*** *Flower structure; development of male and female gametophytes; pollination-types, agencies and examples; outbreeding devices; pollen-pistil interaction; double fertilization; post fertilization events – development of endosperm and embryo, development of seeds and formation of fruit; special modes-apomixis, parthenocarpy, polyembryony; significance of seed dispersal and fruit formation.*

Chapter Analysis

List of Topics		2016		2017		2018
		D	OD	D	OD	D/OD
Pre-fertilisation: Structures and Events	• Development of pollen-grain • Megasporangium • Pollination and its different types • Outbreeding devices • Pollen –pistil interaction	1 Q (5 M)		1 Q (5 M)	1 Q (2M) 1Q (3M)	
Double Fertilization	• Formation of embryo sac			1 Q (2 M)		1 Q (3 M)
Post-Fertilisation Structures and Events	• Post fertilization events			1 Q (5 M)		1 Q (5 M)
Apomixis and Polyembryony	• Polyembryony • Parthenocarpic fruits • Apomictic seeds		1 Q (2 M)		1 Q (5 M)	

- *On the basis of above analysis, it can be concluded that a major 5 mark question is always asked from this chapter. The important topics for 5 mark questions are post fertilisation events, out-breeding devices, polyembryony and apomictic seeds. Other important topics are- pollination and its types, pollen pistil interaction. Many diagram based questions are usually asked from this chapter. Practice drawing neat and well-labelled diagram.*

TOPIC-1
Sexual Reproduction in Flowering Plants

Revision Notes

➢ Flowers are the site of sexual reproduction in flowering plants.

➢ Parts of a typical angiospermic flower are : sepals, petals, stamens and pistils.

- The four whorls of the flower are attached on a central axis called thalamus.
- A flower can be bisexual (contains both male and female reproductive parts) or unisexual (only one of the reproductive part is present).

TOPIC - 1
Sexual Reproduction in Flowering Plants .... **P. 12**

TOPIC - 2
Pollination and Fertilization .... **P. 22**

TOPIC - 3
Post-fertilization Changes and Special Modes of Reproduction .... **P. 33**

Male Reproductive Structures

Androecium (Whorl of Stamens)

- Androecium consists of a whorl of stamens.
- The number and length of the stamens are variable in flowers of different species.
- A stamen has three parts namely, Anther, Filament and Connective.

(a) Anther

- It is the terminal and bilobed part of stamens attached with filament. A bilobed anther is called dithecous.
- Each lobe has two pollen sacs or microsporangia. Therefore, the anther is tetrasporangiate.
- A longitudinal groove runs lengthwise separating the theca.

(b) Filament

- It is the long and slender stalk part of the stamen.
- Its proximal end is attached to the thalamus or petals of the flower.

(c) Connective

- The structure which connects the anther lobes together is known as connective.

Transverse section of an anther

- The anther is tetragonal in structure consisting of four microsporangia or pollen sacs located at the corners, two in each lobe.
- The microsporangia develop to become pollen sacs.
- They extend longitudinally throughout the length of an anther.
- These are packed with pollen grains.

Structure of microsporangium or Pollen sac

- It is circular and is generally surrounded by wall layers namely,
  (a) Epidermis **(b)** Endothecium
  (c) 2 or 3 Middle layers **(d)** Tapetum
- The first two layers perform the function of protection and help in dehiscence of anther to release the pollens.
- The middle layers and the innermost layer, (tapetum) nourishes the developing pollen grains.
- The cells of the tapetum possess dense cytoplasm and more than one nuclei.
- When the anther is young, a group of compactly arranged homogenous cells called sporogenous tissues occupies the centre of each microsporangium.

Microsporogenesis

- When the anther develops, each cell of sporogenous tissue undergoes meiotic division to form microspore tetrads.
- Each cell of sporogenous tissue is a microspore mother cell (MMC) or pollen mother cell (PMC).
- The process of formation of microspores from a pollen mother cell (PMC) through meiosis is called microsporogenesis.

Dehiscence of anther

- The microspores get arranged in a group of four cells and hence are microspore tetrad.
- As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains.
- From each microsporangium, thousands of pollen grains are formed and released due to the dehiscence of anther.

Pollen grain (Male gametophyte)

- Pollen grain germinate and give rise to male gametophyte.
- These are spherical, measuring about 25-50 micrometers in diameter.
- Pollen grains are well preserved as fossils due to the presence of sporopollenin, a tough, resistant and stable material.
- A pollen grain has a two-layered wall namely, Exine and Intine.

(a) Exine :

- Exine is the hard outer layer which is made up of sporopollenin.
- The sporopollenin is one of the most resistant organic materials.
- It can withstand high temperature and strong acids and alkali.
- It cannot be degraded by enzymes.
- The exine has apertures called germ pores where sporopollenin is absent.

(b) Intine

- It is the inner, thin and continuous layer which is made up of cellulose and pectin.
- A mature pollen grain contain two cells namely, vegetative cell and generative cell

(i) Vegetative cell

- It is the bigger cell having abundant food reserve and a large irregularly shaped nucleus.

(ii) Generative cell

- It is the smaller cell that floats in the cytoplasm of the vegetative cell.
- It is spindle shaped with dense cytoplasm and a nucleus.
- The pollen grains are generally shed at the 2-celled stage in flowering plants.
- In other plants, the generative cell divides mitotically to give rise the two male gametes before pollen grains are shed in 3-celled stage.
- Once they are shed, pollen grains have to land on the stigma before they lose viability.
- The period of pollen grains remaining viable varies and depends on the prevailing temperature and humidity.
- The viability of pollen grains of some cereals such as rice, wheat, etc. is 30 minutes while some members of Leguminosae, Rosaceae & Solanaceae have viability for months.
- Pollen grains of some plants like *Parthenium* are allergic for some people leading to chronic respiratory disorders such as asthma, bronchitis, etc.
- Pollen grains are rich in nutrients.
- Pollen tablets are used as food supplements.
- Pollen consumption in the form of tablets and syrups increases performance of athletes and race horses.
- It is possible to store pollen grains for years in liquid nitrogen (–196°C).
- The stored pollen can be used in pollen banks for crop breeding programmes.

Female Reproductive Structure

Gynoecium (Pistil)

- It represents the female reproductive part of the flower.
- If it consists of a single pistil or carpel, it is known as monocarpellary or if it has more than one pistil or carpel, it is called multicarpellary.
- When there is more than one carpel they may be fused together then the pistil is known as syncarpous or may be free then it is known as apocarpous.
- Each carpel has three parts namely Stigma, Style and Ovary.

(a) Stigma

- It is a landing platform for pollen grains.

(b) Style

- It is an elongated slender part beneath the stigma.

(c) Ovary

- It is the basal swollen part of the carpel.
- Inside the ovary is the ovarian cavity called locule where the placenta is located.
- Placenta contains the ovules or megasporangia.
- The number of ovules in an ovary may be one as seen in wheat, paddy, mango, etc., or many as seen in papaya, watermelon, orchids, etc.

Megasporangium (Ovule)

- It is a small structure attached to the placenta by a stalk called funicle.
- The junction where the body of ovule and funicle fuse is called hilum.
- Each ovule has one or two and some times three protective coverings called integuments.
- Integuments encircle the ovule except at the tip where a small opening called micropyle is organized.
- Opposite to the micropylar end is the chalaza which is the basal part of the ovule.
- Within the integuments, there is a mass of cells called nucellus which contains reserve food materials.
- Inside the nucellus there is embryo sac, which is also called as the female gametophyte.
- An ovule has a single embryo sac usually formed from a single haploid megaspore.

Megasporogenesis

- The formation of haploid megaspores from the diploid megaspore mother cell (MMC) as a results of meiosis is called **megasporogenesis**.
- A single megaspore mother cell is differentiated in the micropylar region of the nucellus.
- The megaspore mother cell is a large cell containing dense cytoplasm and a prominent nucleus.
- The megaspore mother cell undergoes meiotic division resulting in the production of four haploid megaspores.

Female gametophyte (Embryo sac)

- In most of the flowering plants, only one megaspore is functional while the other three degenerate.
- The functional megaspore develops into the female gametophyte or embryo sac.
- This method of embryo sac formation from a single megaspore is termed as monosporic development.

Development of Female gametophyte

- The nucleus of the functional megaspore divides mitotically to form two nuclei which move towards the opposite poles, forming two-nucleated embryo sac.
- Two more sequential mitotic nuclear divisions result in the formation of the four-nucleated and later the eight-nucleated stages of the embryo sac.
- These divisions are strictly free nuclear, *i.e.* nuclear divisions are not followed immediately by cell wall formation.
- After eight-nucleate stage, the organization of the typical female gametophyte or embryo sac takes place.
- Generally six of the eight nuclei are surrounded by cell walls and organized into cells.
- The remaining two nuclei called the polar nuclei are found below the egg apparatus in the large central cell.

Distribution of the cells within the embryo sac

- The three cells consisting of two synergids and one egg cell which are grouped together at the micropylar end constitute the egg apparatus.
- The synergids have special cellular thickenings at the micropylar tip called filiform apparatus.
- The filiform apparatus helps to guide the pollen tubes into the synergid.
- Three cells at the chalazal end organize as the antipodals.
- Thus, a typical mature angiosperm embryo sac at maturity is eight-nucleate and seven-celled.

IMPORTANT DIAGRAMS:

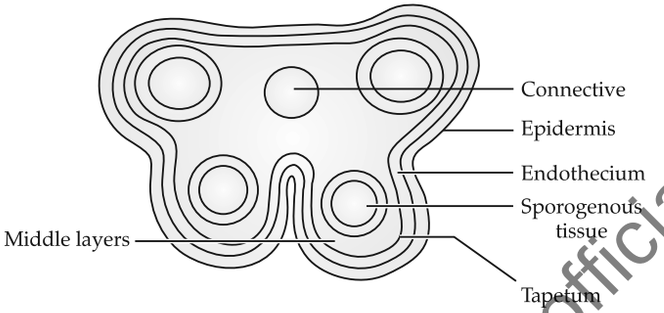


Fig 2.1: Transverse Section of a young anther

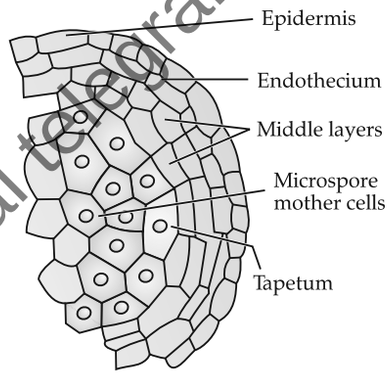


Fig 2.2: Enlarged view of an microsporangium

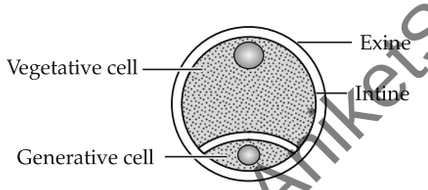


Fig 2.3: Structure of 2 celled male gametophyte (pollen grain)

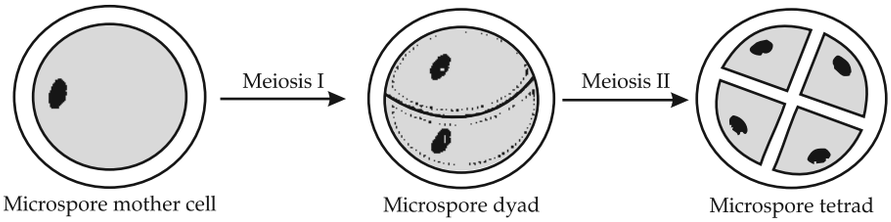


Fig 2.4: Microsporogenesis

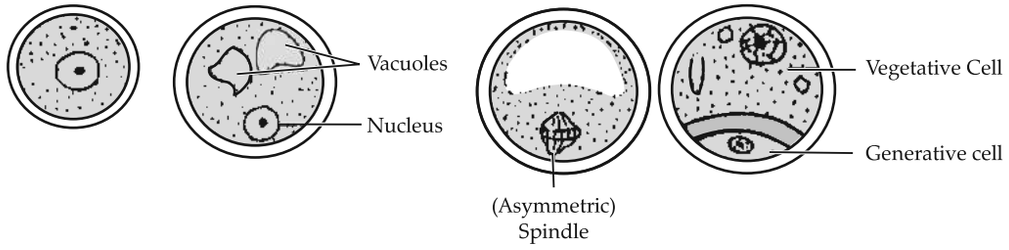


Fig 2.5: Stages of a microspore maturing into a pollen grain

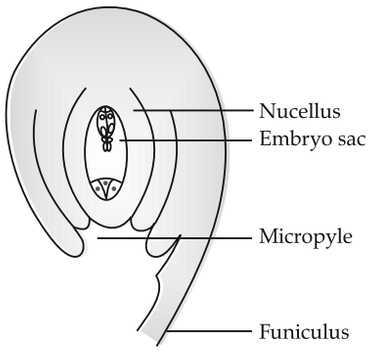


Fig 2.6: A diagrammatic view of a typical anatropous ovule

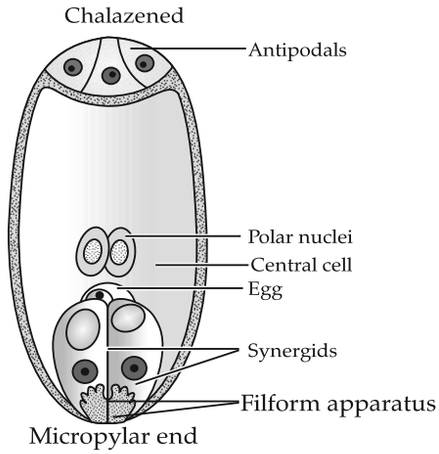


Fig 2.7: A diagrammatic view of the mature embryo

Very Short Answer Type Questions (1 mark each)

Q. 1. State the function of filiform apparatus found in mature embryo sac of an angiosperm.
R **[Delhi Set-III, 2014]**

Ans. Filiform apparatus helps to guide the path of pollen tubes into synergid. **1**
[CBSE Marking Scheme, 2014]

Q. 2. Draw a diagram of microspore of an angiosperm. Label its cellular components only.
R **[Delhi Set-H, 2014]**

Ans. Refer to Topic 1/ Revision Notes- Important diagrams/ Fig 2.3
[CBSE Marking Scheme, 2014] ½ + ½

Q. 3. Give an example of a plant that came to India as a contaminant and is a cause of pollen allergy.
R **[Outside Delhi Set-III, 2014]**

Ans. *Parthenium* or carrot grass. **1**
[CBSE Marking Scheme, 2014]

AI **Q. 4. An anther with a malfunctioning tapetum often fails to produce viable male gametophytes. Give any one reason.** A **[Delhi Set-I, II, 2013]**

Ans. Because the tapetum provides nourishment for the development of pollen grains. **1**

Q.5. How many pollen grains and ovules are likely to be formed in the anther and the ovary of an angiosperm bearing 25 microspore mother cells and 25 megaspore mother cells respectively?
E & A **[SQP, 2018]**

Ans. Microspore mother cells 25 × 4=100 pollen grains and from megaspore mother cells 25 ovules respectively. ½ + ½
[CBSE Marking Scheme, 2018]

Q. 6. How many microsporangia are present in a typical anther of angiosperm. E & A **[CBSE Foreign, 2013]**

Ans. Usually Four. **1**

Short Answer Type Questions-I (2 marks each)

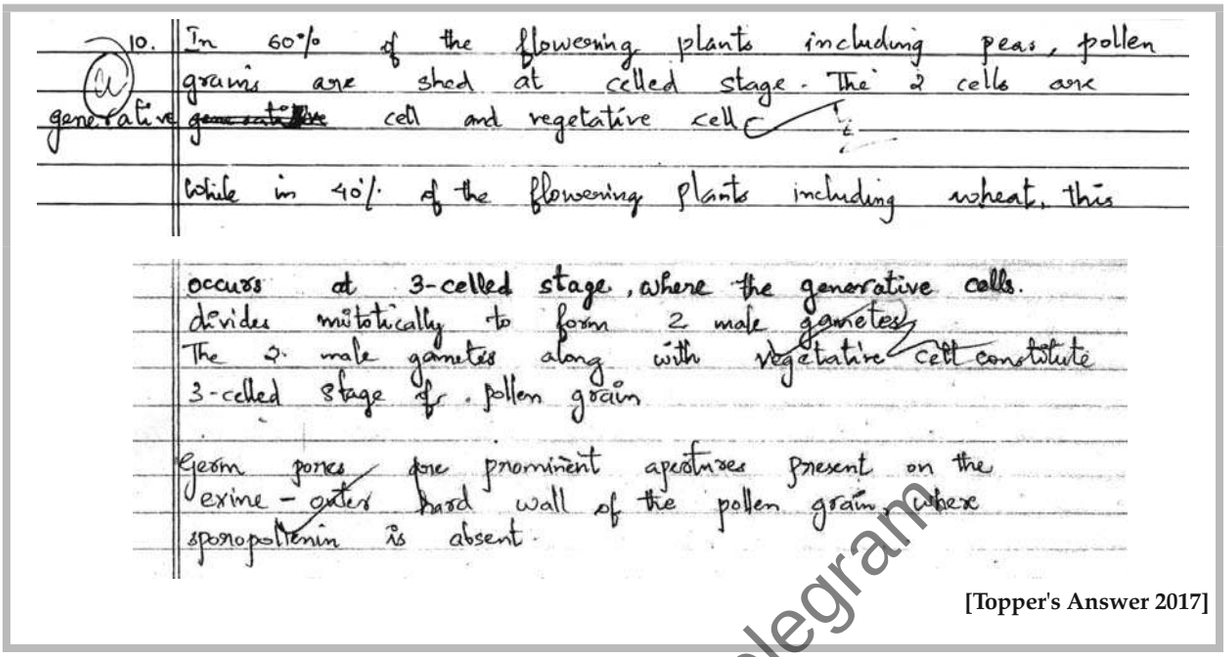
Q. 1. How many cells are present in the grains at the time of their release from anther ? Name the cells.
R **[Outside Delhi Set-III, 2017]**

Ans. Pollen grain may be released at 2-celled stage. One vegetative and one generative cell. **1 + 1**

Q. 2. "Pollen grains in wheat are shed at 3-celled stage while in peas they are shed at 2-celled stage." Explain. Where are germ pores present in a pollen grain ?
R **[Outside Delhi Set-II, 2017]**

Ans. At the time of shedding wheat pollen consist of one vegetative and two male gametes (3 celled), While pea pollen consists of one vegetative and one generative cell (2 celled) ½ + ½
Germ pores are present on the exine (Where sporopollenin is absent) **1**
[CBSE Marking Scheme, 2017]

OR


10. In 60% of the flowering plants including peas, pollen grains are shed at celled stage. The 2 cells are generative cell and vegetative cell.

While in 40% of the flowering plants including wheat, this occurs at 3-celled stage, where the generative cells divides mitotically to form 2 male gametes. The 2 male gametes along with vegetative cell constitute 3-celled stage of pollen grain.

Germ pores are prominent apertures present on the exine - outer hard wall of the pollen grain, where sporopollenin is absent.

[Topper's Answer 2017]

Q. 3. A pollen grain in angiosperm at the time of dehiscence from an anther could be 2-celled or 3-celled. Explain. How are the cells placed within the pollen grain when shed at a 2-celled stage ?

R **[Outside Delhi Set-I 2017]**

Ans. In 2-celled stage, the mature pollen grain contains a generative and vegetative cell, whereas in 3-celled stage, one vegetative cell and two male gametes are present. ½ + ½

The generative cell floats in the cytoplasm of vegetative cell. **1**

[CBSE Marking Scheme, 2017]

AI **Q. 4. Name the organic materials exine and intine of an angiosperm pollen grain are made up of. Explain the role of exine. [Delhi Set-II, 2014]**

Ans. The exine is made up of sporopollenin, which is one of the most resistant organic material. The intine layer is made up of cellulose and pectin materials. The exine is hard and hence protects the pollen grains during adverse conditions. **1 + 1**

[CBSE Marking Scheme, 2014]

Detailed Answer :

Exine is made up of a substance called "sporopollenin" while intine is made up of pectocellulose.

Sporopollenin is a resistant fatty substance therefore, exine functions as a protective covering of pollen grain. It also possesses the proteins for enzymatic and compatibility reactions.

Commonly Made Error

- Students often get confused between the outer and inner layer name i.e. exine and intine.

Q. 5. Write the function of tapetum in anthers.

U **[Delhi Set-II, 2012]**

Ans. The tapetum is the inner most wall layer of the microsporangia (pollen sacs) in anthers. These cells nourish the developing microspore mother cells and pollen grains. Besides this it forms the exine, secrete pollenkitt and special proteins for pollen grains so as to recognize compatible stigmas. **2**

Q. 6. Where is sporopollenin present in plants ? State its significance with reference to its chemical nature.

U **[Delhi Set-I, III, 2012]**

Ans. Present in exine of pollen / pollen grain ½ + ½

Sporopollenin is the most resistant organic materials. It can withstand high temperature and strong acids and alkali. It cannot be degraded by enzymes. **[CBSE Marking Scheme, 2012]** ½ + ½

Q. 7. In a flowering plant, a microspore mother cell produce four male gametophytes while a megaspore mother cell form only one female gametophyte. Explain. A **[Delhi Set-II 2017]**

Ans. A microspore mother cell/PMC on meiosis forms 4 functional pollen grains/male gametophyte **1**

A megaspore mother cell/MMC on meiosis also forms four megaspores but out of it only one is functional and other three degenerate **1**

[CBSE Marking Scheme, 2017]

AI **Q. 8. Draw a diagram of a section of a megasporangium of an angiosperm and label funiculus, micropyle, embryo sac and nucellus.**

[Outside Delhi, Set-I, 2016]

OR

Draw a well labelled diagram of a typical anatropous ovule. [Outside Delhi Set-III, 2014]

Ans. Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.6 **[CBSE Marking Scheme, 2016] 2**

Answering Tip

- Draw and label all the diagrams neatly and correctly.

Q. 9. A mature embryo-sac in a flowering plant may possess 7-cells, but 8-nuclei. Explain with the help of a diagram only. A **[Delhi Set-I 2017 (NCERT)]**

Ans. Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.7 ½ × 4

Commonly Made Error

- Many students, instead of drawing the Embryo sac, draw the entire anatropous ovule. Some students label the diagram incorrectly, e.g., *filiform apparatus* is labelled as *fulliform apparatus*. Some students draw micropylar and chalazal ends in opposite directions. Few of them get confused between *polar nuclei* and *secondary nucleus*.

Answering Tip

- Lay stress on drawing correct diagrams. Also, learn thoroughly the position of antipodal cells and egg apparatus with reference to micropyle.

Q. 10. Mention the ploidy of the different types of cells present in the female gametophyte of an angiosperm. A **[Delhi Set-III 2017]**

Ans. Synergids = n/haploid, egg = n/haploid, polar nuclei = n/haploid, antipodals = n/haploid = ½ × 4 // all types of cell of female gemetophyte are haploid / n = 2 **2**

[CBSE Marking Scheme, 2017]

Answering Tips

- Students should understand the concept of Haploid (n) and Diploid (2n). While studying plant reproduction, at every step, understand the basic concepts of alternation of generation, viz., megasporogenesis, microsporogenesis, fertilisation, embryonic development and endosperm formation.
- Understand the location of haploid and diploid nuclei in embryo sac.

Q. 11. Differentiate between two cells enclosed in a mature male gametophyte of an angiosperm. U **[Outside Delhi Set-III, 2013]**

Ans. There are three cells enclosed in the male gametophyte of angiosperms out of which two are male gametes and one is tube cell or vegetative cell. The two male gametes are small, round and surrounded by a little cytoplasm.

They are situated towards the proximal part of the pollen tube, whereas the tube cell or vegetative cells are irregular in outline and is present in the distal part of the pollen tube. Two male gametes are functional and take part in double fertilization whereas the tube cell/vegetative degenerates after the growth of pollen tube. **2**

Short Answer Type Questions-II

(3 marks each)

AI **Q. 1. Draw the diagram of microsporangium of an angiosperm and label any four parts. State the function of its innermost wall layer.** R **[CBSE, SQP 2017-18]**

OR

Draw and label the enlarged view of microsporangium of an angiosperm. State the function of its innermost wall layer. R **[CBSE, SQP 2016]**

Ans. Refer to Topic 1/Revision Notes/ Important Diagrams/ Fig 2.2

(Any four of the labels) ½ × 4

Tapetum nourishes the developing pollen grains.

[CBSE Marking Scheme, 2017] 1

Commonly Made Error

- Students often forget to answer the 2nd part of the question.

Q. 2. (i) Draw a labelled diagram of a section of an enlarged view of microsporangium of an angiosperm.

(ii) Name the cells and the event they undergo to produce pollen grains. R **[Outside Delhi, Set-II, Comptt. 2016]**

Ans. **(i)** Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.2 ½ × 4 = **2**

(ii) Microspore mother cell/pollen mother cell, through meiosis. ½ + ½ = **1**

[CBSE Marking Scheme, 2016]

Detailed Answer :

(ii) There are the microspore mother cells (MMC) or pollen mother cells (PMC) in the microsporangium that produce pollen grains. They are diploid (2*n*) cells and undergo meiosis to produce pollen grains. The process is called as microsporogenesis.

Q. 3. (i) Describe in sequence the process of microsporogenesis in angiosperms.

(ii) Draw a labelled diagram of two celled final structure formed. R **[Outside Delhi, Set-I, Comptt. 2015]**

Ans. **(i)** The process of formation of microspores or pollen grains from microspore or pollen mother cell (MMC or PMC) by meiosis is called microsporogenesis. It takes place in pollen sacs or microsporangia of each anther lobe.

The cells of sporogenous tissue of microsporangium functions as potential MMC/PMC in the anther. They undergo meiosis and as a result form four microspores or pollen grains arranged in tetrads. The pollen grains separate from the tetrads and give rise to two celled male gametophytes while still *in situ*. In the majority of angiosperms, the pollen is released from the anther at 2 celled stage while in some at 3-celled stage as the generative cell divides to form 2 male gametes.

(ii) Refer to Revision Notes/ Important Diagrams/ Fig 2.3 **2 + 1**

Q. 4. Why are angiosperm anther called dithecous ? Describe the structure of its microsporangium.

U **[Delhi Set-I, 2014]**

Ans. A typical angiosperm anther is bilobed with each lobe having two pollen sacs. Hence, angiosperm anther are called dithecous. **1**

Structure of Microsporangium : It is circular and is generally surrounded by wall layers namely, an endothecium, 2 or 3 middle layers and a tapetum. **1**

(i) The endothecium performs the function of protection and helps in dehiscence of anther to release the pollen.

(ii) The middle layers and the innermost layer, tapetum nourishes the developing pollen grains. The cells of the tapetum possess dense cytoplasm and more than one nuclei.

(iii) When the anther is young, a group of compactly arranged homogenous cells called sporogenous tissues occupies the centre of each microsporangium which produce microspores or pollen grains. ½ + ½

[CBSE Marking Scheme, 2014]

Q. 5. Draw a diagram of a male gametophyte of an angiosperm. Label any four parts. Why is sporopollenin considered the most resistant material. R **[Outside Delhi Set-II, Comptt. 2015, Delhi Set-I, II, III, 2011]**

Ans. Diagram of male gametophyte : Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.3 **2**

Sporopollenin is considered to be the most resistant organic material because it is chemically very stable and can withstand high temperature, acidic and alkaline conditions and enzymes. **1**

Q. 6. Draw a labelled diagram of the sectional view of a mature pollen grain of angiosperms. Explain the function of any two of its parts.

R **[CBSE SQP 2012]**

OR

Draw a labelled diagram of a mature pollen grain.
[Delhi Set-I, Comptt. 2013]

Ans. Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.3

Exine : It can withstand high temperature/strong acids/alkali. It protects pollens.

Intine : It is a thin and continuous layer made up of cellulose and pectin. The intine produces pollen tube.

Vegetative cell : It is bigger and has abundant food reserve.

Generative cell : It divides mitotically to give rise to two male gametes. **(Any two) 2 + 1 = 3**

Q. 7. (i) Do all pollen grains remain viable for the same length of time ? Support your answer with two suitable examples.

(ii) How are pollen grains stored in pollen banks ? State the purpose of storing pollen grains in banks.

R **[Delhi Set-I, II, III 2017 comptt]**

Ans. (i) No 1

Examples :

(a) Cereals / rice / wheat - pollen grains / loose viability within thirty minutes of their release. ½

(b) In some members of Rosaceae / leguminosae maintain viability for months. ½

(ii) Using cryopreservation techniques / in liquid nitrogen (– 196° C) ½

Maintaining viability / preserving threatened species / preserving commercially important plants / to be used for crop breeding programmes ½

[CBSE Marking Scheme, 2017]

AI **Q. 8. (i) Draw a labelled sketch of a mature 7-celled, 8-nucleate embryo sac.**

(ii) Which one of the cell in an embryo-sac produce endosperm after double fertilization ?

R **[Foreign Set-I, 2016]**

Ans. (i) Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.7 **2½**

(ii) Central cell. ½

[CBSE Marking Scheme, 2016]

Detailed answer :

(ii) After double fertilization the Primary Endosperm Nucleus (PEN) formed as a result of triple fusion (fusion of one male gamete (*n*) with a diploid secondary nucleus (2*n*) or with two haploid polar nuclei) produces endosperm.

AI **Q. 9. The embryo sac in female gametophyte is seven celled and eight nucleated structure. Justify the statement with the help of a labelled diagram.**

R **[CBSE SQP, 2018]**

Ans. The typical female gametophyte or embryo sac has three cells that are grouped together at the micropylar end and constitute the egg apparatus. The egg apparatus, in turn, consists of two synergids and one egg cell. **1**

Three cells are at the chalazal end and are called the antipodals. ½

The large central cell has two polar nuclei. ½

Thus, a typical angiosperm embryo sac, at maturity is 8-nucleate is 7-celled.

For diagram: Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.7 **1**

[CBSE Marking Scheme, 2018]

Q. 10. (i) Name the organic material exine of the pollen grain is made up of. How is this material advantageous to pollen grain

(ii) Still it is observed that it does not form a continuous layer around the pollen grain. Give reason.

(iii) How are 'pollen banks' useful ?

R **[Outside Delhi Set-I, 2016]**

Ans. **(i)** Sporopollenin. ½
Most resistant to high temperature / strong acids / alkali / no enzymes can degrade it. **(Any one)** ½
(ii) (Germs pores) to allow pollen tube to emerge out / pollen germination. **1**
(iii) Helps in storing pollen grains for years / for crop breeding programmes. **1**
[CBSE Marking Scheme, 2016]

Detailed Answer :

(i) Exine is the hard, outer, protective covering of the pollen grain. It is made up of sporopollenin. Sporopollenin is one of the most resistant organic compounds, which can withstand high temperature, strong acids and alkalies. It cannot be degraded by any of the known enzymes. Hence, it acts as a shield and protects the pollen grain from getting damaged.

(ii) Exine does not form a continuous layer around the pollen grain. Hence, sporopollenin is absent over certain specific regions which are called germ pores. Germ pores serve as outlet for the growth and emergence of pollen tube.

(iii) Pollen grains can be stored for years in liquid nitrogen at – 196°C. After this treatment, they are stored in pollen banks. Such conserved pollen grains can be later used in plant breeding programs. **1+1+1**

AI **Q. 11. Explain giving reasons why pollen grains can be best preserved as fossils.**
E & A **[CBSE SQP, 2016]**

Ans. Pollen grains are best preserved as fossils because of the following reasons :

(i) The sporopollenin of exine is highly resistant to the action of strong acids and alkali and can withstand a high temperature.

(ii) It is not easily degraded by any of the enzyme known so far. **1½ + 1½**

Long Answer Type Questions

(5 marks each)

Q. 1. (i) Draw a labelled diagram of the sectional view of microsporangium of an angiosperm.
(ii) Explain the development of male gametophyte in the microsporangium. R **[Delhi Set-III, 2015]**

Ans. **(i)** Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.1 **[Five correct labelling]** **5 × ½ = 2 ½**

(ii) Each cell of sporogenous tissue, functions as microspore mother cells →, meiosis/ microsporogenesis, → microspore tetrad →, 4-pollen grains (male gametophyte) 2-celled stage. **5 × ½ = 2 ½**
[CBSE Marking Scheme, 2015]

Q. 2. Explain the process of microsporogenesis in angiosperms. U **[Delhi Set-I, Comptt. 2013]**
[Outside Delhi I, 2015]

Ans. Process of microsporogenesis:

(i) When the anther develops, each cell of sporogenous tissue functions as microspore mother cell (MMC) or pollen mother cell (PMC) and undergoes meiotic divisions to form microspore tetrads.

(ii) The process of formation of microspores from a pollen mother cell (PMC) through meiosis is called microsporogenesis.

(iii) The microspores get arranged in a cluster of four cells and hence are microspore tetrad.

(iv) As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains.

(v) In each microsporangium, thousands of pollen grains are formed and released with the dehiscence of anther. **1 × 5 = 5**

Q. 3. (a) Draw a diagrammatic sketch of a transverse section of an anther of an angiosperm. Label its different walls and the tissue forming microspore mother cells.
(b) Describe the process of microsporogenesis upto the formation of a microspore.
(c) Write the function of 'germ pore' in a pollen grain of an angiosperm. **[Comptt, Set 1,2,3, 2018]**

Ans. **(a)** For diagram- Refer Revision Notes/ Topic 1 Important Diagrams/ Fig 2.1 **2 ½**
(b) Sporogenous tissue $\xrightarrow{Mitosis}$ / Microspore mother cell $\xrightarrow{Meiosis}$ microspore tetrad **1 ½**
(c) Germ pores allow the germinating / growing pollen tube with contents of the pollen grain / male gametes + vegetative cell to come out of the pollen grains **1**
[CBSE Marking Scheme, 2018]

Detailed Answer:

(b) Refer to LAQ/ Q 2.

(c) Germ pores allow the germination of pollen grain or formation of pollen tubes. It serves as an outlet for the growth and emergence of pollen tube.

AI **Q. 4. (i) Describe the structure of a 3-celled pollen grain of an angiosperm.** U
(ii) Trace its development from sporogeneous tissue in the anther. **[Delhi Set-II, Comptt. 2012]**

OR

Describe in sequence the events that lead to the development of a 3-celled pollen grain from a microspore mother cell in angiosperms.
[Outside Delhi Set-I, 2010]

OR

Describe the development of male gametophyte in angiosperms.

Ans. (i) Structure of 3-celled pollen grain :

(a) Pollen grains are normally spherical in shape.

(b) Each pollen grain has a prominent two-layered wall.

(c) The outer layer is called exine and the inner layer is called intine.

(d) Exine is hard and made up of sporopollenin.

(e) Intine is thin, and it is made up of cellulose and pectin.

(f) At certain places, exine is either absent or very thin and such places are called germ pores.

(g) A mature pollen grain has two cells – a vegetative cell and a generative cell.

(h) The vegetative cell is larger, has abundant reserve food and a large irregular-shaped nucleus.

(i) The generative cell is small and spindle shaped and it floats in the cytoplasm of vegetative cell. It is a cell with in the cell.

(j) The generative cell in some cases divides to form two male gametes, thus making the pollen 3-celled.

(ii) Development of 3 celled pollen grain :

(a) Every cell of the sporogeneous tissue has a potential pollen mother cell (PMC) and can give rise to microspore tetrad or pollen grains.

(b) Each microspore mother cell undergoes meiosis to form a cluster of four haploid cells, called microspore tetrad.

(c) As the anther matures, the microspores dissociate from the tetrad and develop into pollen grains.

(d) The nucleus of the microspore undergoes mitosis to form a large vegetative cell or tube cells and a small spindle-shaped generative cell that floats in the cytoplasm of the vegetative cell.

(e) They develop a two-layered wall, the outer exine made of sporopollenin and the inner intine made of cellulose and pectin.

(f) Usually the pollen grains are liberated at this two-celled stage. In certain species the generative cell divides mitotically to form two male-gametes and the pollen grains are three celled during liberation.

For diagram: Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.3, 2.4, 2.5 **2+3=5**

Answering Tip

- Students should practice the diagram and present it neatly.

Q. 5. Draw a labelled diagram of sectional view of a mature embryo sac of an angiosperm.

R [Delhi Set-I, 2014]

OR

Draw a diagram of a mature embryo sac of an angiosperm and label the following parts in it :

(i) Filiform apparatus

(ii) Synergids

(iii) Central cell

(iv) Egg cell

(v) Polar nuclei

(vi) Antipodals. **[Delhi Set-I, 2013]**

Ans. Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.7 **5**

Q. 6. Describe the structure of microsporangium.

R [Outside Delhi Set-I, 2014], (KVS)

OR

Draw a labelled diagram of an anther lobe at microscopic-mother cell stage. Mention the roles of different wall layers of anther.

[Outside Delhi Set-I, Comptt. 2010]

Ans. Structure of microsporangium of Pollen or Pollen sac :

(i) It is circular and is generally surrounded by wall layers namely, Epidermis, Endothecium, 2 or 3 Middle layers and Tapetum.

(ii) The first two layers perform the function of protection and help in dehiscence of anther to release the pollens.

(iii) The middle layers and the innermost layer, (tapetum) nourishes the developing pollen grains.

(iv) The cells of the tapetum possess dense cytoplasm and more than one nuclei.

(v) When the anther is young, a group of compactly arranged homogenous cells called sporogenous tissues occupies the centre of each microsporangium.

For figure, Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.2

Q. 7. (i) Describe the process of megasporogenesis of angiosperms until the 8-nucleate stage.

(ii) Draw the labelled structure of a mature embryo sac. **R [Outside Delhi Set-I, II, Comptt. 2013]**

OR

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 Set-I, 2012, 2010]

Ans. (i) The process of formation of the megaspore from the megaspore mother cell is called mega-sporogenesis. Ovules generally differentiate a single megaspore mother cell in the micropylar region of the nucellus. This mother cell undergoes meiosis and as a result forms a linear tetrad of 4 megaspores.

Usually one of the four megaspores towards the micropylar end is functional, while the other three degenerate. Only the functional megaspore develops into the female gametophyte (embryo sac).

The nucleus of the functional megaspore divides mitotically to form two nuclei, which move to opposite poles, forming 2-nucleate embryo sac. Two more sequential mitotic nuclear divisions result in the formation of the 4 nuclei and the later 8-nucleate stage of the embryo sac.

(ii) Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.7 **3+2=5**

AI **Q. 8. (i) Describe the development of a 7-celled female gametophyte from a megaspore mother cell in an angiosperm.**

(ii) What is the role of endothecium and tapetum in an anther ?

R **[Delhi Set-III, Comptt. 2012]**

Ans. (i) Development of female gametophyte : The female reproductive part of a flower is gynoecium, which consists of three parts—stigma, style and ovary. The ovules are formed in the ovary and attach to it through placenta. The ovule is surrounded by one to two protective layers called integuments, leaving a small opening at one end termed as a micropyle. The stalk of the ovule is called funiculus. The ovule is composed of multi celled cellular tissue called the nucellus. A hypodermal cell of nucellus at the micropylar end enlarges and becomes a megaspore mother cell that undergoes meiosis to form a linear tetrad of four megaspores. Out of four, only one remains functional and three megaspores degenerate. The functional megaspore undergoes three successive mitotic divisions to form eight nuclei, which arrange themselves into three groups. Three nuclei migrate towards the micro-pylar end and form the egg apparatus. Other three nuclei form antipodal cells at chalazal end. The remaining two nuclei come together as polar nuclei which fuse to form secondary nucleus in the centre of the embryo sac.

(ii) Role of endothecium : Endothecium performs the function of protection and helps in dehiscence of anther to release the pollen.

Role of tapetum : It nourishes the developing pollen grains. **3+2**

TOPIC-2
Pollination and Fertilization

Revision Notes

- The process of transfer of pollen grains from the anther to the stigma of a pistil is known as pollination.
- There are few external agents which help the plants for pollination to take place.
- The Pollination is of three types based on the source of pollens namely,

(a) Autogamy **(b)** Geitonogamy **(c)** Xenogamy

Autogamy

- When the pollen grains are transferred from the anther to the stigma of the same flower, it is known as autogamy.
- In flowers with exposed anthers and stigma, a complete autogamy is rare and hence the anthers and stigma should lie close to each other to enable self-pollination. Alongwith this there should be synchrony in pollen release and stigma receptivity.
- Plants like *Viola* (common pansy), *Oxalis* and *Commelina* produce two types of flowers namely Chasmogamous flowers and Cleistogamous flowers.

(a) Chasmogamous flowers

- They are similar to flowers of other species with exposed anthers and stigma.

(b) Cleistogamous flowers

- They do not open at all.
- Anthers and stigma lie close to each other.
- They are autogamous as there is no chance of cross-pollination.
- When anthers dehisce in the flower buds, pollen grains come in contact with the stigma for pollination.
- Cleistogamous flowers produce assured seed-set even in the absence of pollinators.

Geitonogamy

- When the pollen grains are transferred from the anther to the stigma of another flower of the same plant, it is known as geitonogamy.
- It involves pollination with the help of a pollinating agent. It is structurally cross-pollination but genetically self-pollination.
- It is genetically similar to autogamy because the pollen grains come from the same plant.

Xenogamy

- When the pollen grains are transferred from anther to the stigma of a different plant, it is known as xenogamy. It brings about genetically different types of pollen grains to the stigma.

Agents of pollination :

- There are two type of agents of pollination namely :

(a) Biotic agents **(b)** Abiotic agents

Abiotic Agents

- There are two abiotic agents namely, wind and water which help pollination to takes place.

Pollination by Wind

- The pollination taking place by wind is called anemophily.
- Wind and water pollinated flowers are not very colourful and do not produce nectar.
- Wind pollinated flowers often have a single ovule in each ovary.
- Numerous flowers remain packed into an inflorescence.
- Examples – In Corn cob, the tassels are the stigma and style which wave in the wind to trap pollen grains. Wind pollination is commonly seen in grasses.

Characteristics of Anemophilous flowers

- The flowers produce enormous amount of pollen.
- The pollen grains are light and non-sticky so that they can be transported in wind currents.
- They often possess well-exposed stamens for easy dispersal of pollens into wind currents.
- They have large, feathery and sticky stigma to trap air-borne pollen grains.

Pollination by Water

- The pollination taking place by water is called hydrophily.
- It is limited to about 30 genera, mostly monocotyledons.
- In *Vallisneria*, the female flowers reach the surface of water by the long stalk and the male flowers or pollen grains are released on to the surface of water. These male flowers or pollen grains are carried by water currents and reach the female flowers.
- In sea grasses, the female flowers remain submerged in water and the long, ribbon-like pollen grains are carried inside the water and reach the stigma.
- The pollen grains of most of the water-pollinated species have a mucilaginous covering to protect from wetting.
- Not all aquatic plants use hydrophily. For example, in aquatic plants like water hyacinth, water lily, etc., the flowers emerge above the level of water for entomophily or anemophily *i.e.,* for pollination to takes place by insects or wind.
- It is seen in *Vallisneria* & *Hydrilla* (fresh water), *Zostera* (marine sea-grasses), etc.

Biotic Agents

- Some flowering plants use animals as pollinating agents like Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds and humming birds), bats, some primates (lemurs), arboreal (tree-dwelling) rodents, reptiles (gecko lizard & garden lizard) etc.
- When the pollination takes place by insects, it is known as entomophily.
- Often flowers of animal pollinated plants are specifically adapted for a particular species of animal.
- When the animal comes in contact with the anthers body gets a coating of pollen grains and when it comes in contact with the stigma, it results in pollination.
- Some plants provide safe places as floral reward to lay eggs as seen in *Amorphophallus*, the tallest flower.
- There is a very close obligatory symbiotic relationship between the species of moth (*Pronuba*) and the plant *Yucca*. They cannot complete their life cycles without each other. The moth deposits its eggs in the locule of the ovary and the flower gets pollinated by the moth. The larvae of the moth come out of the eggs as the seeds start developing.
- There are many insects which consume pollen or nectar without bringing about pollination. They are called pollen/nectar robbers.

Characteristics of Entomophilous Flowers

- Flowers are large, colourful, fragrant and rich in nectar.
- When the flowers are small, they form inflorescence to make them visible.
- The flowers pollinated by flies and beetles secrete foul odours to attract these animals.
- The pollen grains are generally sticky.

Outbreeding Devices (Devices for promoting Cross Pollination)

- In order to avoid self-pollination, cross-pollination is encouraged in plants as follows :

(a) Avoiding Synchronization

- In some species, pollen release and stigma receptivity are not synchronized.
- Either the pollen is released before the stigma becomes receptive or stigma becomes receptive before the release of pollen *i.e.*, the anther and stigma mature at different times. This phenomenon is called dichogamy. It prevents autogamy.

(b) Arrangement of Anther and Stigma at different Positions

- In some species, the arrangement of anther and stigma at different positions prevents autogamy.

(c) Self-incompatibility

- It is a genetic mechanism which prevents pollen of one flower to germinate on the stigma of the same flower on of the same plant due to the presence of similar sterile genes in pollen and stigma.

(d) Production of Unisexual Flowers (Dicliny)

- Monoecious plants such as castor and maize, where the male and the female flowers are present on the same plant prevents autogamy but not geitonogamy. On the other hand, dioecious plants like papaya, where the male and female flowers are present on different plants prevents both autogamy and geitonogamy.

Pollen-pistil Interaction

- It is a dynamic process involving pollen recognition followed by promotion or inhibition of the pollen.
- This interaction takes place through the chemical components produced by them.
- If the pollen is compatible, then the pistil accepts it and promotes post-pollination events.
- The pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores.
- The contents of the pollen grain move into the pollen tube.
- The pollen tube grows through the tissues of the stigma and style and reaches the ovary.
- If the pollen is incompatible, then the pistil rejects the pollen by preventing pollen germination on the stigma or the pollen tube growth in the style.
- In some plants, the pollen grains are shed at two-celled stage, the generative cell divides and forms the two male gametes during the growth of pollen tube on the stigma.
- In plants which shed pollen in the three-celled stage, the pollen tubes carries two male gametes from the beginning.
- The pollen tube, after reaching the ovary, enters the ovule through the micropyle chalaza/integuments and then enters one of the synergids through the filiform apparatus.
- The filiform apparatus present at the micropylar part of the synergids guides the entry of pollen tube.
- A plant breeder can manipulate pollen-pistil interaction, even in incompatible pollinations, to get desired hybrids.

Artificial Hybridisation

- It is one of the major approaches of crop improvement programme by using desired pollen grains for pollination.
- This is achieved by emasculation and bagging techniques.
- Emasculation is the removal of anthers by using forceps from the bisexual flower bud of female parent before the anther dehisces.
- The emasculated flowers are then covered with a suitable bag made up of butter paper to prevent contamination of its stigma with unwanted pollen. This is called bagging.
- When the stigma attains receptivity, the mature pollen grains collected from anthers of the male parent are dusted on the stigma. Then the flowers are rebagged and allowed to develop the fruits.
- If the female parent produces unisexual flowers, there is no need for emasculation.
- The female flower buds are bagged before the flowers open.
- When the stigma becomes receptive, pollination is carried out using the desired pollen and the flower rebagged.

Double Fertilisation

- The pollen tube after entering one of the synergids releases its contents including the two male gametes into the cytoplasm of the synergid.
- One of the male gametes moves towards the egg cell and fuses with its nucleus by the process of syngamy to form a diploid cell called zygote.
- The other male gamete moves towards the two polar nuclei located in the central cell and fuses with them to produce a triploid primary endosperm nucleus (PEN).
- As this involves the fusion of three haploid nuclei, it is called triple fusion.
- Since two types of fusions viz. syngamy and triple fusion take place in an embryo sac, it is called double fertilisation.
- The central cell after triple fusion becomes the primary endosperm cell (PEC) and develops into the endosperm while the zygote develops into an embryo.
- It is an event unique in flowering plants.

IMPORTANT DIAGRAMS:

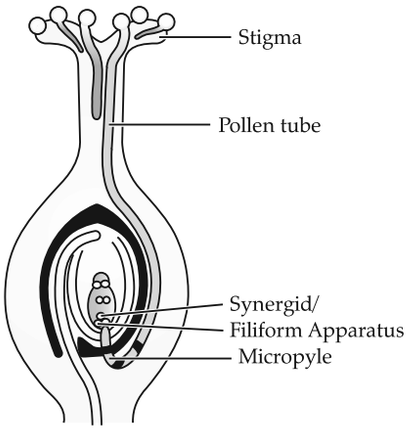


Fig. 2.8: Longitudinal section of a flower showing growth of pollen tube

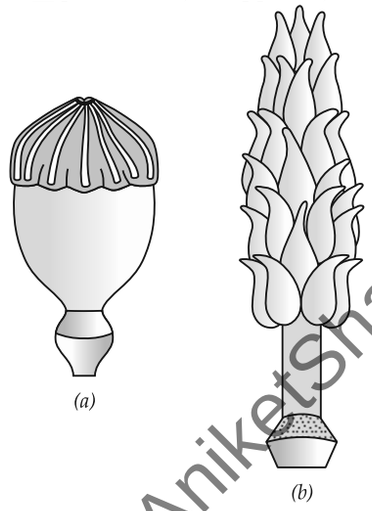
Very Short Answer Type Questions (1 mark each)

Q. 1. Explain the process of pollination in *Vallisneria*.
R **[Delhi Set-I, II, III Comptt. 2016]**

Ans. The female flower reaches the surface of water by long stalk, male flower releases the pollen grains on surface of water, pollen grains are carried by water currents, some of them reach the stigma and achieve pollination. **1**
[CBSE Marking Scheme, 2016]

Answering Tip
- Discuss, with examples, the characteristics of different types of pollination and reasons for their adaptation.

Q. 2. These pictures show the gynoecium of
(i) *Papaver* and (ii) *Michellia* flowers. Write the difference in the structure of their ovaries.
U **[Delhi Set-I, 2015] [Delhi, Comptt. 2015]**



Ans. **(i)** Multicarpellary ovary showing fused syncarpous pistil.
(ii) Multicarpellary ovary showing free apocarpous pistil.
[CBSE Marking Scheme, 2015] ½ + ½

Q. 3. What is pollen–pistil interaction and how is it mediated ? R **[Delhi Set-I, 2014]**

Ans. It is a dynamic process involving pollen recognition followed by promotion or inhibition of the pollen.
The interaction takes place through the chemical components produced by them. **1**
[CBSE Marking Scheme, 2014]

Answering Tip
- Concept of pollen–pistil interaction should be known by the students.

Q. 4. Why do cleistogamous flowers assure seed sets ? U **[Outside Delhi Set-I, II, Comptt. 2013]**

Ans. Cleistogamous flowers are invariably autogamous as there is no chance of cross pollination. **1**

Q. 5. If the stamens are well exposed, usually which mode of pollination the plant is expected to follow ? A **[CBSE SQP 2013]**

Ans. If the stamens are well exposed, the plant is expected to follow wind pollination. **1**
[CBSE Marking Scheme, 2013]

AI **Q. 6. How do the pollen grains of *Vallisneria* protect themselves ?** R **[Delhi Set-II, 2012]**
OR
Why do the pollen grains of *Vallisneria* have mucilage covering ? [Delhi Comptt., 2010]

Ans. The pollen grains of most of the water pollinated species have a mucilaginous covering to protect from wetting. **[CBSE Marking Scheme, 2012] 1**

AI **Q. 7. Write one advantage and one disadvantage of cleistogamy to flowering plants.**
K **[CBSE, Comptt, Set 1,2,3, 2018]**

Ans. **Advantage** - Assured seed set / maintain purelines ½
Disadvantage - No variation / only parental characters are preserved / it can lead to inbreeding depression ½
(Any one) [CBSE Marking Scheme, 2018]

Q. 8. How many pollen grains and ovules are likely to be formed in the anther and ovary of an angiosperm bearing 25 microspore mother cells and 25 megaspore mother cells respectively.
E & A **[CBSE Foreign, 2013]**

Ans. 100 pollen grains, 25 ovules. **1**

Q. 9. A bilobed anther has 100 microspore mother cells per microsporangium. How many male gametophytes can this anther produce. A **[Delhi 2010]**

Ans. 1600. **1**
Detailed Answer:
Each bilobed, dithecous anther has 4 microsporangia. Number of pollen mother cell (PMC) in one microsporangia is 100.
Therefore total number of PMC in 4 microsporangia would be 400.
Each PMC produces 4 male gametophyte (pollen grain), thus total number would be 4 × 400 = 1600 male gametophytes.

Short Answer Type Questions-I (2 marks each)

Q. 1. Gynoecium of a flower may be apocarpous or syncarpous. Explain with the help of an example each. R **[Outside Delhi Set-II, 2016]**

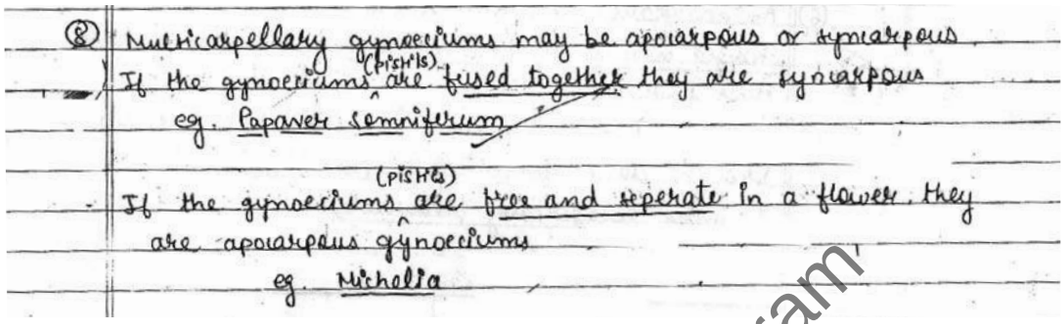
Ans. Carpels are free (apocarpous), *e.g.* : *Michelia*.
½ × 2 = 1

Carpels are fused (syncarpous), *e.g.* : *Papaver*.
(Any other suitable correct *e.g.*)
½ × 2 = 1
[CBSE Marking Scheme, 2016]

Detailed Answer :

Gynoecium represents the female reproductive part of the flower. If a gynoecium has multiple, distinct (free, unfused) carpels, it is apocarpous. The example includes strawberry, buttercup etc. If a gynoecium has multiple carpels fused into a single structure, it is syncarpous. The example includes Tulip and most flowers. **1+1=2**

Ans.



[Topper's Answer 2016]

Commonly Made Error

- Students often get confused between terms- syncarpous and apocarpous.

Answering Tip

- Carefully understand the terms with suitable example.

Q. 2. Write the differences between wind–pollinated and insect–pollinated flowers. Give an example of each type. U **[Delhi Set-II, 2014]**

Ans.

S.No.	Wind pollinated flowers	Insect pollinated flowers
(i)	Pollen grains are light and non-sticky so that they can be transported in wind currents.	The flowers are large, colourful, fragrant and rich in nectar. Pollens are generally sticky, so that they can stick on the insects body.
(ii)	They possess well-exposed stamens so that the pollen grains are easily dispersed into wind currents and large feathery stigma to easily trap air-borne pollen grains. Wind pollinated flowers often have a single ovule in each ovary and numerous flowers packed into an inflorescence. Example: Grasses	A number of flowers are clustered into an inflorescence. The flowers pollinated by flies and beetles secrete foul odours to attract these animals. Examples: Orchids

[CBSE Marking Scheme, 2014] 2

Commonly Made Error

- Students often get confused between insect and wind pollination. Some of them while explaining wind pollinated flowers, write that the stamen should be light and winged (instead of pollen grain).

Answering Tip

- Understand the differences between the two- insect and wind pollinated flowers carefully with the help of examples.

AI **Q. 3. State the similarity and differences between geitonogamy and xenogamy.?**
U **[Outside Delhi Set-I, II, Comptt. 2013]**
OR
Differentiate between geitonogamy and xenogamy in plants. Which one between the two will lead to inbreeding depression and why ? [Delhi Set-I, II, III, 2010], (KVS)

Ans.

S. No.	Geitonogamy	Xenogamy
(i)	Transfer of pollen grains from the anther to stigma of another flower of the same plant.	Transfer of pollen grains from anther to the stigma of a different plants.
(ii)	It does not cause genetic variation.	It causes genetic variations.

Geitonogamy will lead to inbreeding depression because genetically it is similar to autogamy. **2**

Q. 4. Geitonogamous flowering plants are genetically autogamous but functionally cross-pollinated. Justify. U **[Delhi Set-I, 2013]**

Ans. Geiotonogamy is cross-pollination involving a pollinating agent, it is genetically similar to autogamy since the pollen grains come from the same plant. **2**

AI Q. 5. State one advantage and one disadvantage of cleistogamy. U [Outside Delhi Set-I, 2012]

[Delhi Set-III, 2013]

Ans. Refer VSAQ/ Q. 7. **1 + 1**

Q. 6. (i) How does cleistogamy ensure autogamy ?

(ii) State one advantage and one disadvantage of cleistogamy to the plant. U [Delhi Set-II, 2013]

Ans. **(i)** The cleistogamous flowers remain closed and never open. They are bisexual. Therefore, this condition of flowers *i.e.*, cleistogamy ensures autogamy *i.e.*, they ensure the transfer of pollen from the anther to the stigma of the same and single bisexual flower *e.g., Commelina* and *Viola*.

(ii) The main advantage of cleistogamy is guaranteed or assured pollination and therefore, fertilization and seed setting.

The main disadvantage of cleistogamy is that variants cannot be produced due to autogamy. It results in poor crop yield and poor resistance to environmental stresses. **1 +1 = 2**

AI Q. 7. Comment upon the mode of pollination in *Vallisneria* and *Eichhornia* which have emergent flowers. E & A [CBSE SQP, 2018]

Ans. In *Eichhornia* the flowers emerge above the level of water and are pollinated by insects or wind. **1**

In *Vallisneria*, the female flower reaches the surface of water by the long stalk and the male flowers or pollen grains are released on to the surface of water. They are carried passively by water currents and some of them eventually reach the female flowers and the stigma. **1**

[CBSE Marking Scheme, 2018]

Q. 8. How does the study of different parts of a flower help in identifying wind as its pollinating agent ? U [Delhi Set-III, 2012]

Ans. Wind pollinating flowers has the following characteristics :

(i) Pollen grains are light and non sticky.

(ii) The flowers often possess well-exposed stamen and large feathery stigma.

(iii) Wind-pollinated flowers have a single ovule in each ovary.

(iv) These flowers have small calyx and corolla.

½ × 4

Commonly Made Error

- Students get confused and write adaptations of insect pollination.

Q. 9. In angiosperms the zygote is diploid while primary endosperm nucleus is triploid. Explain.

U [Outside Delhi Set-I, 2013], (KVS)

Ans. In angiosperms, the zygote is diploid (2n). It is formed by the fusion of haploid (n) egg and a haploid male gamete. This diploid zygote gives rise to diploid embryo.

Male gamete + egg $\xrightarrow{\text{syngamy}}$ Zygote → Embryo

(n) (n) (2n) (2n)

The primary endosperm nucleus is triploid (3n) because it is formed by the fusion of diploid (2n) secondary nucleus and a haploid (n) male gamete.

Male gamete + Secondary nucleus →

(n) (2n)

Primary endosperm nucleus → endosperm **2**

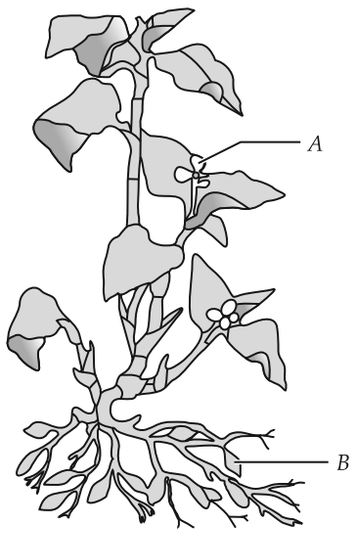
(3n) (3n)

Q. 10. Why is fertilization in angiosperms referred to as double fertilization ? Explain.

U [Outside Delhi Set-I, III, Comptt. 2013, 2012]

Ans. Fertilization in angiosperms is referred as double fertilization, because two male gametes of a single male gametophyte fuse differently with two different cells/nuclei of the same embryo sac to produce two different structures. One male gamete fuses with the egg to form diploid zygote which gives rise to diploid embryo and another male gamete fuses with two haploid polar nuclei or diploid secondary nucleus to form triploid primary endosperm nucleus (3n) which gives rise to triploid endosperm. Hence, the phenomenon of two fusions (syngamy and triple fusion occur) in an embryo sac is known as double fertilization. 2

Q. 11. Identify the type of flower shown in A and B. Which out of the two will produce an assured seed set ? R [CBSE, SQP 2012]



Ans. The flower A is chasmogamous flower having exposed anthers and stigma whereas B is cleistogamous flower which do not open at all.

Cleistogamous flowers produce an assured seed set. **1 + 1**

Short Answer Type Questions-II (3 marks each)

Q. 1. Flowering plants have developed many devices to discourage self-pollination and to encourage cross-pollination. Explain three such devices.
A **[Delhi Set-I, II & III Comptt., 2016]**

Ans. **(i)** Pollen release and stigma receptivity are not synchronized. Either the pollen is released before the stigma becomes receptive or stigma becomes receptive much before the release of pollen.
(ii) Anther and stigma are placed at different positions in such a way that pollen cannot come in contact of stigma of the same flower.
(iii) Self incompatibility which inhibits the pollen germination/pollen tube growth in the pistil of same flower or another flower of same plant.
(iv) Production of unisexual flowers. This condition prevents both autogamy and geitonogamy. **(Any three) 1 × 3 = 3**
[CBSE Marking Scheme, 2016]

Q. 2. Make a list of any three out breeding devices that flowering plants have developed and explain how they help to encourage cross-pollination.
R **[Outside Delhi Set-I, 2014]**

Ans. Outbreeding devices that help to encourage cross pollination are as follows:
(i) Avoiding synchronization :
In some species, pollen release and stigma receptivity are not synchronized.
Either the pollen is released before the stigma becomes receptive or stigma becomes receptive before the release of pollen. It prevents autogamy.
(ii) Arrangement of anther and stigma at different positions :
In some species, the arrangement of anther and stigma at different positions prevents autogamy.
(iii) Self-incompatibility :
It is a genetic mechanism which prevent pollen of one flower to germinate on the stigma of same flower.
(iv) Production of unisexual flowers :
In monoecious plants such as castor & maize, the male and the female flowers are present on the same plant prevents autogamy but not geitonogamy. On the other hand, in dioecious plants like papaya, the male and female flowers are present on different plants prevents both autogamy and geitonogamy.
(Any three)
[CBSE Marking Scheme, 2014] 1+1+1

AI **Q. 3. Explain the steps that ensures cross-pollination in an autogamous flower.** R **[Delhi Set-II, 2013]**

Ans. **(i)** Pollen release and stigma receptivity are not synchronized, *i.e.,* either the anther matures earlier or stigma.
(ii) The anther and the stigma are placed at different positions so that pollens cannot come in contact with the stigma of the same flower.
(iii) Certain plants produce unisexual flowers, *i.e.,* male and female flowers are present on different plants. **1×3=3**

Q. 4. Write the mode of pollination in *Vallisneria* and water lily. Explain the mechanism of pollination in *Vallisneria.* R **[Delhi Set-III, Comptt. 2013]**

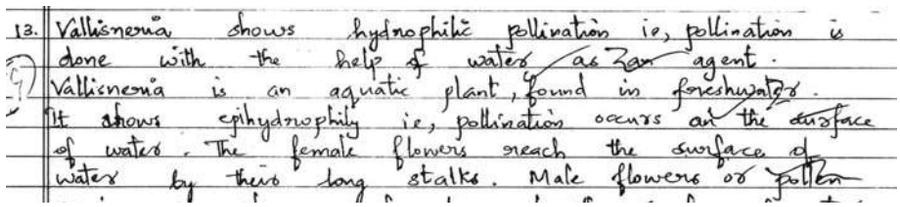
Ans. Mode of Pollination—Water (hydrophily)
Pollination in *Vallisneria* :
The plant is dioecious. On maturity, the male flowers get detached from the parent plant and float up and come to the surface of water. At the same time, the female flowers also rises up to the surface of water by straightening of the coiled stalk. The detached male flowers cluster around the floating female flower and dehisce, thereby performing pollination. The long stalks of the female flower begin to coil down to the bud level where the fruit ripens. **1 + 2**

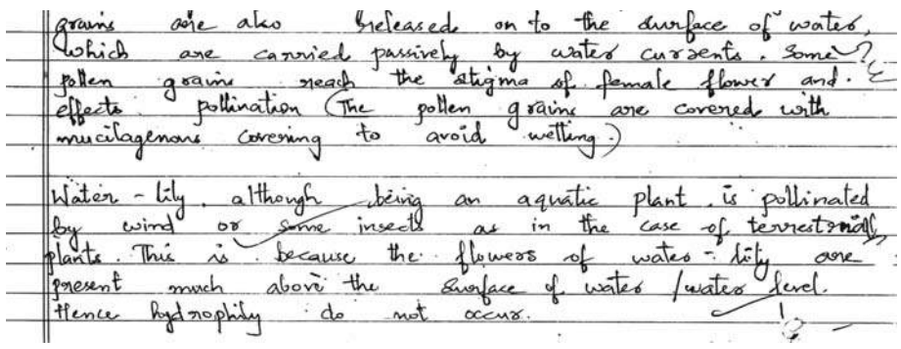
Q. 5. Explain the process of pollination in *Vallisneria.* How is it different in water-lily, which is also an aquatic plant ? U **[Outside Delhi Set-II 2017]**

Ans. In *Vallisneria,* pollination takes place through water, the female flower reach the surface of water by long stalk, male flowers / pollen grain released on to the surface of water, carried passively by water current reaching the female flowers / stigma **½ × 4=2**
In Water lily, pollination takes place through wind or insect, female flower emerges above the surface of water and gets pollinated
[CBSE Marking Scheme, 2017] ½ × 2 =1

OR

Ans.


13. Vallisneria shows hydrophilic pollination ie, pollination is done with the help of water as an agent.
Vallisneria is an aquatic plant, found in freshwater.
It shows epihydrophily ie, pollination occurs at the surface of water. The female flowers reach the surface of water by their long stalks. Male flowers or pollen


grains are also released on to the surface of water, which are carried passively by water currents. Some pollen grains reach the stigma of female flower and effects pollination (The pollen grains are covered with mucilagenous covering to avoid wetting)

Water - lily, although being an aquatic plant, is pollinated by wind or some insects as in the case of terrestrial plants. This is because the flowers of water - lily are present much above the surface of water / water level. Hence hydrophily do not occur.

[Topper's Answer 2017]

Answering Tip

- Discuss, with examples, the characteristics of different types of pollination and reasons for their adaptation.

Q. 6. (i) What are the benefits of choosing a dioecious plant species for plant breeding experiments ?

(ii) How would you proceed to cross-pollinate a monoecious flower ? R **[Foreign, Set- I 2017]**

Ans. **(i)** (Unisexual) self pollination avoided, emasculation not required ½ + ½ = **1**

(ii) (a) Emasculation

(b) Bagging

(c) Pollination by spraying desired pollen

(d) Rebagging ½ × 4 = **2**

[CBSE Marking Scheme, 2017]

Q. 7. Enumerate any six adaptive floral characteristics of a wind - pollinated flower.

R **[Outside Delhi Set-I, II, III, 2011]**

Ans. **(i)** Large production of pollen grains.

(ii) Anther is well exposed.

(iii) Flowers are not attractive and scent emitting.

(iv) Feathery and sticky stigma.

(v) The pollen grains are light and non-sticky so that they can be transported in wind currents.

(vi) Flowers do not possess nectar.

[CBSE Marking Scheme, 2011] ½ × 6 = **3**

Answering Tip

- Pollination by air, water and insects should be learned separately.

Q. 8. Explain three outbreeding devices.

R **[CBSE, SQP 2015]**

Ans. **(i)** Pollen release and stigma receptivity is not synchronised.

(ii) Anther and stigma are placed at different position.

(iii) Self incompatibility.

(iv) Production of unisexual flowers. **(Any three)**

[CBSE Marking Scheme, 2015] 1+1+1

Q. 9. Explain the process of emasculation and bagging of flowers. State their importance in breeding experiments.

U **[Outside Delhi Set-I, Comptt. 2012]**

Ans. **Emasculation:** If the female parent bears bisexual flowers, removal of anthers from the flower's bud before the anther dehiscence, using a pair of forceps is referred to as emasculation.

Bagging: Emasculated flowers have to be covered with a bag of suitable size, generally made up of butter paper, to prevent contamination of its stigma with unwanted pollen. This process is called bagging.

Importance: When the stigma of bagged flower attains receptivity, mature pollen grains collected from anthers of the male parents are dusted on the stigma, the flowers are rebagged and the fruits are allowed to develop.

If the female parent produces unisexual female flowers, there is no need of emasculation. The female flower buds are bagged before the flowers open. When the stigma becomes receptive, pollination is carried out using the desired pollen and the flower is rebagged. **2 + 1**

Answering Tip

- Emphasise the importance of key words by analysing them. For example, split the word *emasculation* into 'e + masculine' to stress that it involves removal of male part. Since it is an important step in plant hybridization, therefore, discuss it in the proper context and not in isolation merely as a definition. Discuss emasculation, and bagging while teaching artificial hybridisation.

Q. 10. How is it possible in *Oxalis* and *Viola* to produce assured seed-sets even in the absence of its pollinators ? E & A **[Foreign, 2012]**

Ans. *Oxalis* and *Viola* bear cleistogamous flowers which never open. They have bisexual flowers with anther and stigma lying very close to each other. When anthers dehisce in the closed flowers the pollen grains fall down on stigma, thus effecting pollination followed by fertilization which leads to assured seed set. **3**

Q. 11. What does an interaction between pollen grains and its compatible stigma result in after pollination ? List two steps in sequence that follow after the process. E & A **[Delhi Set-I, II, III, Comptt. 2016]**

Ans. There is continuous interaction between pollen grain and pistil which is mediated by the chemical components of pollen.

Two steps :

Pollen grain germinates on the stigma to produce pollen tube and the contents of the generative cell move into the pollen tube. Pollen tube grows through the tissue of stigma and style by secreting enzyme. 1 + 1 = 2

AI **Q. 12. If a chromosome number of a plant species is 16, what would be the chromosome number and ploidy of the (a) microspore mother cell and the (b) endosperm cells ?** U **[CBSE, SQP 2010]**

Ans. **(a)** Microspore mother cell → 16, which is a diploid (2n) number.

(b) Endosperm → 24—Because it is a triploid (3n) structure, formed as a result of triple fusion i.e, the fusion of one male gamete with two haploid (n) polar nuclei or with a diploid secondary nucleus. **1½ + 1½**

Long Answer Type Questions **(5 marks each)**

Q. 1. (i) As a senior biology student you have been asked to demonstrate to the students of secondary level in your school, the procedure(s) that shall ensure cross-pollination in a hermaphrodite flower. List the different steps that you would suggest and provide reasons for each one of them.

(ii) Draw a diagram of a section of a megasporangium of an angiosperm and label funiculus, micropyle, embryo sac and nucellus.

C **[Outside Delhi Set-I, 2016]**

Ans. **(i)** Emasculation, removal of anthers from the flower bud before the anther dehisce to avoid self pollination. **½ + ½ = 1**

Bagging, to prevent contamination of its stigma with unwanted pollen grains. **½ + ½ = 1**

Rebagging, the stigma of the mature ovary are dusted with desired pollen grains and rebagged to allow the fruit to develop.

(ii) Refer to Topic 1/ Revision Notes/ Important Diagrams/ Fig 2.6 **2**

[CBSE Marking Scheme, 2016]

Detailed Answer :

(i) Cross pollination of a hermaphrodite flower can be achieved by :

(a) Emasculation : It is the process of removal of anthers (using forceps) from the bisexual flower bud without affecting the female reproductive part, *i.e.*, pistil.

(b) Bagging : The emasculated flower is then covered with a suitable bag so as to prevent contamination of the stigma with unwanted pollen grains.

When the stigma of the bagged flower becomes receptive, the pollen grains collected from the other flower are dusted onto the stigma and then the flower is re-bagged and allowed to develop the fruits. **3**

(ii) Refer to Revision Notes/ Topic 1- Important Diagrams/ Fig 2.6 **2**

AI **Q. 2. (i) Explain the post-pollination events leading to seed production in angiosperms.**

(ii) List the different types of pollination depending upon the source of pollen grain.

R **[Delhi Set-I, 2016]**

Ans. **(i)** Pollen pistil interaction, germination of pollen tube that carries two male gametes, double fertilization/syngamy and triple fusion, development of endosperm, development of embryo, maturation of ovule into seed. **½ × 6 = 3**

(ii) Autogamy / self pollination / Geitonogamy **1**
Xenogamy / cross pollination. **1**

[CBSE Marking Scheme, 2016]

Detailed Answer :

(i) Post-pollination changes leading to seed production are :

(a) Germination of pollen tube which will ultimately transfer two male gametes to the embryo sac.

(b) Double fertilization : In this, one male gamete will fuse with the egg forming zygote (syngamy).

Male gamete (*n*) + Egg (*n*) → Zygote (2*n*)

Other male gamete will fuse with central cell (2 polar nuclei) forming triploid Primary Endosperm Nucleus (PEN).

Male gamete (*n*) + Central cell (2*n*) → PEN (3 n) (Triple fusion)

(c) Zygote will develop into an embryo while PEN gives rise to endosperm.

(d) Integuments get hard and form the seed coat.

(e) Ovule is thus converted into a seed.

(f) Seeds are the fertilised ovules that are developed inside a fruit.

(ii) Depending on the source of pollen grains, pollination are of following types :

(a) Autogamy : Where pollen of a flower reaches the stigma of the same flower.

(b) Geitonogamy : Pollen grain of one flower reaches the stigma of another flower of same plant.

(c) Cross pollination or Xenogamy : When pollen grain of a flower from one plant pollinates the stigma of a flower on another plant. **3+2=5**

Q. 3. (i) State one difference and one similarity between geitonogamy and xenogamy.

(ii) Explain any three devices developed in flowering plants to discourage self pollination and encourage cross pollination.

A **[Outside Delhi Set–I, II, III Comptt. 2017]**

Ans. **(i) Difference :** In geitonogamy, pollen grains from one flower are transferred to the stigma of another flower on the same plant whereas in xenogamy the pollen grains are transferred to the stigma of a flower on another plant (of the same species) which is genetically different.

Similarity : In both types of pollination, pollen grains from the anther are transferred to the stigma of another flower of the same species **2**

(ii) (a) Pollen release & stigma receptivity not synchronised / hence the maturity of stigma and pollen are different / Protandry / Protogyny

(b) Anther and Stigma are placed at different positions so that pollen cannot come in contact with stigma of the same flower.

(c) Self incompatibility / Self sterility.

(d) Production of unisexual flowers

(Any three) 1 × 3

[CBSE Marking Scheme, 2017]

AI **Q. 4. (i) Geitonogamy and xenogamy, both require pollinating agents, yet they are very different from each other. Explain how.**

(ii) Describe the characteristics of flowers that are pollinated by wind. A **[Foreign Set-III 2017]**

Ans. **(i)** Geitonogamy is transfer of pollen grains from the anther to stigma / pollination of another flower of same plant // self-pollination and genetically same pollen to the stigma. 1

Xenogamy is transfer of pollen grain from anther of one flower to stigma of another flower of another plant of the same species / pollination of a flower of a different plant // cross pollination and genetically different type of pollens to the stigma. 1

(ii) (a) Pollen grains are light, non-sticky

(b) Well exposed stamens

(c) Large and feathery stigma

(d) Flowers often have a single ovule in each ovary / inflorescence **(Any three)**

[CBSE Marking Scheme, 2017] 5

Q. 5. A flower of tomato plant following the process of sexual reproduction produces 240 viable seeds. Answer the following questions giving reasons :

(i) What is the minimum number of pollen grains that must have been involved in the pollination of its pistil ?

(ii) What would have been the minimum number of ovules present in the ovary ?

(iii) How many megaspore mother cells were involved ?

(iv) What is the minimum number of microspore mother cells involved in the above case ?

(v) How many male gametes were involved in this case ? A **[CBSE SQP 2016]**

Ans. **(i)** 240, one pollen grain participates in fertilization of one ovule. ½ + ½

(ii) 240, one ovule after fertilization forms one seed. ½ + ½

(iii) 240, each MMC forms four megaspores out of which only one remain functional. ½ + ½

(iv) Atleast 60, as each microspore mother cell meiotically divides to form four pollen grains (240/4 = 60). ½ + ½

(v) 480, each pollen grain carries two male gametes (which participate in double fertilization) (240 × 2 = 480). ½ + ½

[CBSE Marking Scheme, 2016]

Q. 6. Explain the events upto fertilization that occur in a flower after the pollen grain has landed on its compatible stigma. U **[Foreign Set. I, 2016]**

Ans. The pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores, the content of the pollen grain moves into the pollen tube, pollen tube grows through the tissues of the stigma and style and reaches the ovary, the generative cell divides and forms two male gametes during the growth of pollen tube (in the stigma), the pollen tube enters the ovule through micropyle and then enters one of the synergids (through filiform apparatus), the pollen tube releases two male gametes (in the cytoplasm of synergids), one of the male gamete fuses with egg cell to form zygote (2n) (syngamy), the other male gamete fuses with two polar nuclei (in central cell) to form primary endosperm nucleus (PEN-3n)/PEC.

[CBSE Marking Scheme, 2016] ½ × 10 = 5

Detailed Answer :

(i) When the pollen grain falls on the stigma, they germinate and give rise to the pollen tube that passes through the style and enter into the ovule.

(ii) After this, the pollen tube enters one of the synergids and releases two male gametes.

(iii) Out of the two male gametes, one gamete fuses with the nucleus of the egg cell and forms the zygote. The process is known as syngamy.

(iv) The other male gamete fuses with the two polar nuclei located in the central cell to form a triploid primary endosperm nucleus (PEN). Since, the process involves the fusion of three haploid nuclei, it is known as triple fusion.

(v) Thus, triple fusion is the fusion of male gamete with two polar nuclei inside the embryo sac of the angiosperm.

(vi) Since two types of fusions (syngamy and triple fusion) take place in an embryo sac it is known as double fertilisation.

(vii) Double fertilisation is unique to flowering plants.

(viii) After triple fusion, the central cell becomes the primary endosperm cell (PEC).

(ix) Primary endosperm nucleus develops into the endosperm while the zygote develops into an embryo.

Male gamete + Egg $\xrightarrow{\text{Syngamy}}$ Zygote → Embryo
(n) (n) ($2n$) ($2n$)

Male gamete + Secondary nucleus $\xrightarrow{\text{Triple fusion}}$ Primary endosperm nucleus → Endosperm
(n) ($2n$) ($3n$)
($3n$)

Q. 7. (i) Draw a labelled schematic diagram of the transverse section of a mature anther of an angiosperm plant.

(ii) Describe characteristic features of an insect pollinated flower. U **[Delhi Set-II, 2013]**

Ans. **(i)** For figure- Refer Topic I/Revision Notes/ Important Diagrams/ Fig 2.1

(ii) Characteristic features of insect pollinated flowers :

(a) The flowers are brightly coloured, showy, large and if small they becomes conspicuous by grouping as in capitulum and umbel etc.

(b) The flowers are sweetly scented so as to attract the insects for pollination.

(c) The flowers have nectar secreting glands which secrete abundant nectar which attract the pollinating insects.

(d) Flowers may have edible pollen *e.g.*, *rosa* and *clematis*.

(e) The flowers have stamens and stigma inserted.

(f) Flowers possesses pollen kit as an yellowish sticky substance. **5**

Q. 8. (i) Differentiate between : autogamy, geitonogamy, and xenogamy.

(ii) Explain the events that occur during pollen-pistil interaction. U **[Delhi Set-II, Comptt. 2013; Delhi Set-I, II, III, 2011]**

Ans. **(i)** **(a) Autogamy :** Pollination is achieved within the same flower. Transfer of pollen grains from the anther to stigma of the same flower. Autogamy in flowers requires synchrony in pollen release and stigma receptivity.

(b) Geitonogamy : Transfer of pollen grains from the anther of one flower to the stigma of another flower on the same plant. Although geitonogamy is functionally cross-pollination involving pollinating agents but genetically, it is similar to autogamy since the pollen grains come from the same plant.

(c) Xenogamy : Transfer of pollen grains from anther to the stigma of a different plant *i.e.*, cross pollination. This is the pollination that bring genetically different types of pollen grains to the stigma.

(ii) Pollen-pistil Interaction :

(a) It is a dynamic process involving pollen recognition followed by promotion and inhibition of the pollen.

(b) This interaction takes place through the chemical components produced by them.

(c) If the pollen is compatible, then the pistil accepts it and promotes post-pollination events.

(d) The pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores.

(e) The contents of the pollen grain move into the pollen tube.

(f) The pollen tube grows through the tissues of the stigma and style and reaches the ovary.

(g) If the pollen is incompatible, then the pistil rejects the pollen by preventing pollen germination on the stigma or the pollen tube growth in the style.

(h) In some plants, the pollen grains are shed at two-celled stage, the generative cell divides and forms the two male gametes during the growth of pollen tube on the stigma.

(i) The plants which shed pollen in the three-celled stage, the pollen tube carries two male gametes from the beginning.

(j) The pollen tube, after reaching the ovary, enters the ovule through the micropyle, chalaza/integument and then enters one of the synergids through the filiform apparatus.

(k) The filiform apparatus present at the micropylar part of the synergids guides the entry of pollen tube.

(l) A plant breeder can manipulate pollen-pistil interaction, even in incompatible pollinations, to get desired hybrids. **1 × 3 + 2 = 5**

Answering Tip

- Students should calculate the difference between autogamy, geitonogamy, and xenogamy.

Q. 9. (i) Can a plant flowering in Mumbai be pollinated by pollen grains of the same species growing in New Delhi ? Provide explanations to your answer.

(ii) Draw the diagram of a pistil where pollination has successfully occurred. Label the parts involved in reaching the male gametes to its desired destination. R **[Outside Delhi Set-I 2017]**

Ans. **(i)** Yes, By artificial means (any relevant explanation) ½ + ½

(ii) Diagram with following labellings

Stigma, Pollen tube, Synergid / Filiform Apparatus, Micropyle ½ × 4

Refer to Topic 2/ Revision Notes/ Important Diagrams/ Fig 2.8

[CBSE Marking Scheme 2017] 2

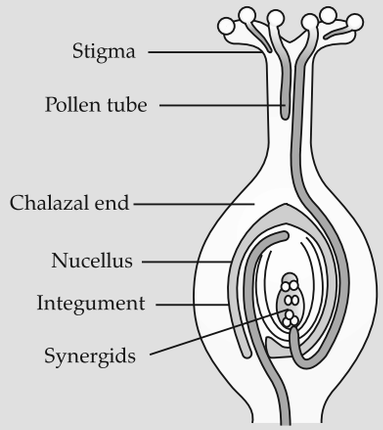
Q. 10. (i) Draw the longitudinal section of a flower showing growth of pollen tube upto the embryo sac. Label the following parts :

(a) Stigma **(b) Pollen tube**
(c) Integument **(d) Chalazal end**
(e) Nucellus **(f) Synergids.**

(ii) What is double fertilisation in Angiosperms ? Why is it so called ?

R **[Outside Delhi Set-I, II, III, Comptt. 2016]**

Ans. (i)



6×½=3

(ii) One of the male gametes moves towards the egg cell and fuses with its nucleus thus completing syngamy. This results in the formation of a diploid cell—the zygote. The other male gamete moves towards the two polar nuclei located in central cell and fuses with them to produce a triploid primary endosperm nucleus. Since two types of fusions take place in an embryo sac, the phenomenon is known as double fertilization.

1+1=2

[CBSE Marking Scheme, 2016]

Detailed Answer :

(ii) Here, two gametic fusions or fertilization in the female gametophyte or embryo sac of angiosperms takes place, i.e. one male gamete fuses with the egg to form zygote and the other male gamete fuses with the secondary nucleus to form the primary endosperm nucleus. The former fertilization is called as syngamy and the latter as the triple fusion. Thus, fertilization occurs twice in the same embryo sac, therefore, this is called as the double fertilization. This phenomenon is unique in angiosperms and is not found in any other group of plant kingdom.

Q. 11. (a) Describe any two devices in a flowering plant which prevent both autogamy and geitonogamy.

(b) Explain the events upto double fertilisation after the pollen tube enters one of the synergids in an ovule of an angiosperm.

R **[CBSE, Outside Delhi/Delhi, 2018]**

Ans. (a) (i) Dioecy/Production of unisexual flowers (in different plants)

(ii) Self incompatibility 1+1

(b) (i) Pollen tube releases 2 male gametes in the cytoplasm of synergids.

(ii) One male gamete fuses with egg cell, syngamy, resulting in diploid zygote.

(iii) Other male gamete fuses with polar nuclei /triple fusion, to form triploid PEN (Primary endosperm nucleus)/PEC (Primary endosperm cell). **1 × 3**

CBSE Marking Scheme, 2018

Detailed Answer:

(i) Production of unisexual flowers: Presence of male and female flowers on different plants such that each plant is either male or female (dioecy). In dioecious plants (e.g. papaya), male and female flowers are present on different plants (dioecy). This prevents both autogamy and geitonogamy.

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

(b) Events which occur during double fertilisation are:

(i) Two male gametes are released by the pollen tube into the cytoplasm of synergid.

(ii) Out of the two male gametes, one gametes fuses with the nucleus of the egg cell and forms the zygote, which forms an embryo. The process is known as syngamy.

(iii) The other male gamete fuses with the two polar nuclei located in the central cell to form a triploid primary endosperm nucleus (PEN).

(iv) Since, the process involves the fusion of three haploid nuclei, it is known as triple fusion. After triple fusion, the central cell becomes the primary endosperm cell (PEC).

(v) Since two types of fusions (syngamy and triple fusion) take place in an embryo sac it is known as double fertilisation.

TOPIC-3
Post-Fertilization Changes and Special Modes of Reproduction

Revision Notes

Post-fertilisation Events

- The development of endosperm and embryo, the maturation of ovule(s) into seed(s) and ovary into fruit are post-fertilisation events.

Endosperm Development

- The primary endosperm cell divides repeatedly by mitosis to form a triploid endosperm tissue.
- Endosperm cells are filled with reserve food materials which are used for the nutrition of the developing embryo.

- During the endosperm development, the primary endosperm nucleus undergoes successive mitotic nuclear divisions to give rise to free nuclei. This stage is called free-nuclear endosperm.
- Then the endosperm becomes cellular due to the cell wall formation.
- For example, the tender coconut water is a free-nuclear endosperm which is made up of thousands of nuclei and the surrounding white kernel is the cellular endosperm.

Embryo Development

- The embryo develops at the micropylar end of the embryo sac where the zygote is situated.
- The zygotes divides only after the formation of certain amount of endosperm in order to provide nutrition to the developing embryo.
- The development of embryo is similar in monocotyledons and dicotyledons upto octant stage.
- The zygote gives rise to the proembryo and subsequently to the globular, heart-shaped and mature embryo.

Dicotyledonous Embryo

- It has a central embryonal axis and two lateral cotyledons.
- The portion of embryonal axis above the level of cotyledons is the epicotyl, which terminates into plumule (stem tip).
- The cylindrical portion below the level of cotyledon is hypocotyl that terminates into radicle (root tip).
- The root tip is covered with a root cap.

Monocotyledonous Embryo

- They possess only one cotyledon.
- In the grass family, the cotyledon is called scutellum which is situated lateral to the embryonal axis.
- At its lower end, the embryonal axis has the radicle and root cap enclosed in an undifferentiated sheath called coleorhizae.
- The portion of embryonal axis above the level of attachment of scutellum is the epicotyl.
- It has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure called coleoptile.

Seed

- Seed is the final product of sexual reproduction.
- It is the fertilized ovule formed inside fruits.
- It consists of seed coat(s), cotyledon(s) and an embryonal axis.
- The cotyledons are simple, thick and swollen due to storage of food as seen in most of the dicots.
- Mature seeds may be non-albuminous or albuminous.

Non-albuminous or Non-endospermic Seeds

- These seeds have no residual endosperm as it is completely consumed during embryo development.
- Examples - pea, groundnut, beans.

Albuminous or Endospermic Seeds

- These seeds retain a part of endosperm as it is not completely used up during embryo development.
- Examples, wheat, maize, barley, castor, coconut, sunflower.
- In some seeds like black pepper, beet, etc., the remnants of nucellus is also persistent. It is called perisperm.
- Integuments of ovules harden as tough protective seed coats.
- It has a small pore (micropyle) through which oxygen and water enter into the seed during germination.
- As the seed matures, its water content gets reduced and the seeds become dry (10-15 % moisture by mass). The general metabolic activity of the embryo slows down.
- The embryo may enter a state of inactivity (dormancy).
- If favourable conditions are available such as adequate moisture,oxygen and suitable temperature, they germinate.

Fruit

- The ovary develops into a fruit after pollination and fertilization.
- The transformation of ovules into seeds and ovary into fruit proceeds simultaneously.
- The wall of ovary develops into pericarp.
- The fruits may be fleshy as seen in guava, orange, mango, etc., or may be dry as seen in groundnut, mustard, etc.,
- Many fruits have mechanisms for dispersal of seeds.
- Fruits are of two types namely :
  - **(a) True fruits :** When the fruit develops only from the ovary and other floral parts degenerate and fall off, they are called true fruits. Examples- mango, maize, grape.
  - **(b) False fruits :** When parts of flower other than ovary also contribute to the fruit formation, they are called false fruits. Examples– apple, strawberry, cashew, etc.
- In some species such as banana, the fruits develop without fertilisation, these fruits are called parthenocarpic fruits.

- Parthenocarpy can be induced through the application of growth hormones. Such fruits are seedless.

Advantages of Seeds

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

Viability of Seeds after Dispersal

- In few species, the seeds lose viability within a few months or live for several years.
- Some seeds remain alive for hundreds of years.
- The oldest is lupine (*Lupinus arcticus*) excavated from Arctic Tundra. The seed germinated and flowered after an estimated record of 10,000 years of dormancy.
- 2000 years old viable seed is of the date palm (*Phoenix dactylifera*) discovered during the archeological excavation at King Herod's palace near the Dead Sea.

Apomixis and Polyembryony

- Apomixis is (apo = with out; mixis = mixing together) means the production of seeds without fertilisation.
- It is seen in some species of Asteraceae and grasses.
- Apomixis is a form of asexual reproduction that mimics sexual reproduction.
- Occurrence of more than one embryos in a seed is called as polyembryony.

Development of Apomictic Seeds

- In some species, the diploid egg cell is formed without reduction division and develops into the embryo without fertilisation.
- In species like Citrus and Mango varieties, some of the nucellar cells surrounding the embryo sac divide and protrude into the embryo sac and develop into the embryos. Hence, in these species each ovule contains many embryos.

Importance of Apomixis in Hybrid Seed Industry

- Hybrid seeds have to be produced every year.
- If the seeds collected from hybrids are sown, the plants in the progeny will segregate and lose hybrid characters.
- The production of hybrid seeds is costly. Hence the cost of hybrid seeds is also expensive for the farmers.
- If the hybrids are made into apomicts, there is no segregation of characters in the hybrid progeny. This helps farmers to use the hybrid seeds to raise new crop year after year without losing hybrid characteristics.

IMPORTANT DIAGRAMS:

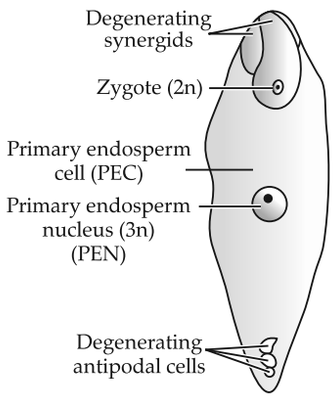


Fig 2.9: Fertilised embryo sac showing zygote and primary endosperm nucleus

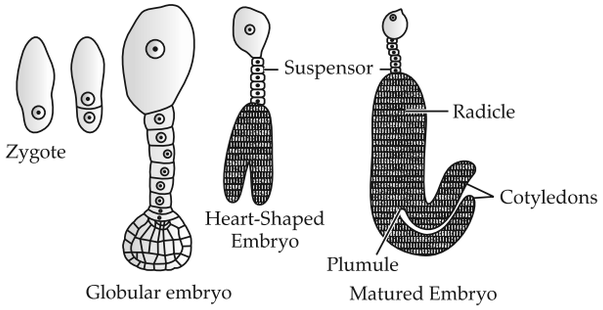


Fig. 2.10: Stages in embryo development in a dicot

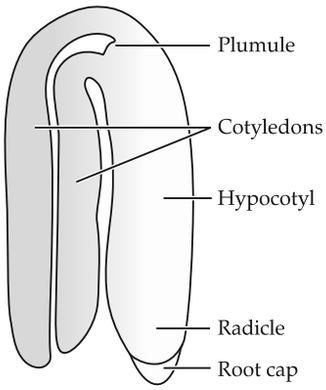


Fig 2.11: A typical dicot embryo

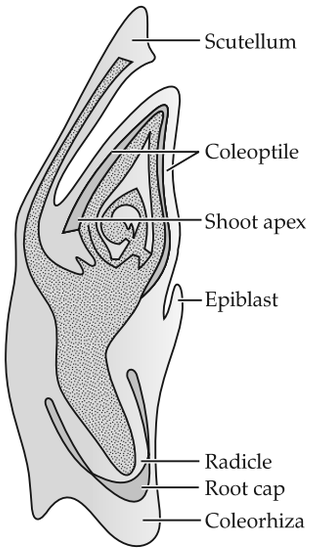
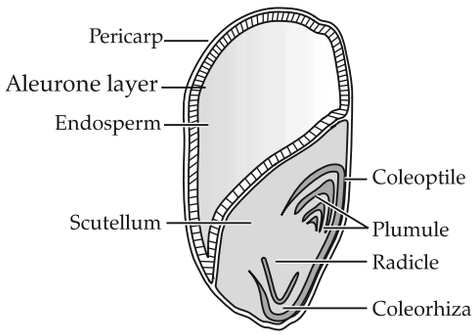


Fig 2.12: L.S of an embryo of grass



L.S. of Maize grain

Fig 2.13: L.S grain of maize

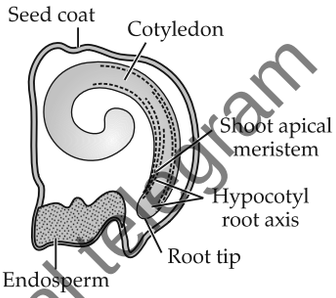


Fig 2.14: L.S. monocot seed of onion

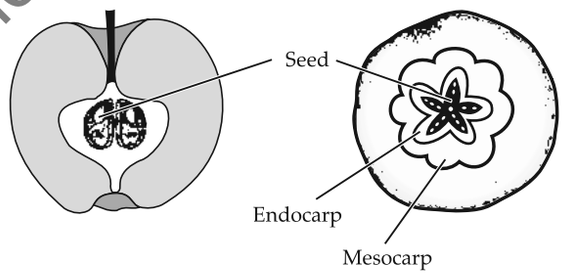
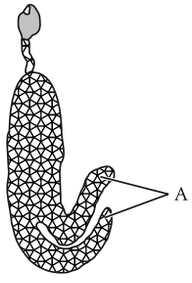


Fig 2.15: Sectional view of an apple

Very Short Answer Type Questions **(1 mark each)**

Q. 1. Identify 'A' in the figure showing a stage of embryo development in a dicot plant and mention its function. R **[Outside Delhi Set-I, Comptt. 2016]**



Ans. Cotyledons–Store food (for growth of embryo of the seed)

[CBSE Marking Scheme, 2016] ½ + ½ = **1**

Commonly Made Error

- Students gets confused between embryo and their function.

Q. 2. Name the type of fruit apple is categorised under and why ? Mention two other examples which belong to the same category as apple.

R **[Outside Delhi Set-III, Comptt. 2016]**

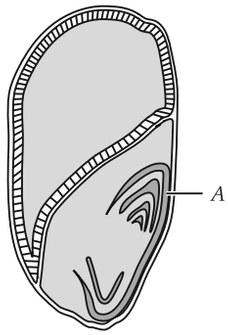
Ans. False fruit, thalamus contributes to fruit formation: Strawberry, Cashew (any other correct examples)

½ + ½

[CBSE Marking Scheme, 2016]

Q. 3. Given below is a section of a Maize grain. Identify 'A' and state its function.

R **[Outside Delhi Set-II, III Comptt. 2016]**



Ans. Coleoptile, protecting the shoot apex/plumule.
[CBSE Marking Scheme, 2016] ½ + ½

AI **Q. 4. Meiocyte of rice has 24 chromosomes. Write the number of chromosomes in its endosperm.**
A **[Delhi Set-I, Comptt. 2013]**

Ans. Number of chromosomes in meiocyte = 24 = 2n.
Haploid number (n) = 12.
Therefore, the number of chromosomes will be $n \times 3 = 36$, because the endosperm in angiosperms is triploid (3n) as it is formed by the fusion of 2 polar nuclei (n) and one gamete. **1**

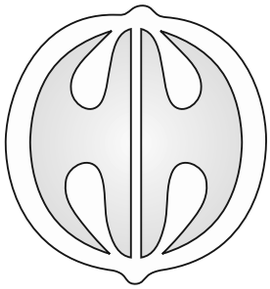
Commonly Made Error
- Students are not aware of the concept. Calculation and concept error is commonly seen.

Q. 5. Mention the fate of the components of the embryo sac after fertilization. U **[CBSE SQP 2013]**
[Delhi, Comptt. 2012, 2010]

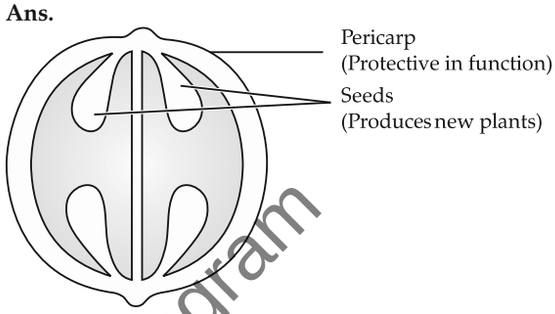
Ans. **(i)** The egg cell forms the zygote (2n) which give rise to embryo.
(ii) Synergids and antipodals degenerate.
(iii) Polar nuclei form primary endosperm nucleus (3n), which forms the endosperm. 1

Answering Tip
- The fate of different floral parts after fertilization must be discussed and learned point wise.

Q. 6. In the following figure of a fruit, label the part that is protective in function and the part that is responsible for producing new plants.
R **[CBSE SQP 2012]**



Ans.



1

Q. 7. 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. E & A **[Delhi Set-I, 2011]**
OR
If you squeeze a seed of orange you might observe many embryos of different sizes. How is it possible? Explain. [Delhi Set-I, 2010]

Ans. Some nucellar cells / surrounding the embryo sac start dividing and protrude into the embryo sac and develop into embryos. In such species each ovule contains many embryos. **1**
[CBSE Marking Scheme, 2010]

Q.8. In case of polyembryony, an embryo A develops from the synergids and the embryo B develops from the nucellus. State the ploidy of embryo A and B. A **[CBSE, SQP, 2018]**

Ans. A- Haploid ; B- Diploid ½ + ½
CBSE Marking Scheme, 2018

Q. 9. Apple and cashew are not called true fruits, why ?
A **[Outside Delhi, 2011]**

Ans. These fruits are not called true fruits because thalamus which is a part of flower other than ovary takes part in fruit formation. A true fruit is one which develops only from the ovary. Apple and cashew are thus false fruits. **1**

Short Answer Type Questions-I **(2 marks each)**

Q. 1. 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 ?
A **[Delhi Set-I, 2015]**

Ans. Fruit is a ripened ovary where seed develops from ovule. Mango is a true fruit because it develops only from the ovary of the flower. Apple is a false fruit because here in this case along with ovary thalamus of flower also takes part in the formation of fruit. Banana is a seedless fruit as it develops without the stimulus of pollination and fertilization. Such fruits are also called as parthenocarpic fruits. **2**

Commonly Made Error
- Students often get confused between the terms- true fruits, false fruit and parthenocarpic fruit. Carefully understand the concept with examples.

Q. 2. Some angiosperm seeds are said to be albuminous, whereas a few others are said to have a perisperm. Explain each with the help of an example.
A **[Delhi Set-II, 2014]**

Ans. Albuminous seeds retain a part of endosperm as it is not completely used up during embryo development. *e.g.,* wheat, maize, barley, castor, sunflower.
When remnants of nucellus are persistent it is said to have a perisperm. Example; black pepper, Sugar beet. **2**
[CBSE Marking Scheme, 2014]

AI **Q. 3. Why are some seeds of citrus referred to as polyembryonic ? How are they formed ?**
U **[Outside Delhi Set-I, Comptt. 2013]**

Ans. Some seeds of citrus are referred to as polyembryonic because they contain more than one embryo. This phenomenon is called as polyembryony. In citrus, one embryo develops normally as a result of sexual reproduction and other additional embryos are produced from the cells of nucellus or integument apomictically. The cells of nucellus or integument surrounding the embryo sac protrude into it, divide and produce the embryos. **2**

Q. 4. Draw a sectional view of an apple and label the different parts of an ovary in it. Fruits develop from an ovary. Then why is apple referred to as a false fruit ? R **[Foreign Set-III 2017]**

Ans. **For diagram:** Refer to Topic 3/ Revision Notes/ Fig 2.15
Thalamus also contributes to fruit formation
[CBSE Marking Scheme 2017] 1 + 1

Q. 5. Differentiate between pericarp and perisperm.
A **[Delhi Set-I 2017] (Comptt.)**

Ans. **Pericarp** - wall of the fruit (which develops from the wall of ovary) **1**
Perisperm - persistent residual nucellus **1**
[CBSE Marking Scheme 2017]

Q. 6. How do plants produce seeds through apomixis? Explain with the help of an example.
U **[Delhi Set-I, Comptt. 2013]**

Ans. In apomixis or agamospermy, seeds are formed without the fusion of gametes. Diploid cells of the nucellus or integuments develop into an embryo, giving diploid seeds with a genetic constitution identical to the parent. Apomixis takes place in orange and onion. **2**

Q. 7. Explain the function of each of the following :
(i) Coleorrhiza
(ii) Germ pores U **[Delhi Set-II, 2012]**

Ans. **(i)** Protects, the radicle of (monocot) embryo.
(ii) Allow germination of pollen grain / formation of pollen tubes. **1+1=2**
[CBSE Marking Scheme, 2012]

Q. 8. Differentiate between albuminous and non-albuminous seeds, giving one example of each.
U **[Delhi, Set-II, 2011]**

Ans. **Albuminous** – (with residual) endosperm is not completely used up during embryonic development. *e.g.*, wheat/maize/castor/sunflower.
Non albuminous – (with out residual) endosperm is completely consumed during embryonic development. *e.g.*, pea / groundnut.
[CBSE Marking Scheme, 2011] 2

Answering Tip
- Examples of both terms should be given with defintion.

Q. 9. Banana is a parthenocarpic fruit, whereas oranges show polyembryony. How are they different from each other in respect to seeds ?
A **[Delhi Set-I, II, III, 2011]**

Ans. The banana is a parthenocarpic fruit as it develops without fertilization, whereas in oranges, additional embryos develop directly from diploid cells other than the egg, like nucellus and integument. In banana, the ovary may develop into the fruit without fertilization. The parthenocarpic fruits never contain seeds. **2**

Q. 10. For a layman, both apples and mangoes are 'fruits'. Do you agree ? Give reasons in support of your answer. A **[Delhi Set-III Comptt. 2017]**

Ans. No. **1**
Apple - thalamus, (false fruit) ½
Mango - Ovary, (true fruit) ½
The parthenocarpic fruits never contain seeds.
[CBSE Marking Scheme, 2017]

Answering Tips
- Understand the concept of fruits carefully.
- Learn the differences between true fruits, false fruits and parthenocarpic fruits in tabular form for easy understanding and retention. Lay stress on examples of each.

Short Answer Type Questions-II **(3 marks each)**

Q. 1. List the changes that occur when an ovule matures into seed. K **[CBSE, SQP, 2018]**

Ans. **(a)** Integuments of ovules harden as tough protective seed coats.
(b) The micropyle remains as a small pore in the seed coat.
(c) As the seed matures, its water content is reduced.
(d) Seeds become relatively dry (10-15 per cent moisture by mass).
(e) The general metabolic activity of the embryo slows down.
(f) The embryo may enter a state of inactivity called dormancy. **½ × 6**
CBSE Marking Scheme, 2018

Q. 2. Do you think apomixis can be compared with asexual reproduction ? Support your answer,

giving one reason. How is apomixis beneficial to farmers? Explain.

A **[CBSE, Comptt, Set 1,2,3, 2018]**

Ans. Yes, seeds are produced without fertilisation. **½ × 2**

Production of hybrid seeds is costly, if hybrids with desirable characteristics can be made into apomicts, there is no segregation of characters in the hybrid progeny, farmer can continue using hybrid seeds year after year and not buy new seeds. **½ × 4**

CBSE Marking Scheme, 2018

Detailed Answer:

Yes, apomixis can be compared with asexual reproduction as like asexual reproduction, apomixis is the mechanism of seed production without involving the process of meiosis and syngamy.

Importance of apomixis to farmers: The method of producing hybrid seeds by cultivation is very expensive for farmers. Also, by sowing hybrid seeds, it is difficult to maintain hybrid characters as characters segregate during meiosis. Apomixis thus prevents the loss of specific characters into hybrid. If hybrids with desirable characteristics can be made into apomicts, there is no segregation of characters in the hybrid progeny and farmer can continue using hybrid seeds year after year and without buying new seeds. Also, it is cost-effective method for producing seeds.

Q. 3. (i) How does a farmer use the dormancy of seeds to his advantage ?

(ii) What advantages a seed provides to a plant ?

A **[Outside Delhi Set-II, 2016]**

Ans. **(i)** For storage (dehydration) of seeds to be used as food, to raise the crop in the next season. **½ + ½**

(ii) Seed formation is more dependable, better adaptive strategy for dispersal to new habitat, hard seeds provide protection to the young embryo, being a product of sexual reproduction they generate new genetic combinations / genetic variations / sufficient food reserve for the young seedling to be nourished.

[CBSE Marking Scheme, 2016] ½ × 4

Detailed Answer :

(i) Dormancy of mature seeds is crucial for storage of seeds. It can be used by farmers as food throughout the year and also to raise crop in the next season.

(ii) Importance of seeds to plants :

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

(b) They have food reserves. So young seedlings are nourished until they are capable of photosynthesis.

(c) The hard seed coat protects the young embryo.

(d) Being products of sexual reproduction, they generate new genetic combinations leading to variations. **1+2**

Answering Tip

- Students should write the advantages of seeds in bullet points.

AI **Q. 4. (i) How are parthenocarpic fruits produced by some plants and apomictic seeds by some others? Explain.**

(ii) When do farmers prefer using apomictic seeds?

U **[Outside Delhi Set-III, 2016]**

Ans. **(i)** Ovary develops into fruit without fertilisation. **1**

Formation of seeds without fertilisation without reductional division/develop into embryo without fertilisation. **1**

(ii) To maintain hybrid characters (year after year in a desired plant), to avoid buying hybrid seeds every year (expensive seeds).**½ × ½ = 1**

[CBSE Marking Scheme, 2016]

Detailed Answer :

(i) Parthenocarpic fruit are fruits that develop without fertilisation. *e.g.*, Banana. They can be induced artificially through the application of growth hormones and such fruits are seedless.

Apomictic seeds are produced in some species when the diploid egg cell is formed without reduction division and develops into the embryo without fertilisation. In many species (*e.g.,* many Citrus & Mango varieties) some of the nucellar cells surrounding the embryo sac divide, protrude into the embryo sac and develop into the embryos. In such species each ovule contains many embryos. **2**

(ii) Farmers prefer apomictic seeds, when the hybrids are made into apomicts. It is because, in apomictic seeds, there is no segregation of characters in the hybrid progeny. Therefore, the farmers can keep on using the hybrid seeds to raise new crop year after year. **1**

Q. 5. Double fertilization 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 fertilization events that are responsible for it. A **[Delhi Set-I, 2015]**

Ans. Development of endosperm (preceding the embryo) takes place in both, developing embryo derives nutrition from endosperm

Endosperm is retained / persists / not fully consumed in castor, endosperm is consumed in groundnut. **1+1+1=3**

[CBSE Marking Scheme, 2015]

Detailed Answer :

Endosperm development precedes embryo development. The triploid primary endosperm nucleus (PEN) undergoes repeated mitotic divisions, without cytokinesis. At this stage of development, the endosperm is called free-nuclear endosperm. Cell wall formation takes place later on. As a result the endosperm becomes partly or fully cellular. The cells of the endosperm store food materials, which are later used by the developing embryo.

In non-albuminous or non-endospermic seeds, the endosperm may be completely utilized by the developing embryo before the maturation of seeds as in pea, bean, groundnut etc. In albuminuous or endospermic seeds, a portion of endosperm persists in the mature seeds. *e.g.*, castor. **3**

Q. 6. Describe the development of endosperm after double fertilization in an angiosperm. Why does endosperm development precedes that of zygote?

U **[Outside Delhi Set-I, 2015]**

Ans. **(1)** After triple fusion, the central cell develops to form primary endosperm cell which contain triploid primary endosperm nucleus.

(2) The primary endosperm cell undergoes successive cell divisions to form triploid endosperm which has abundant food reserves.

(3) The primary endosperm nucleus undergoes successive nuclear divisions to form many free nuclei. This types of endosperm development is called free nuclear endosperm, after which cell walls are laid and the endosperm becomes cellular endosperm. E.g. coconut water is nuclear endosperm (containing many free nuclei). While white kernel around is cellular endosperm.

The endosperm development precedes that of zygote to ensure that endosperm containing abundant food reserves is formed earlier and can nourish the developing embryo.

Q. 7. Explain any three advantages the seeds offer to angiosperms. U **[Outside Delhi Set-III, 2014]**

Ans. **(i)** Since reproductive processes such as pollination and fertilization are independent of water, seed formation is more dependable.

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

(iii) As they have sufficient food reserves, young seedlings are nourished until they are capable of photosynthesis on their own.

(iv) The hard seed coat provides protection to the young embryo.

(v) Being products of sexual reproduction, they generate new genetic combinations / variations.

(vi) Dehydration and dormancy of mature seeds are crucial for survival under adverse conditions. **(Any three)** **3**

[CBSE Marking Scheme, 2014]

Q. 8. List the post-fertilization events in angiosperms.

R **[Delhi Set-III, 2014]**

Ans. **The various post-fertilization events occurring in angiosperms are :**

(i) Primary endosperm nucleus gives rise to endosperm. It is formed before the development of the embryo, as it provides nourishment to the developing embryo.

(ii) The zygote at the micropylar end undergoes successive divisions to form mature embryo.

(iii) Ovule is converted into seed.

(iv) Ovary develops into fruit. **3**

AI **Q. 9. Draw a labelled mature stage of a dicotyledonous embryo.**

R **[Outside Delhi Set-I, 2014], (DDE)**

Ans. Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.11 **3**

Q. 10. (i) Draw a diagram of a sectional view of monocot seed (grain).

(ii) Label and write the functions of coleoptile, coleorhiza, endosperm.

R **[Outside Delhi Comptt. Set-III 2017]**

Ans. Refer to Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.13

Functions :

Coleoptile - sheath of plumule / protection of plumule

Coleorhiza - sheath of radicle / protection of radicle

Endosperm - filled with reserve food materials for nutrition of developing embryo **1 ½ + 1 ½**

[CBSE Marking Scheme, 2017]

Q. 11. Describe with the help of three labelled diagrams the different embryonic stages that include the mature embryo of dicot plants.

U **[Delhi Set-II, 2014]**

Ans. **Following are the steps that occur during the development of an embryo :**

First, the zygote starts dividing and gives rise to proembryo. The cells of this proembryo further divide, forming a globular, heart-shaped and finally mature embryo. A typical dicot embryo consists of an embryonal axis and two lateral cotyledons.

The portion of the embryonal axis above the level of cotyledons is called epicotyl. It contains the plumule (shoot tip). The portion below the cotyledons is called hypocotyl. It contains the radicle (root tip). The root tip is covered by the root cap.

For diagram: Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.9 **3**

Q. 12. In angiosperms, the zygote is diploid, while the primary endosperm cell is triploid. Explain.

A **[Outside Delhi Set-I, 2013]**

Ans. A zygote is the product of syngamy, it is formed by the fusion of a haploid male gamete and a haploid female gamete, *i.e.*, egg cell.

Male gamete + Egg $\rightarrow$ Zygote

(n) *(n)* *(2n)*

A primary endosperm cell is the product of the fusion of a secondary nucleus (2*n*) and a haploid male gamete (*n*).

Secondary nucleus + male gamete → Primary endosperm nucleus
(2*n*) (*n*) (3*n*) **3**

Q. 13. (i) Give one example each of albuminous and non-albuminous seeds.

(ii) Name the parts of the ovule and the embryo sac of an angiosperm that develop into :

(a) perisperm, (b) seed coats,

(c) endosperm, (d) embryonal axis.

R **[Delhi Set-I, Comptt. 2012]**

Ans. (i) Example :

Non-albuminous seed : Pea, bean, mustard.

Albuminous seed : Castor, maize, coconut. **(Any one)**

(ii) (a) Perisperm : Residual persistent nucellus.

(b) Seed coats : Integuments.

(c) Endosperm : Primary endosperm nucleus.

(d) Embryonal axis : Tigellum. **1½ + 1½ = 3**

Q. 14. Differentiate between perisperm and endosperm, giving one example of each.

U **[Delhi Set-II, 2012]**

Ans. Differences between perisperm and endosperm :

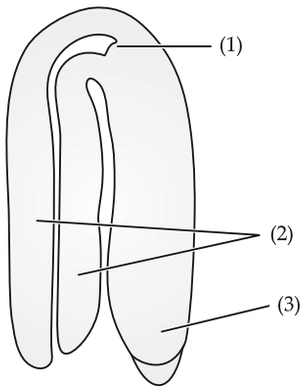
Perisperm	Endosperm
In some seeds such as black pepper, sugar beet, remnants of nucellus are also persistent. This residual, persistent nucellus is called perisperm.	The secondary nucleus of the embryo sac after triple fusion becomes the primary endosperm nucleus and develops into the endosperm, *e.g.,* castor, groundnut.

3

Answering Tip

- Learn the differences between perisperm and endosperm with examples in tabular form for better retention and understanding.

Q. 15. In the figure of a typical dicot embryo, label the parts (1), (2) and (3). State the function of each of the labelled part. R **[CBSE SQP 2012], (DDE)**



Ans. Label 1 : Origin of plumule; plumule grows into shoot.

Label 2 : Cotyledons; food storage.

Label 3 : Origin of radicle; radicle grows into root.
1½ + 1½

AI **Q. 16. With the help of an example of each explain the following ?**

Apomixis, Parthenocarpy, Polyembryony.

R **[Delhi Set-I, Comptt. 2012]**

Ans. (i) Apomixis : It is a type of an asexual process which imitates the sexual reproduction by formation of seed without fertilization. It can be referred to as special type of sexual reproduction which does not involve the process of meiosis and syngamy.

(ii) Parthenocarpy : The formation of fruit without fertilization is called parthenocarpy. Such fruits are seedless and called as parthenocarpic fruits. *e.g.,* Banana.

(iii) Polyembryony : The occurrence of plural embryos in a seed is called polyembryony, *e.g.,* citrus fruits like orange. Normally, one embryo is formed in a seed as a result of fertilization but additional embryos may develop apomictic.
1+1+1

Q. 17. Explain how false, true and parthenocarpic fruits are different from each. Give one example of each.

U **[Delhi Set-I, Comptt. 2012]**

Ans. (i) True fruit : It is the fruit which develops only from the ovary part of flower. *e.g.,* maize, wheat.

(ii) False fruit : It is the fruit which develops from ovary but in addition other parts of the flower like thalamus, calyx or corolla also take part in fruit formation. *e.g.,* apple, strawberry.

(iii) Parthenocarpic fruits : These are the fruits which develop without the act of fertilization. *e.g.,* Banana. **1×3=3**

Q. 18. Apomixis resembles asexual reproduction, as well as mimics sexual reproduction in plants. Explain with the help of a suitable example.

R **[Foreign Set-I, II, III 2017]**

Ans. Since there is no fertilisation in apomixis, it resemble asexual reproduction and development of embryo / seed / fruit formation is mimicing sexual reproduction. **½ + ½ = 1**

In Citrus / Mango, some of the nucellar cells surrounding the embryo sac, act as diploid egg cell, which are formed without reduction division and develop into embryo, without fertilisation.
½ × 4 = 2

[CBSE Marking Scheme 2017]

AI **Q. 19. Parthenocarpy and apomixis have been observed in some plants. Give an example of each. State a similarity and a difference observed between the two processes.** A **[Delhi Set-III 2017]**

Ans.

Parthenocarpy	Apomixis
Fruit is formed without fertilisation	Seed is formed without fertilisation
Seedless fruits are produced	Fruits with seeds are produced (Any one difference) = 1

Eg. : Banana / grapes / any other correctly = ½	**Eg. :** species of Asteraceae / grasses / any other correctly = ½

Similarity : In both the processes, development takes place without fertilisation = 1

[CBSE Marking Scheme, 2017] 3

Q. 20. If the meiocyte of a maize plant contains 20 chromosomes, write the number of chromosomes in the endosperm and embryo of the maize grain and give reasons in support of your answer.

E & A **[CBSE, Comptt, Set 1,2,3, 2018]**

Ans. Endosperm = 30 , Embryo = 20 **½ × 2**

Diploid meiocyte (20 chromosomes) form haploid gametes (10 chromosomes). \

Two haploid gametes fuse to form diploid (20) zygote which develops into a (diploid = 20) embryo / syngamy of two haploid gametes to form a diploid zygote. **1**

One haploid gamete (chromosome 10) fuses with two polar nuclei (chromosome 10 + 10) to form (triploid - 30) endosperm nuclei (which divides to form endosperm) / Triple fusion of three haploid nuclei (1 gamete + 2 polar nuclei) to form a triploid endosperm. **1**

[CBSE marking Scheme, 2018]

Commonly Made Error

- Students often get confused between number of chromosomes in the endosperm and embryo.

Answering Tip

- Take sufficient practice of such questions.

Long Answer Type Questions

(5 marks each)

Q. 1. (i) Draw a diagram of a fertilized embryo sac of a dicot flower. Label all its cellular components.

(ii) Explain the development of a mature embryo from this embryo sac. U **[Delhi Set-I, Comptt 2015]**

Ans. **(i) For figure:** Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.9

(Five correct labelling 5 × ½ = 2½)

(ii) Zygote starts mitotic division and gives rise to pro-embryo → globular and heart shaped → mature embryo with radical – plumule and two cotyledons, primary endosperm nucleus divides and forms endosperm, which may persist or used up in nourishing the embryo.

5 × ½ = 2 ½

[CBSE Marking Scheme, 2015]

Detailed Answer :

(ii) The pollen tube releases two male gametes. One fuses with the egg cell and forms a diploid zygote. Other male gamete fuses with secondary nucleus in the central cell to form a triploid primary endosperm nucleus (PEN). The primary endosperm nucleus develops into endosperm. The embryo formation starts after a certain amount of endosperm is formed to nourish it. The zygote divides mitotically to form a proembryo, which later results in the formation of globular, heart shaped embryo with one or two cotyledons. The mature embryo consists of two cotyledons and the embryonal axis between them.

AI **Q. 2. (i) Why does endosperm development precede embryo development in angiosperm seeds ? State the role of endosperm in mature albuminous seeds.**

(ii) Describe with the help of three labelled diagrams the different embryonic stages that include mature embryo of dicot plants.

U **[Outside Delhi Set-II, 2014]**

Ans. **(i)** As it provides nutrition for the developing embryo. It is an adaptation to provide assured nutrition to the developing embryo.

Provides nutrition during and after germination. **2**

(ii) The zygote (in the embryo sac) divides to form pro embryo and subsequently the globular, heart shaped and mature embryo as shown in the diagram.

Note : For diagram: Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.10

[CBSE Marking Scheme, 2014] 3

Q. 3. (i) Why is fertilization in an angiosperm referred to as double fertilization ? Mention the ploidy of the cells involved.

(ii) Draw a neat labelled sketch of L.S. of an endospermous monocot seed.

U **[Delhi Set-II,2014]**

Ans. **(i)** Fertilization of haploid egg cell by one haploid male gamete, to form diploid zygote, is called syngamy. **½ × 3=1½**

Fertilization of two polar nuclei by the other haploid male gamete to from triploid primary endosperm nucleus, This is called triple fusion.

The fertilization thus occurs twice in the embryo sac. Therefore it is called as double fertilization.

Ploidy of cells :

Endosperm cell – triploid

Fertilized egg cell – diploid Synergids – haploid

Antipodals – haploid **½ × 3=1½**

(ii) Figure I (L.S. monocot seed of onion)- Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.14

Figure II (L.S. grain of maize)- Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.13

(Any four labels including endosperm either from Fig. I or Fig. II.)

[CBSE Marking Scheme, 2014] 2

Q. 4. Write the changes a fertilized ovule undergoes within the ovary in an angiosperm plant.

R **[Outside Delhi Set-I, II, III, 2013; CBSE SQP 2013]**

Ans. A fertilized ovule undergoes the following changes in the ovary in an angiosperm plant :

Unfertilized ovule → Fertilized ovule → Seed

Funiculus	→ Present
Hilum	→ Present
Integument	→ Seed coat
Outer integument	→ Testa
Inner integument	→ Tegmen
Chalaza	→ Present
Micropyle	→ Present
Nucellus	→ Absent or present as perisperm

Embryo Sac :

Antipodal cells	→ Degenerate
Synergid cells	→ Degenerate
Secondary nucleus	→ Endosperm
Egg	→ Embryo

When the unfertilized ovule undergoes double fertilization, it makes fertilized ovule and then seeds. In this process funiculus and hilum are present. Outer integument makes testa and inner integument is tegmen. Chalaza and micropyle are present but nucellus is absent, partly persists as perisperm.

In embryo sac, antipodals and synergids degenerate. The central cell makes endosperm and the egg changes into embryo. **3 + 2 = 5**

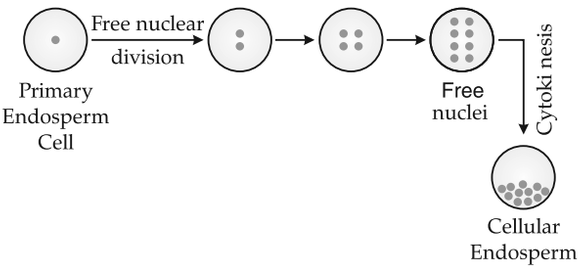
Q. 5. (i) Describe the endosperm development in coconut.

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

(iii) How are pea seeds different from castor seeds with respect to endosperm ?

U **[Outside Delhi Set-I, II, 2013]**

Ans. (i) Coconut endosperm development is free nuclear type :



The primary endosperm nucleus divides by free nuclear division. The nucleus divides repeatedly into at last 128 nuclei. Then by the process of cytokinesis it partly changes in to cellular endosperm. **3**

(ii) The water of tender coconut, technically the liquid endosperm is rich in nutrients like fat, proteins, carbohydrates, minerals, vitamins as endosperm provides nutrition to developing embryo. **1**

(iii) Pea seed is non-endospermic as endosperm is absent because endosperm is consumed completely during embryo development, while castor seed is endospermic as endosperm is present. **1**

Q. 6. Draw a labelled diagram of L.S. of an embryo of grass (any six labels).

R **[Outside Delhi Set-I, II, 2011]**

Ans. Refer Topic 3/Revision Notes/ Important Diagrams/ Fig 2.12 **5**

[CBSE Marking Scheme, 2011]

Q. 7. (i) With labelled diagrams, depict stages in embryo development in a dicotyledenous plant.

(ii) Endosperm development precedes embryo development. Why ? R **[Delhi Set-I Comptt. 2017]**

Ans. (i) Refer Topic 3/ Revision Notes/ Important Diagrams/ Fig 2.10

(ii) Endosperm is filled with reserve food materials which are used for as nutrition of the developing embryo. **4 + 1 = 5**

[CBSE Marking Scheme, 2017]

Q. 8. Differentiate, giving one example of each, between the following :

(i) Parthenogenesis and parthenocarpy.

(ii) Perisperm and pericarp.

U **[Outside Delhi Set-I, Comptt. 2011]**

Ans. (i) Parthenogenesis and parthenocarpy :

Parthenogenesis	Parthenocarpy
When the female gametes undergo development to form a new organism without fertilization, this phenomenon is called parthenogenesis.	Fruits that develop without fertilization are called parthenocarpic fruits and the process is called parthenocarpy.

2 ½

Answering Tip

- Understand parthenocarpy and parthenogenesis. Break the word into fragments 'partheno =virgin' and 'carpo = fruit' for better understanding.

(ii) Perisperm and pericarp :

Perisperm	Pericarp
In some seeds such as black pepper and sugarbeet, remnants of nucellus are persistent. This residual, persistent nucellus is the called perisperm.	The transformation of ovules into seeds and ovary into fruits proceeds simultaneously. The wall of the ovary develops into the wall of fruits called pericarp.

2½

Q. 9.(i) When a seed of an orange is squeezed, many embryos, instead of one are observed. Explain how it is possible.

(ii) Are these embryos genetically similar or different? Comment.

A **[Outside Delhi Set-II, III 2017]**

Ans. **(i)** Polyembryony, nucellar cells surrounding embryo sac start dividing, protrude into the embryo sac and develop into many embryos.

1 + 1 + 1

(ii) These embryos are genetically similar, as produced from nucellar cells by mitotic division / formed without fertilisation (but different from the embryo formed by fertilization) 1 + 1

[CBSE Marking Scheme 2017] 5

AI **Q. 10. (i) A capsicum flower has 240 ovules in its ovary. But, it produces a fruits with only 180 viable seeds.**

(ii) Describe the development of an endosperm in a viable seed. Why does endosperm development precede embryo development ?

(iii) Give an example of an angiosperm seed that has a perisperm. Name the part the perisperm develops from. E & A **[Delhi Set-2017]**

Ans. **(i)** Less number of pollen grains / male gametes were available / all pollen grains did not germinates / all pollen grains did not form pollen tubes / many pollen were not compatible / 60 ovules not fertilised / only 180 fertilised **1**

(ii) PEN undergoes successive nuclear divisions to give rise to free nuclei / free nuclear endosperm, cell wall formation occurs and the endosperm becomes cellular. **1 + 1**

Cells of endosperm are filled with reserve food materials that are used for nutrition of developing embryo. **1**

(iii) Black pepper / Sugar beet ½

Nucellus ½

[CBSE Marking Scheme 2017]

Q. 11. A flower of brinjal has 520 ovules in its ovary. However, it produces a fruit with only 480 viable seeds.

(i) What could have prevented the rest of the 40 ovules from maturing into viable seeds ? Explain giving a reason.

(ii) Describe the development of a dicot embryo in a viable seed.

(iii) Why certain angiospermic seeds are albuminous while others are ex-albuminous ? Explain.

E & A **[Delhi Set-II 2017]**

Ans. **(i)** Less number of pollen grains / less number of male gametes were available / all pollen grains did not germinate / all pollen grains did not form pollen tubes / many pollen were noncompatible / 40 ovules did not get fertilised / only 480 ovules were fertilised 1

(ii) Zygote divides (mitotically) to give rise to pro embryo, globular, heart shaped, mature embryo Refer Topic 3/ Revision Notes/ Important Diagrams/Fig. 2.2 (if changes accepted in revision notes 2.10) (give marks if all stages shown correct diagrammatically)

½ × 4 = 2

(iii) Albuminous : Endosperm is not completely used up during embryo development / residual endosperm found in the seed **1**

Ex-albuminous : Endosperm is completely consumed / no residual endosperm is left in seed **1**

[CBSE Marking Scheme 2017

Q. 12. (i) How is apomixis different from parthenocarpy ?

(ii) Describe any two modes by which apomictic seeds can be produced.

R **[Outside Delhi Set-I, Comptt. 2016]**

Ans. **(i) Parthenocarpy :** The formation of fruit without the act of fertilization is called parthenocarpy and the fruits so developed are called as parthenocarpic fruits. These fruits are seedless. e.g., banana. While apomixis is a special type of sexual reproduction which does not involve meiosis and syngamy. In fact it is a form of asexual reproduction that mimics the sexual reproduction in which the seeds are produced without fertilization.

(ii) Apomictic seeds can be produced by any of the following methods.

(a) Apospory : It is the formation of diploid embryo sac directly from a cell of nucellus.

(b) Diplospory or generative apospory : It is the formation of diploid embryo sac from the megaspore mother cell without meiosis.

The diploid egg of the diploid embryo sac develops into embryo without syngamy i.e., parthenogenetically.

(c) Apogamy : The synergids or antipodals of the diploid embryo sac may develop into embryo parthenogenetically. **(Any two) 3 + 2**

Know the Terms

- **Anemophily :** Pollination by wind is called anemophily.
- **Apomixis :** It is production of seeds without involving the process of meiosis and syngamy.
- **Chiropterophily :** Pollination by bat is called chiropterophily.
- **Coleorrhiza :** It is undifferentiated sheath that encloses the radicle and root cap in a monocot seed.
- **Emasculation :** It is the process of removal of anthers (using forceps) from the bisexual flower bud without affecting the female reproductive part *i.e.,* pistil.
- **Entomophily :** Pollination by insects is called entomophily.
- **False fruits :** Fruits that develop from accessory parts other than ovary are called as false fruits.
- **Geitonogamy :** It is the transfer of pollen grains from the anther to the stigma of another flower of the same plant.
- **Hydrophily :** Pollination by water is called hydrophily.
- **Megasporogenesis :** It is the process of formation of the four megaspores from the megaspore mother cell (MMC) in the region of nucellus through meiosis.
- **Microsporogenesis :** It is process of formation of mircospores from a pollen mother cell (PMC) through meiosis.
- **Ornithophily :** Pollination by bird is called ornithophily.
- **Parthenocarpic fruits :** Fruits that develop without fertilisation are called parthenocarpic fruits.
- **Perisperm :** Remnants of nucellus in matured seed are known as perisperm.
- **Pollen-pistil interaction :** All the events – from pollen deposition on the stigma until pollen tubes enter the ovule – are together referred as pollen–pistil interaction.
- **True fruits :** Fruits that develop from the ovary are called true fruits.
- **Self-Pollination or autogamy :** It is the transfer of pollen from anther to the stigma of the same flower.
- **Xenogamy :** It is the transfer of pollen grains from anther to the stigma of a different plant.

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