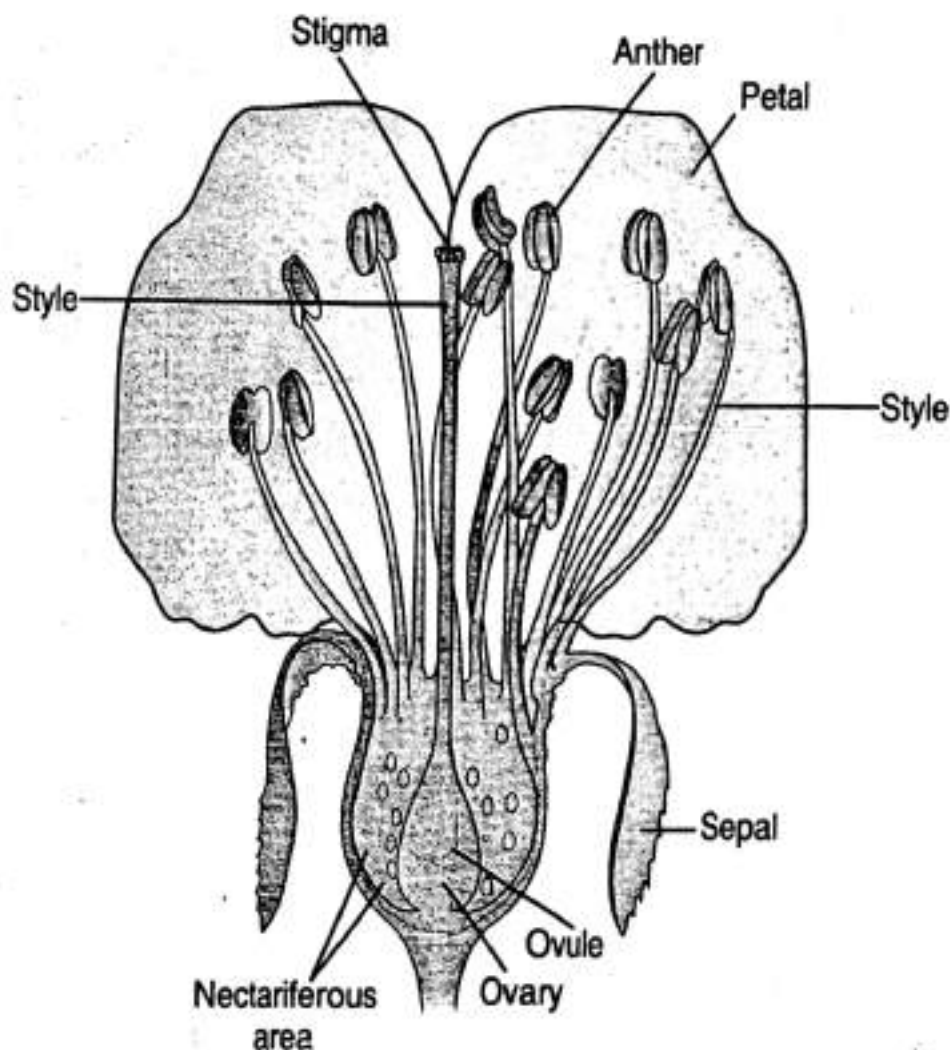


# SEXUAL REPRODUCTION IN FLOWERING PLANTS

- All angiospermic or flowering plants shows sexual reproduction.
- Fruits and seeds are end product of sexual reproduction.
- Androecium (unit stamen) and gynoecium (unit carpel) are male and female part respectively of reproductive whorls.

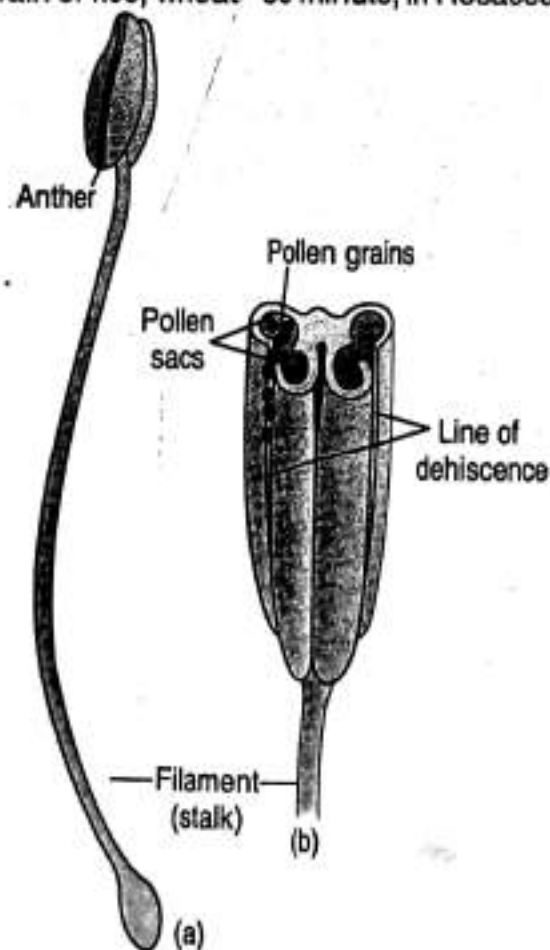


A diagrammatic representation of L.S. of a flower

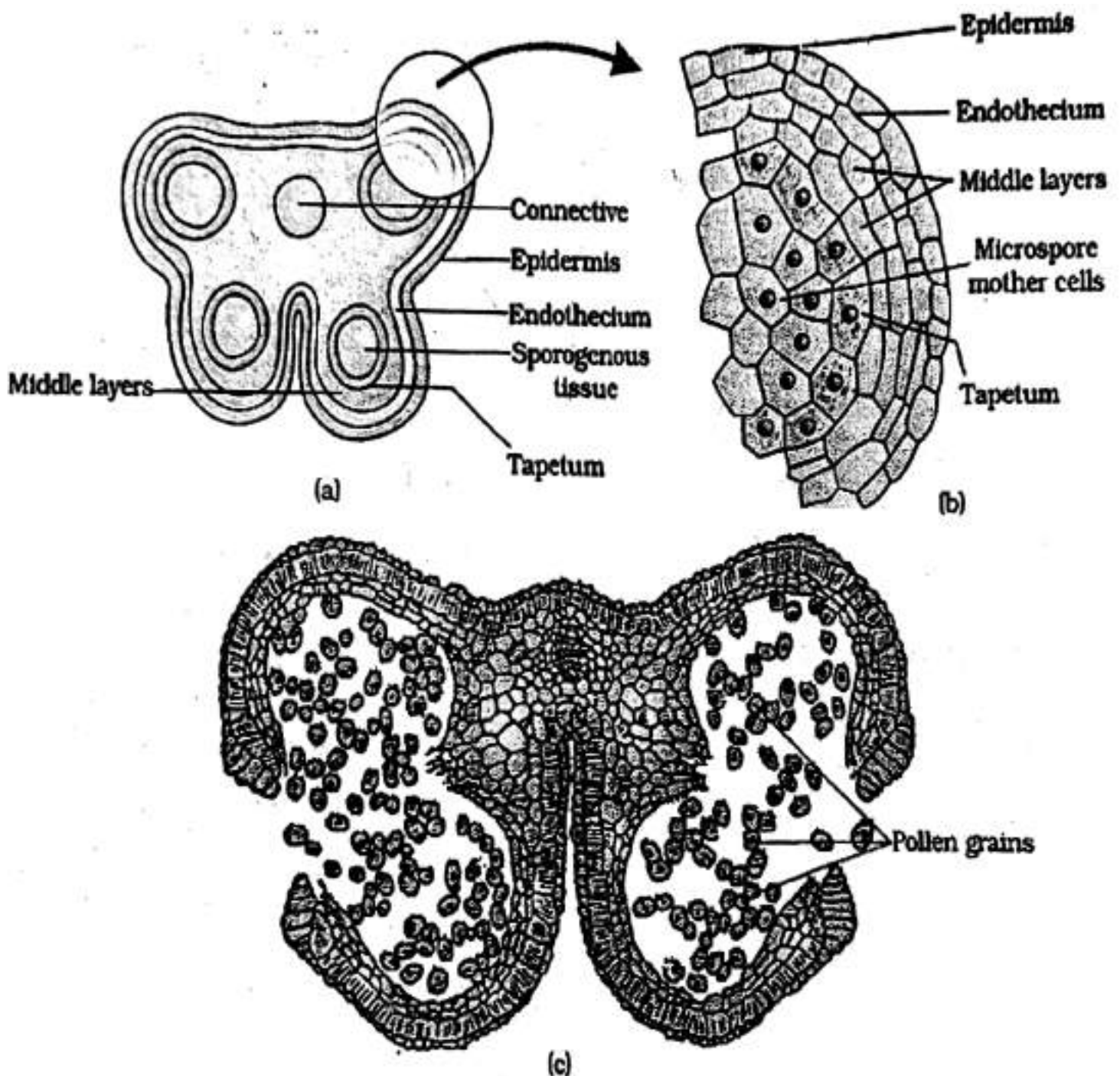
## Pre-fertilization structures and events :

- Several structural and hormonal changes leads to formation and development of the floral primodium. Inflorescence is formed that bears floral buds and then flower.
- **Stamen:** The long, slender stalk called filament and the terminate generally bilobed structure called anther (**dithecous**)
- Anther has four microsporangia, two in each lobes. The microspomgia develop further and become pollen acs, packed with pollen grains.

- ❑ Microsporangium is generally surrounded by four layer of walls the epidermis, endothecium, middle layer and tepetum. Tepetum nourish the developing pollen grain.
  - ❑ Sporogenous tissues occupies the centre of each microsporangium.
  - ❑ **Microsporogenesis:** The process of formation of microspores from a pollen mother cell through meiosis division.
    - The cells of sporogenous tissues undergoes meiotic division to form microspore dissociate and develops into pollen grains.
    - The pollen grain represents the male gametophytes. Each pollen grain have two layered wall, the outer exine made up of sporopollenin and inner wall is called intine made up of cellulose and pectin.
    - Pollen grain exine has prominent apertures called germ pores pollen grain contain 2 cells the vegetative cell and generative cell.
    - The most of the angiosperms pollen grain are shed in 2-celled stage.
    - Pollen grains are rich in nutrients and are used as pollen tablets and food supplement.
    - Pollen grain of many species cause severe allergies and bronchial afflictions (asthama, bronchitis).
    - *Parthenium* or carrot grasses cause pollen allergy.
    - Pollen grains of large number of species are stored in liquid nitrogen at temperature  $-196^{\circ}\text{C}$ . Viability of pollen grains varies with species to species and should land on stigma before this period of germinate.
- Viability of pollen grain of-rice, wheat-30 minute, in Rosaceae, leguminosae and solanaceae for month.



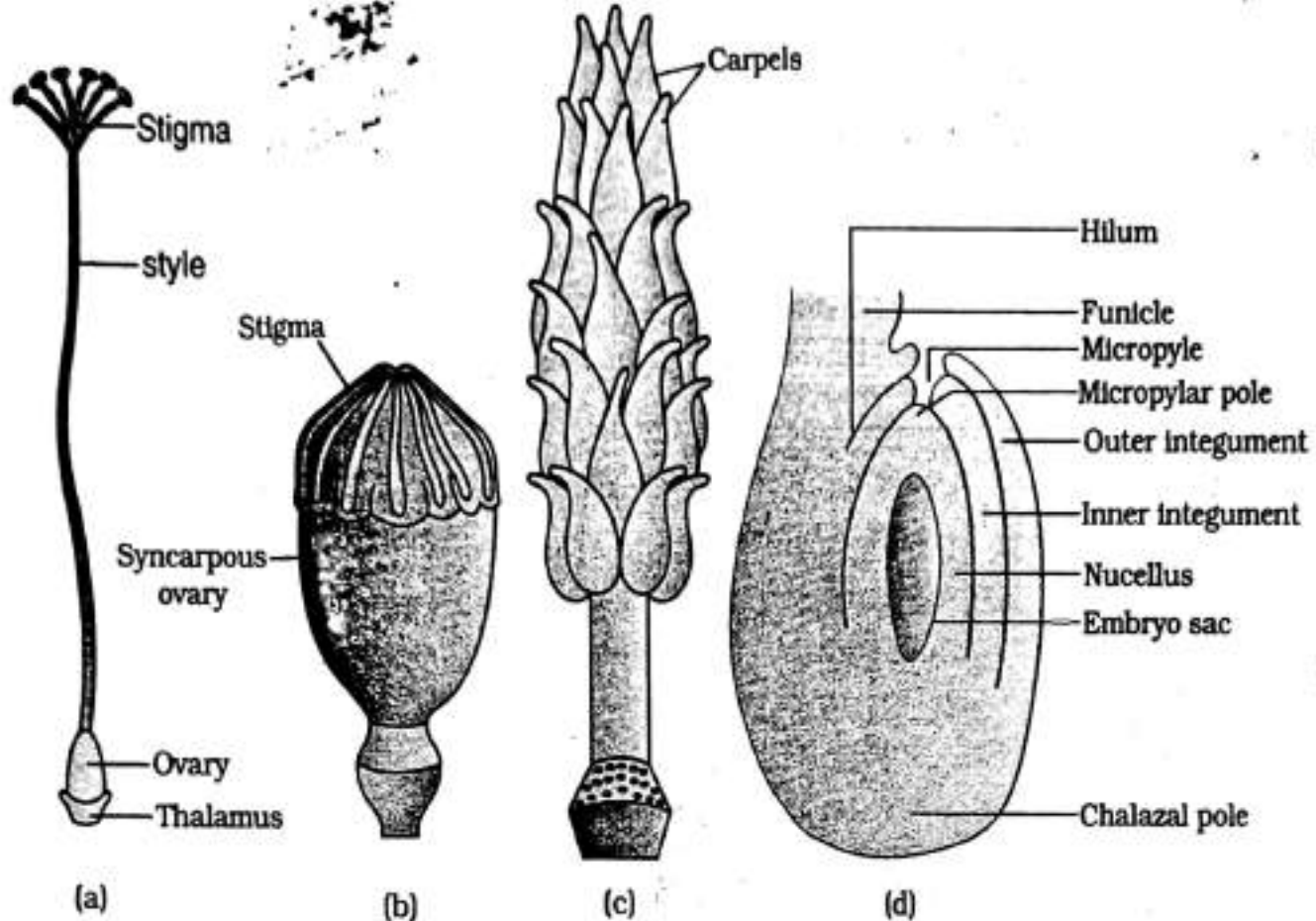
(a) A typical stamen :  
 (b) three-dimensional cut section of anther



**Figure -** (a) Transverse section of a mature anther; (b) Enlarged view of one microsporangium showing wall layers; (c) A dehiscent anther

The Pistil, Mega sporangium (ovule) and embryo sac.

- Gynoecium may consists of single pistil (monocarpellary) or more than on pistil (poly carpellary) which may be fused (syncarpous) or free (apocarpous).



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

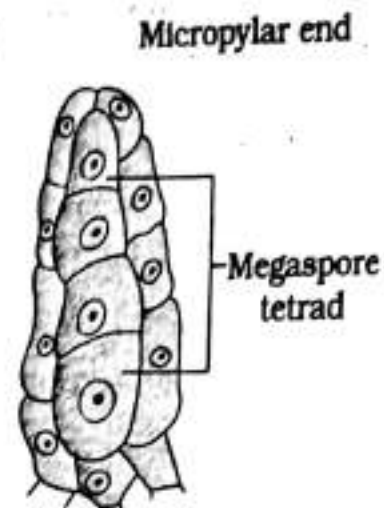
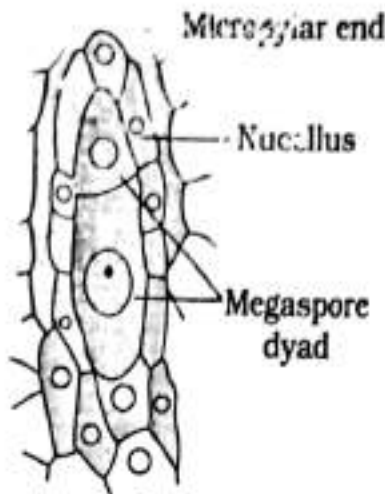
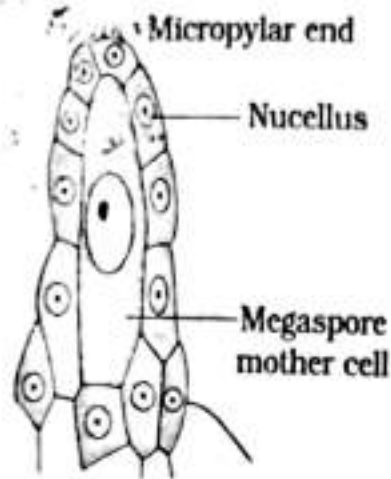
- Each pistil has three parts the stigma, style and ovary. Inside the ovary is ovarian cavity (locule). The placenta is located inside the ovarian cavity. Megasporangia (ovules) arise from placenta.
- The ovule is a small structure attached to the placenta by means of a stalk called funicle.
- Each ovule has two protective layers called integuments.
- There is a small opening present in integuments called micropyle and opposite of micropyle is called chalaza.
- Enclosed within the integuments is a mass of cells called the nucellus (reserve food materials)

### Mega sporogenesis :

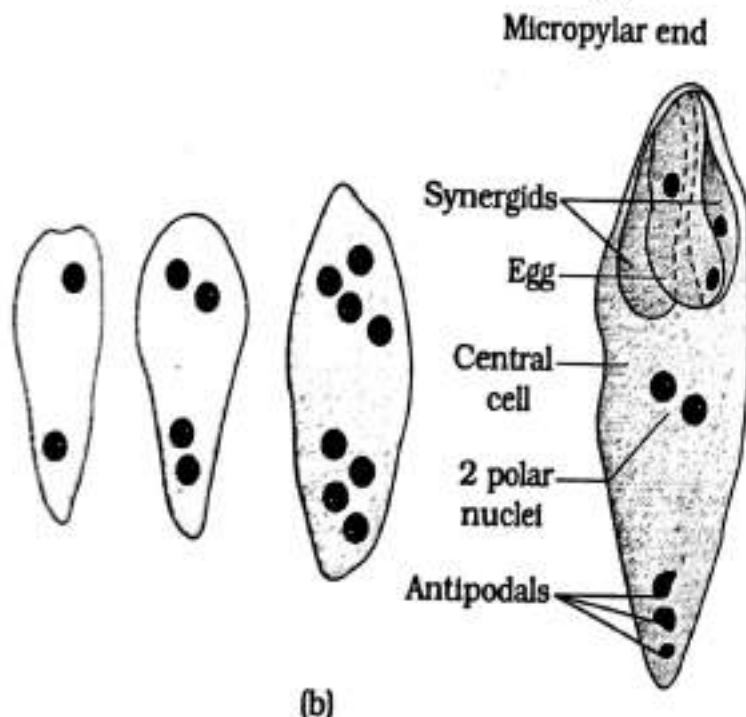
Formation of megaspore from megaspore mother cell.

- Ovule differentiates a single megaspore mother cell (MMC) in the micropylar region of nucellus. MMC undergoes meiosis division that results in the production of four megaspores.
- In most of the flowering plants three megaspores degenerate. 1 megaspore develops into female gametophyte (embryosac).
- The nucleus of functional megaspore divides mitotically to form two nuclei which move to opposite poles to form 2-nucleate embryo sac. Two more sequential mitotic divisions result in 8-nucleate embryo sac.
- Six of the eight nuclei surrounded by cell wall and remaining two nuclei (polar nuclei) are situated below the egg apparatus.
- Three cells are grouped at micropylar end to constitute egg apparatus and three cells at chalazal end form antipodal cells. At maturity embryo sac is 8-nucleate and 7-celled.

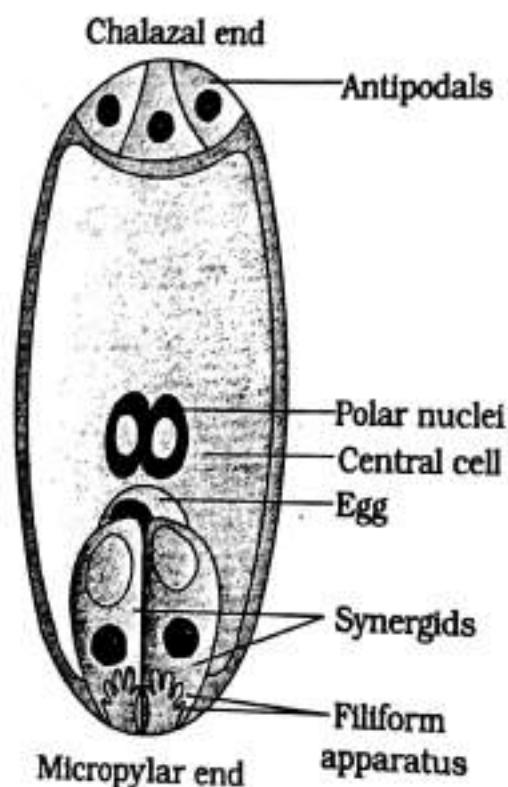




(a)



(b)



(c)

(a) Parts of the ovule showing a large megaspore mother cell, a dyad and a tetrad of megaspores; (b) 1, 2, 4, and 8-nucleate stages of embryo sac and a mature embryo sac; (c) A diagrammatic representation of the mature embryo sac.

**Pollination :** Transfer of pollen grains (shed from the anther) to the stigma.

(a) **Autogamy** – transfer of pollen grain from anther to stigma of same flower.

(i) **Cleistogamous**- flower which do not open. eg:- oxalis, commelina

(ii) **Chasmogamous** - exposed anther and stigma

(b) **Geitonogamy** - transfer of pollen grain from anther to stigma of different flower of same plant.

(c) **Xenogamy** - transfer of pollen grain from anther to stigma of different plant's flower of same species.



Agents of pollination includes abiotic (water, wind) and biotic (insect, butterfly, honey bee etc.) large number of pollen grains are produced by plants using abiotic mode of pollination as most of pollen grains are wasted during transfer.

### **Pollination by wind**

- Well exposed stamens - early dispersed into wind.
- Often-feathery stigma - trap air borne pollen grain
- Single Ovule in each ovary.
- Number of flower packed into an inflorescence  
eg: corn, grasses,

### **Pollination by water**

- Quite rare in flowering plant (30 general mostly monocotyledons)
- Algae, bryophyta and Pteridophyte
- Water pollinated plant - vallisneria, Hydrilla, Zostera, hyacinth and water lily.
- Pollen grains are protected from wetting by mucilaginous covering.

□ Both wind and water pollinated flowers are not very colourful and do not produce nectar.

□ Pollination by animals -

Primates (lemurs), arboreal (tree-dwelling) rodents, reptiles (gecko Lizard and garden Lizard).

□ Pollination by insect -

- Flowers are large, colourful, fragrant and rich in nectar.
- Small flower arranged into a inflorescence
- Foul odour attract beetle
- Flower of *Amorphophallus* provide safe place for egg laying for insects.
- Yucca and moth cannot complete their life cycle without each other.
- Many insect may consume pollen or the nectar without bringing about pollination. Such lower-visitor called pollen/nectar robbers.

**Out breeding devices:** the various mechanism take discourage self pollination and encourage cross pollination as continued self

Pollination leads to in breeding depression. It includes -

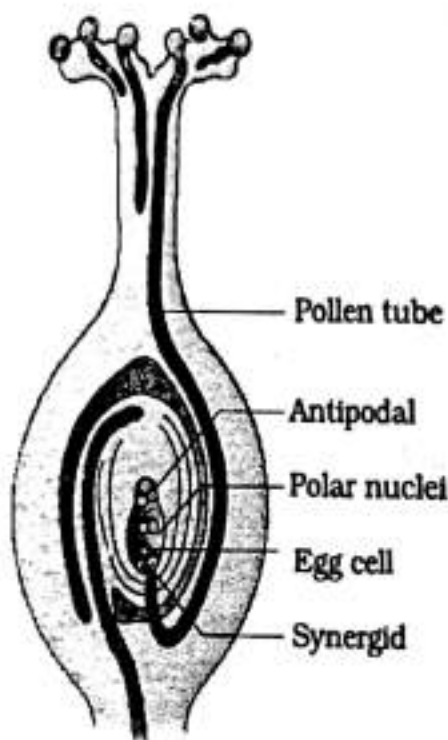
- Pollen release and stigma receptivity not synchronized.
- Anther and stigma are placed at different position.
- Inhibiting pollen grain germination in pistil.
- Production of unisexual flowers.
- Male flower and female flower present on different plant (papaya) (dioecy) prevent autogamy and geitonogamy.

### **Pollen pistil interaction :**

The pistil has ability to recognize the compatible pollen to initiate post pollination events that lead to fertilization. Pollen grain produce pollen tube through germ pores to facilitate transfer of male gametes to embryo sac.

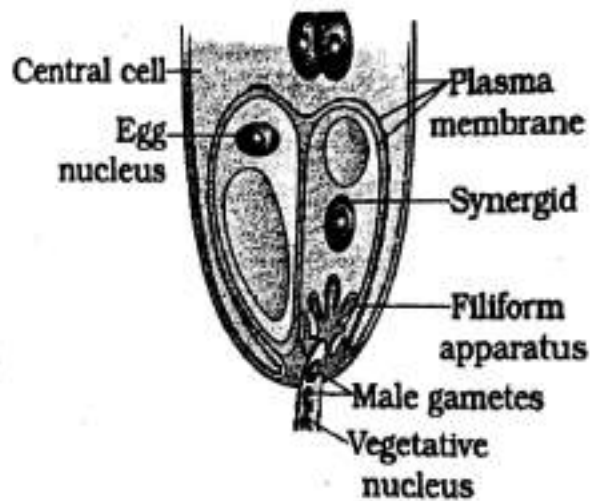
**Double fertilization** - after entering the egg synergids, each pollen grain releases two male gametes. One male gametes fuse with egg (syngamy) and other male gametes fuse with two polar nuclei (triple fusion) to produce triploid primary endosperm nucleus (PEN). Since two types of fusion takes place in an embryo/sac the phenomenon is called double fertilization.

□ The  $2n$  develop into the endosperm and zygote develops into embryo.

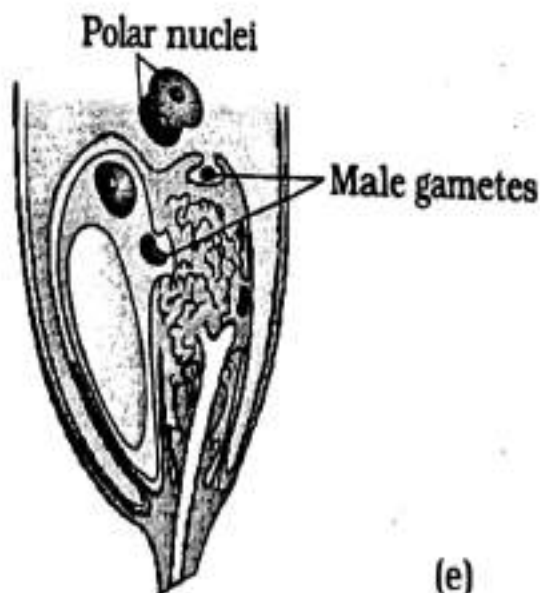


Longitudinal section of a flower showing growth of pollen tube

(c)



(d)



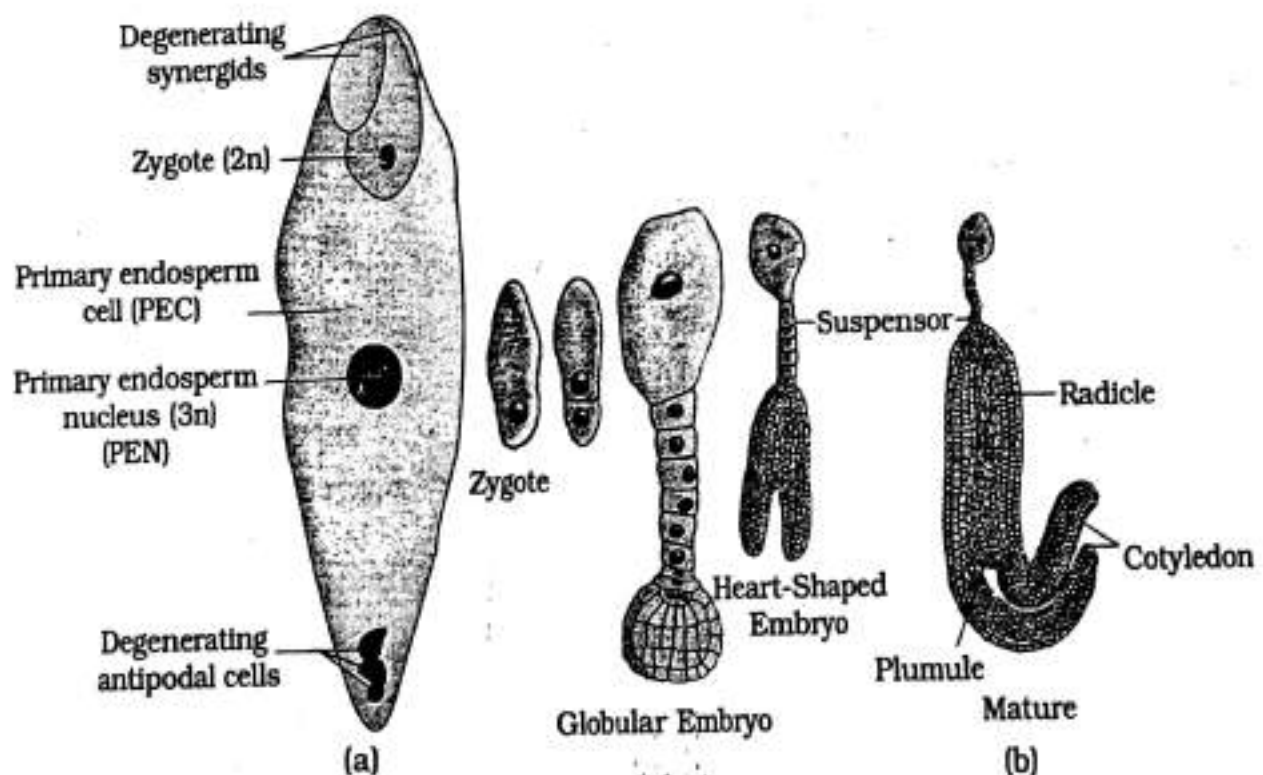
(e)

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

- ❑ **Post fertilization events:** It include endosperm and embryo development, maturation of ovules into seeds and ovary into fruits
- ❑ PEN develop into endosperm and free nuclear endosperm found in coconut water.
- ❑ When endosperm completely consumed during development of embryo before seed maturation such kind of seeds are non-endospermic or ex-albuminous seed. Eg: Pea, ground nut, bean. Castor and coconut have endosperm.
- Seed with endosperm is called endospermic or albuminous seed. Eg: Wheat, rice and maize.

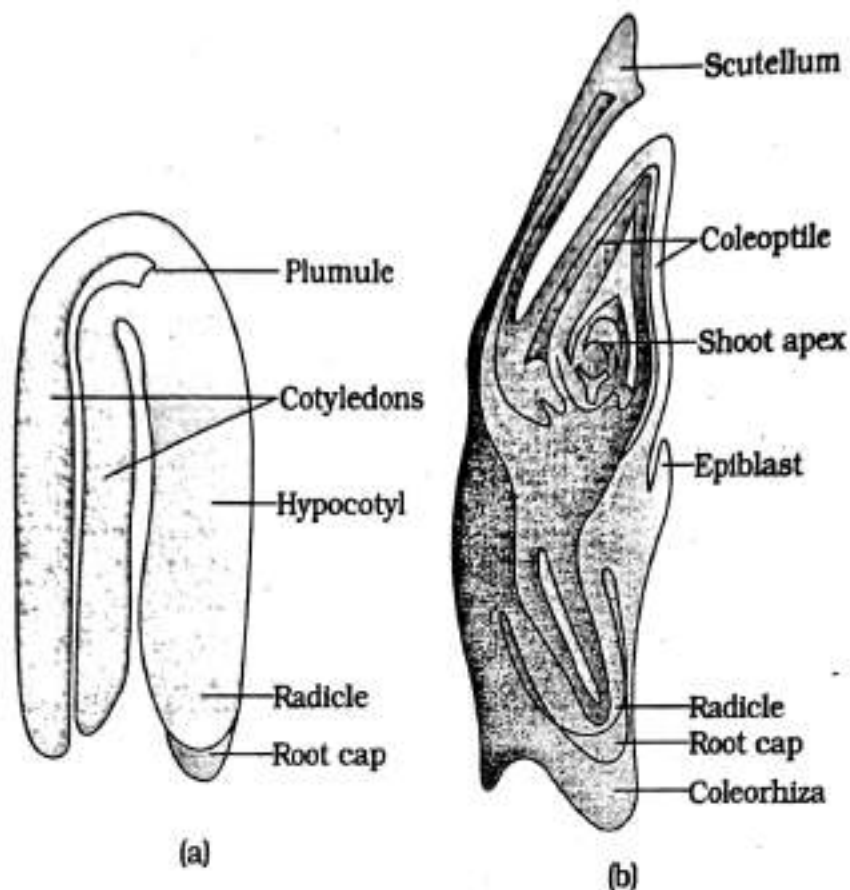
### Embryo :-

- ❑ The zygote gives rise to the pro-embryo and subsequently to the globular, heart-shaped and mature embryo.
- ❑ Dicotyledonous embryo consists embryonal axis and two cotyledons.
- ❑ Monocotyledonous embryo possess only one cotyledons. The cotyledon is called scutellum.
- ❑ The residual, persistant nucellus is the perisperm present in black papper and beet.



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





- ❑ Seed contain only 10-15 % moisture by mass and it is a dormant stage of plant's life cycle.
- ❑ The wall of ovary develops into the wall of fruit called pericarp.
- ❑ Fruit may be fleshy - guava, orange and mangoes  
dry - groundnut, mustard
- ❑ False fruit - develop from other than ovary. eg : Apple, strawberry, cashew
- ❑ Parthenocarpic fruit- Fruit develop without fertilization. It is seedless and can be made by application of hormone. eg: Banana.
- ❑ Apomixis - formation of seeds without fertilization.
- ❑ Polyembryony - occurrence of more than one embryo in a seed. eg: citrus fruit

#### **Artificial hybridization**

- ❑ Removal of anthers from the flower bud before the anther dehiscence using a pair of forceps. This step is referred to as emasculation.
- ❑ Emasculated flowers have to be covered with a bag of suitable size, generally made up of butter paper, to prevent contamination of its stigma with unwanted pollen, the process is called bagging
- ❑ After bagging flower attains receptivity nature pollen grains collected from anther of desired male parent are dusted on stigma and the flowers are rebagged and the fruits allowed to develop.
- ❑ The loss of hybrid seeds become too expensive for the farmer because, if the seed collected from hybrids are sown, the plants in the progeny will segregate and do not maintain hybrid character. If these hybrids are made by apomixis, there is no segregation of character in the hybrid progeny.

## Exercise-1

### [NCERT BASED QUESTIONS]

#### Simple Questions

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1. Which one of the following statements is correct?
  - (1) The anther consisting of four microsporangia
  - (2) Microsporangia develops into pollen sacs
  - (3) Microsporangium is surrounded by four wall layers
  - (4) All of the above
2. Which one of the following statements is not true?
  - (1) Tapetum nourishes the developing pollen grains
  - (2) Sporogenous tissue occupies the centre of each microsporangium
  - (3) Each cell of sporogenous tissue is a potential pollen
  - (4) Tapetal cells are uninucleate
3. Which one of the following statements is not true?
  - (1) Orchids has many ovules in an ovary
  - (2) The body of the ovule fuses with funicle in the region called hilum
  - (3) Integuments encircle the ovule except chalaza
  - (4) An ovule generally has a single embryo sac
4. Which one of the following is an example of water pollinated plants?
  - (1) Hydrilla
  - (2) Water hyacinth
  - (3) Water lily
  - (4) All
5. Moth and the Yucca plant can not complete their life cycles without each other because
  - (1) The moth deposits its eggs in the locule of the ovary in the flower
  - (2) Yucca plants get pollinated by the moth
  - (3) The larvae of the moth come out of the eggs as the seed start developing
  - (4) All of the above
6. Pollen-pistil interaction is a dynamic process involving
  - (1) Pollen recognition
  - (2) Promotion of the pollen
  - (3) Inhibition of the pollen
  - (4) All of the above
7. If the female parent bears bisexual flowers, the stigma is protected from contamination (from unwanted pollen) by
  - (1) Emasculation in bisexual flowers
  - (2) Emasculation in unisexual flowers
  - (3) Bagging of male flower
  - (4) All of these
8. In the process of double fertilisation
  - (1) The pollen tube releases the two male gametes into the cytoplasm of the egg cell
  - (2) The pollen tube releases the two male gametes into the cytoplasm of the synergid
  - (3) One male gamete fuses with nucleus of egg cell and other male gamete fuse with the two polar nuclei
  - (4) Both (2) and (3)

9. Perisperm is present in the seeds of  
 (1) Black pepper (2) Castor (3) Sunflower (4) Groundnut
10. The production of seeds without fertilisation is called  
 (1) Parthenocarpy (2) Apomixis (3) Parthenogeny (4) Syngamy
11. Which one of the following statements is not true about pollen grain?  
 (1) It has diameter about 25-50  $\mu\text{m}$   
 (2) Exine is made up of sporopollenin  
 (3) Sporopollenin is absent at germ pores  
 (4) Intine is made up of glycoprotein and mucilage
12. Which one of the following statements is not true?  
 (1) An ovule generally differentiate a single megaspore mother cell in the micropylar region  
 (2) One of the megaspore develops into the embryo sac  
 (3) Typical angiosperms embryo sac is 8-nucleate and 7 celled  
 (4) Filiform apparatus situated at chalazal end
13. Transfer of pollen grains from anther to stigma of a different plant is called  
 (1) Xenogamy (2) Geitonogamy (3) Chasmogamy (4) Cleistogamy
14. Which one of the following statements is not true?  
 (1) Insect - pollinated flowers are large, colourful, fragrant and rich in nectar.  
 (2) Wind pollinated flowers are not very colourful and do not produce nectar.  
 (3) Water pollinated flower are not very colourful and do not produce nectar  
 (4) Lemurs, rodents, gecko lizard and garden lizard are not pollinators
15. Many insects may consume pollen or the nectar without bringing about pollination. Such floral visitors are referred to as  
 (1) Pollinators (2) Developers (3) Pollen robbers (4) Pollen eaters
16. During fertilisation  
 (1) Pollen tube after reaching the ovary, enters the ovule through the micropyle  
 (2) Pollen tube enters one of the synergids through the filiform apparatus  
 (3) Pollen tube enters egg cell through the micropyle  
 (4) Both 1 and 2
17. Which one of the following statements is not correct ?  
 (1) The portion of embryonal axis above the level of cotyledons is epicotyl  
 (2) Lower end of hypocotyl is covered with a root cap  
 (3) In the grass family root cap enclosed in an undifferentiated sheath called coleoptile  
 (4) In the grass family the cotyledons is called 'scutellum'
18. Occurrence of more than one embryo in a seed is referred as polyembryony. True statement is  
 (1) It is formed by the nucellar cells (2) It is present in citrus and mango  
 (3) It is formed by synergids cells (4) Both (1) and (2)
19. Insect pollinated flowers usually possess  
 (1) Sticky pollens with rough surface (2) Large quantiles of pollens  
 (3) Brightly coloured pollens (4) Dry pollens with smooth surface

20. Aleurone layer is present in  
 (1) The peripheral part of scutellum (2) The peripheral part of coleoptile  
 (3) Cotyledons (4) The peripheral part of endosperm
21. Which one of the following is synonymus with meiocytes?  
 (1) Gamete mother cell (2) Gamete  
 (3) Sperm (4) Monoecious
22. In anatropus ovules, the micropyle is  
 (1) In straight line to the funicle (2) Side by side with funicle  
 (3) At right angles with funicle (4) At  $15^\circ$  with funicle
23. Seeds are called products of sexual reproduction because they.  
 (1) Give rise to new plants (2) Are formed by fusion of gametes  
 (3) Are formed by fusion of pollen tubes (4) Can survive for longer periods
24. The tissue in plant seeds that serves the same nutritive function as yolk in chicken embryos is the  
 (1) Seed coat (2) Endosperm (3) Epicotyl (4) Embryo
25. The fruits having edible thalamus are  
 (1) Apple, Custard apple, Guava (2) Apple, Strawberry, Pear  
 (3) Pear, Pineapple, Strawberry (4) Jackfruit, Guava, Pineapple
26. Which one of the following structures found in dicot seed will be genetically identical with its maternal plant?  
 (1) Testa (2) Radicle (3) Plumule (4) Cotyledon
27. Which prevents self-pollination?  
 (1) Herkogamy (2) Dichogamy (3) Self-Sterility (4) All of the above
28. In the anther wall  
 (1) Tapetum lies just inner to the endothecium  
 (2) Middle layers lie between endothecium and tapetum  
 (3) Endothecium lies inner to the middle layers  
 (4) Tapetum lies next to the epidermis
29. Which one of the following events is not directly affected by light in a vegetable garden?  
 (1) Seed germination (2) Food manufacture  
 (3) Fertilisation (4) Flowering
30. If an endosperm of an angiosperm has 24 chromosomes what would be number of chromosomes in the megaspore mother cell of the same plant?  
 (1) 8 (2) 16 (3) 24 (4) 32
31. In angiosperms the functional megaspore of a linear tetrad is the  
 (1) Second from micropyle (2) Third from micropyle  
 (3) Fourth from micropyle (4) First nearest to the micropyle
32. The pollen grain is related to the embryosac as  
 (1) Male gametophyte is to the egg  
 (2) Male gametophyte is to the female gametophyte  
 (3) Sperm is to the egg  
 (4) Sperm is to the female gametophyte
33. When the anther is young, a group of compactly arranged homogenous cells occupies the centre of each microsporangium called the  
 (1) Tapetum (2) Pollen sacs (3) Sporogenous tissue (4) Microspore



34. Transfer of pollen grains from the anther to the stigma of the same flower is known as  
 (1) Autogamy (2) Geitonogamy (3) Xenogamy (4) Cleistogamy
35. In the grass family the cotyledon is situated towards one side of the embryonal axis called the  
 (1) Hypocotyl (2) Coleoptile (3) Coleorhiza (4) Scutellum
36. Which one of the following structures of a flower is correctly matched with its main function?  
 (1) Anther produces sporocytes  
 (2) Petal attracts pollinators  
 (3) Ovary maintains the orientation of the flower  
 (4) Sepal protect flower from pathogens
37. Milky water of green coconut is  
 (1) Liquid of female gametophyte (2) Liquid endosperm  
 (3) Liquid chalaza (4) Liquid nucleus
38. After fertilisation, the seed coats of seeds develop from  
 (1) Ovule (2) Chalaza (3) Integuments (4) Nucellus
39. Pollen tube usually enters the embryo sac  
 (1) Directly penetrates the egg (2) Between one synergid and central cell  
 (3) Through one of the synergids (4) By knocking of antipodal cells
40. What statement is true about microspore of angiosperms?  
 (1) Resultant of mitotic division (2) First cell of gametophytic generation  
 (3) Resultant of double fertilisation (4) First cell of endosperm
41. Which one of the following is not the characteristics of vegetative cell?  
 (1) It is bigger (2) It has abundant food reserve  
 (3) It has a large irregularly shaped nucleus (4) It is spindle shaped with dense cytoplasm
42. Multicarpellary, syncarpous pistil found in  
 (1) Papaver (2) Michelia  
 (3) Both I and II (4) None of the above
43. A recent record of 2000 years old viable seed is of the  
 (1) Lupine (2) Date palm (3) Orchid (4) Lupinus
44. The microsporangia after development became  
 (1) Sporogenous tissue (2) Tapetum  
 (3) Pollen sacs (4) Endothecium
45. In over 60 percent of angiosperms pollen grains are shed at  
 (1) One celled stage (2) Two - celled stage  
 (3) Three - celled stage (4) Four - celled stage
46. As the anthers mature, and dehydrate, the microspores dissociate from each other and develop into  
 (1) Microspore tetrad (2) Pollen grains  
 (3) Microspore mother cell (4) Sporogenous tissue
47. Which one of the following serves as a landing platform for pollen grains?  
 (1) Stigma (2) Style (3) Ovary (4) Placenta



### ***Answer Exercise - 1***

1. (4)	2. (4)	3. (3)	4. (1)	5. (4)	6. (4)
7. (1)	8. (4)	9. (1)	10. (2)	11. (4)	12. (4)
13. (1)	14. (4)	15. (3)	16. (4)	17. (3)	18. (4)
19. (1)	20. (4)	21. (1)	22. (2)	23. (2)	24. (2)
25. (2)	26. (1)	27. (4)	28. (2)	29. (3)	30. (2)
31. (3)	32. (2)	33. (3)	34. (1)	35. (4)	36. (2)
37. (2)	38. (3)	39. (3)	40. (2)	41. (4)	42. (1)
43. (2)	44. (3)	45. (2)	46. (2)	47. (1)	48. (3)