SEXUAL REPRODUTION IN FLOWERING PLANTS

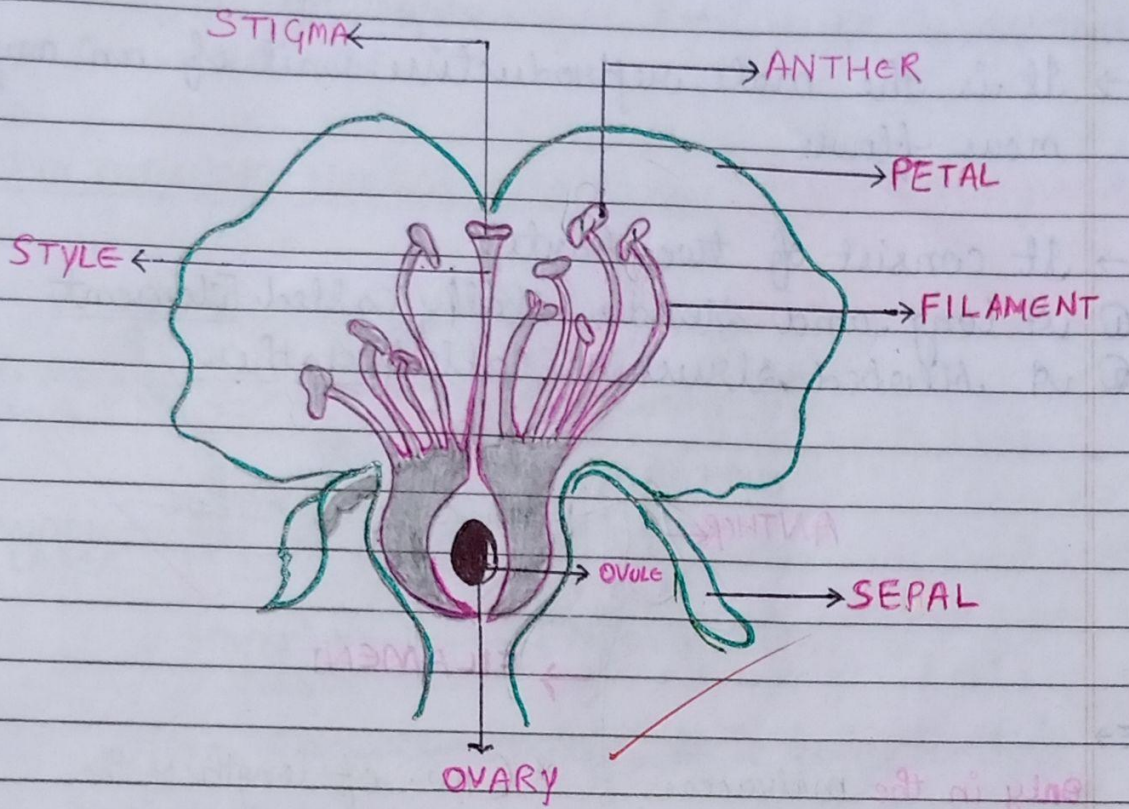


Fig - Diagrammatic representation of a flower

→ The organs specialised to perform sexual reproduction in angiosperms are flowers.

→ Flowers are basically modified condensed shoots.

→ A typical flowers has 4 whorls of flower leaves viz., Sepals (calyx), Petals (corolla), Stamen (androceium - male reproductive parts) Carpels (gynoceium - female reproductive parts).

→ Petals and sepals together form the floral envelope which is called Perianth while an individual member of perianth, when sepals and petals are not clearly differentiated, is called tepal

Pre-Fertilisation: Structures and Events

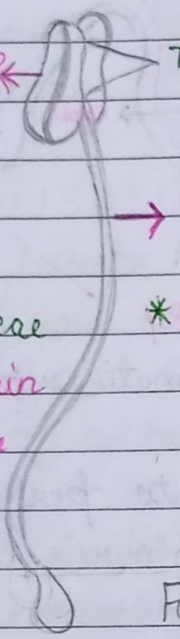
Date: _____ Page: 20

MALE REPRODUTIVE ORGAN-

(i) STAMEN

→ It is the male reproductive unit of an angiosperm flower.

→ It consist of two parts
① A long and slender stalk called Filament
② A bilobed structure called Anther



NOTE→ Only in the malvaceae family which contain rose, cotton etc. have unilobed Anther

* (no. of length of the stamens is variable in different flowers)

Fig- Stamen

Proximal end of filament is attached to the thalus. The part at which anther & filament join known as connective

→ The anther is usually bilobed with each lobe having two theca i.e. they are dithecous

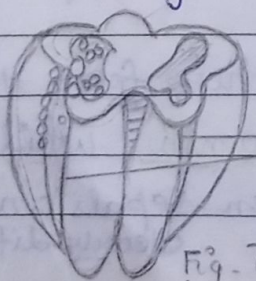


Fig. Three dimensional cut section of an anther.

→ The anther is four sided (tetragonal)

- Consist of 4 microsporangia located at the corners, two in each lobe.

(ii) STRUCTURE OF MICROSPORANGIUM

→ Microsporangia develop into Pollen Sacs. They extend longitudin-ally.

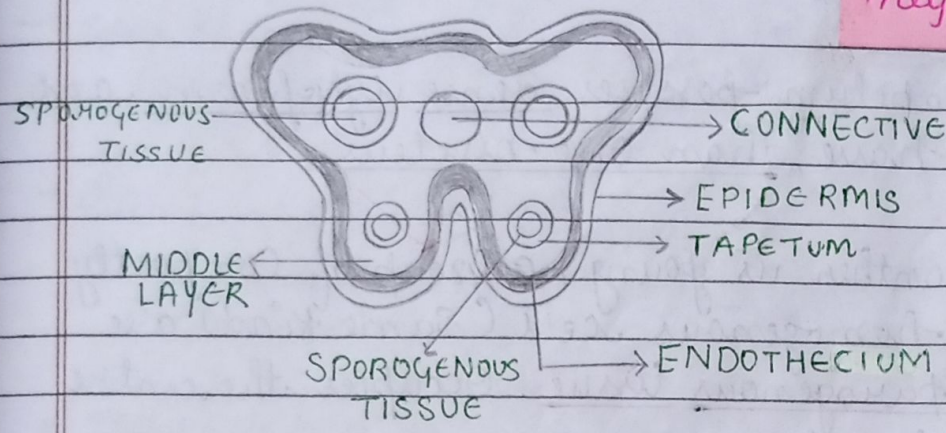


Fig – Transverse Section of a young anther.

→ Appears circular in outline
→ Surrounded by 4 wall layers.

* EPIDERMIS, ENDOTHECIUM, MIDDLE LAYER → DEHISCENCE OF ANTHER
FUNCTION – PROTETION
* TAPETUM – Nourishing the Pollen grain

→ EPIDERMIS – One cell thick and protective in function

→ ENDOTHECIUM – Single layered, cells have, cell thickning with a little pectin and lignin in in some cases, it helps in anther dehiscence (splitting at maturity)

→ MIDDLE LAYER – 1–6 layers, they degenerate during maturity of the anther.

→ TAPETUM – ◦ Tapetal cells are nutritive.

◦ By this ubisth bodies are produced which help in ornamentation of microspore wall.

◦ A compound sporopollenin is secreated by which bodies which is deposited in the exine of microspore wall.

◦ Cells of tapetum posseses dense cytoplasm and generally have more than one nucleus.

→ When the anther is young, a group of compactly arranged homogenous cell (same kind) are called Sporogenous tissue. Occupies the centre of each microsporangium.

* MICROSPOROGENESIS :-

Anther develops → cells of sporogenous tissue will undergo meitotic division → microspore tetrads (To Form)

As each cell is capable of giving rise to microspore tetrad. each one is patential pollen or microspore mother cell this is known as (PMC) (Pollen Mother cell)

* The formation of microspore from a pollen mother cell through meiosis is called Microsporogenesis.

→ As the anther mature and dehydrate, the microspore dissociate from each other and develop into Pollen Grains.

Inside each microsporangium several thousands of microspores or pollen grains are formed that are released with the dehiscence of anther.

(iii) POLLEN GRAIN:- When tetrad breaks each microspore is called Pollen Grain.

→ Male gametophyte
→ Generally, Spherical in shape measuring about 25-50 micrometers in diameter

→ Has 2-layered wall
hard outer layer – exine (thick, hard)
inner wall – intine.

* PROPERTIES OF Exine

- Made of Sporopollenin.
- Dude to sporollenin, it withstand high temperatures and acids and alpali.
- It has germ pore where sporopollenin is absence.
- Exine has various patterns and designe.

* PROPERTIES OF Intine

- It is a thin layer
- It is made up of cellulose and pectin.

"Study of Pollen Grains known as Polynology."

MICROSPORE TO POLLEN GRAINS

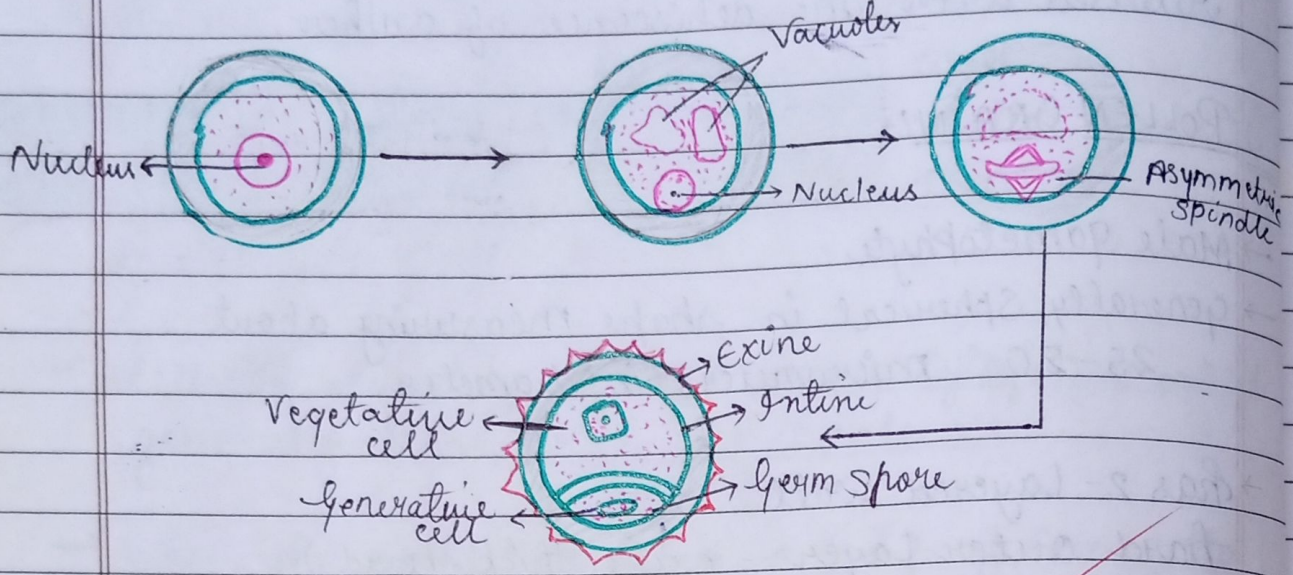


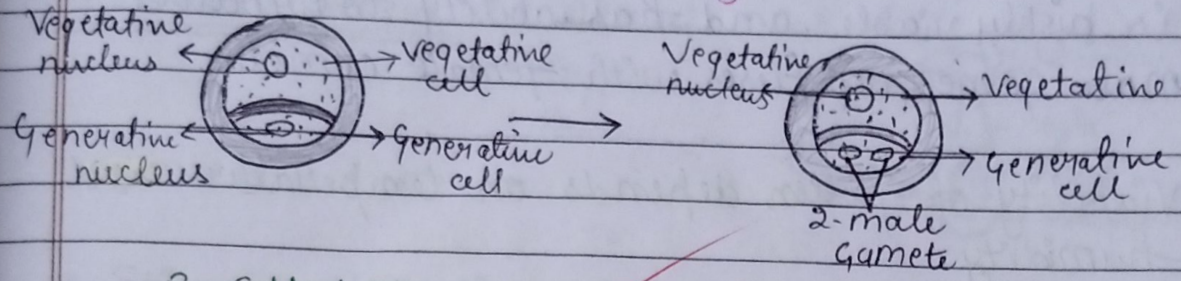
Fig- Stages of a microspore maturing into a Pollen Grain.

When a microspore starts maturing a vacule forms inside the cytoplasm and a asymmetric spindle occur due to the formation of vaccule the nucleus shift to perifem side and after electric spindle occurs two nucleus formed in the cell and a cellulose layer is formed making two cells known as vegetative cell (bigger) and generative cell (smaller one). This is known as 2-celled stage of microspore.

Note → The Symmetric Spindle divides through mitosis known as asymmetric mitosis.

Note → A pollen grain shed at 2-celled stage. It have to form male gametes in pollen tube until it reaches to ovule.

Note→ In some species, the generative nucleus divided mitotically to form 2 male gametes before pollen grains are shed. It is known as 3-cells stage.



2-Celled Stage of microspore

3-celled stage of microspore

POLLEN ALLERGY :-

The overaction or oversensitivity of immune System causes allergy.

Therefore, when a immune system of a people is oversenstive to pollen grain it is known as pollen allergy

For ex- Parthenium causes pollen allergy

USES OF POLLEN GRAIN

- Pollen grains can be used as food supplements.
- They are used in making tablets and syrups
- They are used to increase the performances of athletes and race horses.

POLLEN GRAIN VIABILITY

The time period at which a pollen grains is highly viable and has ability to produce male gamete and fuses with female gamete.

- Viability of pollen depends on temperature and humidity.
- It varies from species to species.

Note: Rice, wheats, pollen grains lose viability within 30 minutes, whereas members of Leguminosae and solanaceae has viability of few months.

POLLEN BANKS

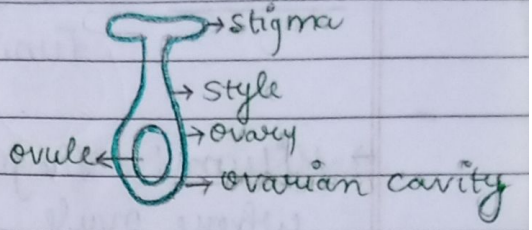
It is the store house of pollen grains.
The stored pollen grains are used for further fertilisation progammes.
In pollen banks the viability of pollen grains are maintained for so long by process of Cryopreservations.

CRYOPRESERVATIONS

It is the process in which chemical are used to maintain the viability of pollen grain for years. Mainly Liquid Nitrogen is used for this purpose whose temperature is -196°C

FEMALE REPRODUCTIVE ORGAN –

- **PISTIL/CARPEL** :- Stigma
  - Style
  - Ovary



→ **Stigma** :- It is the upper part of pistil where pollen grain lands

→ **Style** :- The long slender part below the stigma is known as style.

→ **Ovary** :- It is the basal bulged part of pistil.

→ **Ovule** :- ovule is present inside the ovary. It has two layers :-
- Inner integumen
- Outer integumen

→ **Locule or Ovarian Cavity** :- ovarian cavity is present inside the ovary. It contains placenta which connects locule and ovule.

Ovary → Locule —Placenta→ Ovule

- **Ovule** :-

Megaspore-angium.

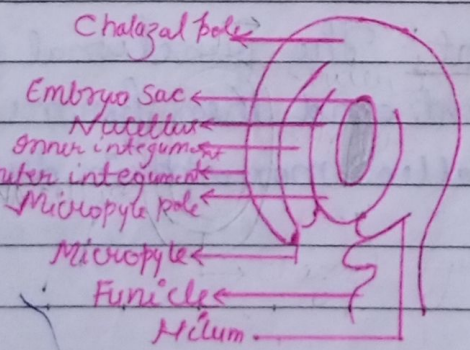


Fig- Diagrammatic view of a typical anatropous ovule.

Date: _____ Page: 3

→ Nucellus :- Mass of cells present inside the ovule.

→ Funicle :- The ovule is attached with placenta by Funicle.

→ Hilum :- The junction b/w an ovule and funicle where ovule fuses with funicle.

→ Micropyle :- The integument layer covers the whole ovule except one region which is called micropyle opening.

→ Chalaza :- This is the basal part of ovule opposite to the micropyle end.

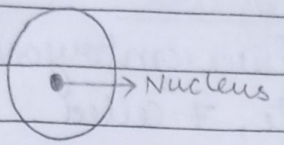
- Mega Spore Mother Cell → The specialised cells which undergo meosis and forms four megaspore. It is diploid (2n) in nature. (megasporogenesis)

Note → Out of four megaspore three degenerates and the one remaining megaspore is known as function megaspore.

- ## MEGAGAMETOGENESIS

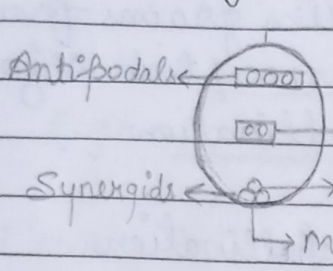
- Monosporic Development :- The functional megaspore undergoes development and then forms embryosac. This is called monosporic development.

- **Embryosac :-** The megaspore forms a embryosac through reduction division.



Now the nucleus undergoes mitotic division.

This mitotic division results in a 8-nucleate embryosac (1→2→4→8)



Fig→ 8-nucleate embryosac

- **Antipodals :-** The 3 cells which are present at the chalazal end in the embryosac are called antipodals

- **Central cell :-** The two polar nuclei has common cell membrane and it is called the central cell.

- **Egg-Apparatus :-** The three cells grouped at the micropyle end called egg apparatus togetherly

- **Synergids :-** The two very bottom cells are called Synergids

- **Filiform apparatus :-** A complex of cell wall invaginations in a synergid cell, similar to those in transfer cells.

Note→ Filiform apparatus plays an important role in guiding the pollentube to synergids.

- Mature Embryosac :- A mature embryosac is 8-nucleate, 7-celled.

POLLINATION

Pollination :- The transfer of pollen grains from the anther of the stamen to the receptive stigma of the carpel / pistil is called pollination.

- Types of pollination :-
  - Self pollination
  - Cross pollination

→ If the male gamete has to transfer to stigma of same flower, it requires no agencies. This is called Self-pollination.

→ If the male gametes has to be transfer to stigma of another same kind of flower then requires some agencies. This is called cross-pollination.

Note→ Self-pollination has 2 types • Autogamy → Homogamy, Cleistogamy
• Geitonogamy
Cross-pollination has only 1 types • Xenogamy

SELF-POLLINATION

① → Autogamy → The anther in stigma of chasmogamas flower are brought together by growth, bending or folding. In Vinca the growth of style brings

the stigma in contact with ripe others. e.g - Pea, rice etc.

Autogamy
- → Homogamy
- → Cliestogamy

→ The method in which both the anthers and the stigma of bisexual flowers mature at the same time is called Homogamy
E.g - Mirabilies 4 o'clock

→ Flowers are intersexual, they remains close causing self-pollination. It occurs late in flowering season in some plants are known as Cliestogamy
E.g - Oxalis, Viola etc

② → Geitonogamy :→ It is the type in which pollen grains of one flower are transferred to the stigma of another flower belonging to either the same flower or genetically same plant.
e.g - Cucurbita.

Note → Homogamy and cliestogamy are parts of Autogamy.

Differences :-

Chasmogamous Flower	Cleistogamous Flower
i) They are open flower	They are close flower
ii) Their is cross-pollination seen in these flower.	only self-pollination is seen in these flower.
iii) Flowers are often prominant	Flowers are not much distinctable.

Note — Eg. of chasmogamous flower — Hibiscous
Eg. of clistogamous flower — oxalis, Viola.

CROSS-POLLINATION

→ **Xenogamy** :- Pollen grains of one flower is transferred to stigma of different flower.
It brings genetically different types of pollen grains to stigma.

POLLINATORS → The carrier or agencies which are required to carry pollen grains or to carry out the process of pollination.

TYPES OF POLLINATORS OR AGENTS

- ABIOTIC AGENTS
  - → WIND POLLINATION
  - → Water POLLINATION
- BIOTIC AGENTS
  - → ANIMALS
    - Reptiles
    - Birds
    - Mammals
    - Insects
      - Malacophily
        - ex :- cobra (snake)

* **ABIOTIC POLLINATIONS** :-
Winds and water are abiotic agent.

Note → If pollen grains are transferred by wind it is said **Anemophily**.
e.g. Rice, Corn and oats etc.

Note → If pollen grains are transferred by water it is said Hydrophily.

Eg → Vallisneria, Hydrilla and Zostera.

Requirements

- Anemophily :-

- Pollen grains should be light weight.
- Flowers should be chasmogamas.
- Plollen grains should not be sticky.
- Stigma should be sticky
- Flower not need to be attractive.
- Pollen grains should be in large number.

- Hydrophily :-

- Pollen grain Should be light weight.
- Flowers should be Chasmogamous
- Pollen grain should be in large number.
- Anther have to be in range of water.
- Stigma have to be long and sticky

* BIOTIC POLLINATION

Animals, Insects, Bats, Bird are biotic pollination.

Note → If pollengrains are transferred by Animals it is said Zoophily . e.g. bears, rabbits etc.

Note → If pollen grains are transferred by Insects it is said Entomophily. e.g- Rose, Jasmine.

Date: Page

Note → If pollen grains are transferred by Bats it is said Chiropterophily. For ex- Adansonia, Kadam

Note → If pollen grains are transferred by Birds it is said Ornithophily for ex- Butea, Bombox, Parrot

- Requirements for biotic pollination :-

→ Pollengrain should be sticky
→ Flowers should be attractive (brightly coloured
good fragerance
nectar)
→ Flower should provide landing platform for insects.
→ Pollen grain should be of light weight.
→ Pollen grain should be in large number.
→ In case of bats, flower should bloom at night.

Note → Pollen bed :- The layer on pollen grain which make it sticky.

- Prepatency :- Pollen grains of another flower geminate more rapidly over the stigma than the pollen grain of same flower.

* Pollen-Pistil Interaction

It involves the events from the deposition of pollen on the stigma till the entry of pollen tube into the ovule.

• Recognition of Compatible Pollen

- The pistal has the ability to recognise and accept the right pollen or reject the incompatible pollen either of the same species or of other species.
- The ability of the pistil to recognise the pollen (followed by its acceptence or rejection) is the result of continous dialogue mediated by chemical components of pollen interacting with those of the pistil.

* After recognition of the correct pollen, pistil promotes post-pollination events that leads to fertilisation.

• Growth of a Pollen Tube

Once a pollen grain settles on a compatible pistil it may germinate in response to a sugary fluid secreted by the mature stigma. Lipids at the surface of the stigma may also stimulate pollen tube growth for compatible pollen tube reaches an ovule, it ~~is~~ bursts to deliver the two sperm cells.

ARTIFICIAL HYBRIDISATION

- It is one of the major approaches of crop improvement programme.
- In such crossing only the desired pollen grains are used for pollination and stigma is protected from contamination.
- It is achieved by the following methods:-

(A) Emasculation (B) Bagging

[A]. Emasculation

- The anther is removed from the bud before it dehisces using a pair of forceps, if the female parent bears bisexual flowers.

[B]. Bagging

- The emasculated flower is covered by a bag of suitable size generally made up of butter paper.
- So as not to allow contamination of the stigma by unwanted pollen grain.

Note→ If the female parent is unisexual, emasculation is not necessary.

DOUBLE FERTILISATION

- **Syngamy**

Male gamete fuses with female gamete to form zygote.

M.G + F.G → Zygote.

- **Triple Fusion**

Second male gamete fuses with the two polar nuclei to form Primary Endosperm nucleus which is triploid

M.G + 2 Polar Nuclei ⟶ Primary Endosperm Nucleus (3n)

- **Double Fertilisation**

- Since two types of fusions, syngamy and triple fusion takes place in an embryo sac the phenomenon is termed double fertilisation.

- This process was demonstrated for the first time by Nawaschin in 1898 in Lilium and Fritillaria.

- Note → The most important and unique characteristic feature of angiosperms is the participation of both male gametes in the act of fertilisation.

- **Nourishment of Zygote**

Zygote takes nourishment from endosperm to form

Date: Page:

embryo. Endosperm is the tissue which provide nourishment to the growing embryo or dividing nucleus.

- **Outerbreeding devices**
  Prevent self pollination and promote cross pollination even in bisexual flower.

- **Herkogamy**
  It is the mechanical device that prevent self self pollination & promote cross-Pollination.

- **Embryogenesis :-**

  The formation of embryo from zygote through mitosis.

- **Micropyle opening**
  It is opening for absorption of water and mineral and exchange of gases.

Post Fertilisation : Structures and Events

* It takes place soon after double fertilisation. It includes development of endosperm and embryo, maturation of ovules into seed and and ovary into fruit.

DEVELOPMENT OF AN ENDOSPERM

→ Endosperm development precedes embryo development.
The process takes place by following steps.

i Primary endosperm cell divides repeatedly and forms triploid endosperm tissue.

ii P.E.T (Primary Endosperm tissue) undergoes successive free nuclear division to give rise to free nuclei. At this stage, it is called Free nuclear endosperm

iii From periphery wall endosperm become cellular

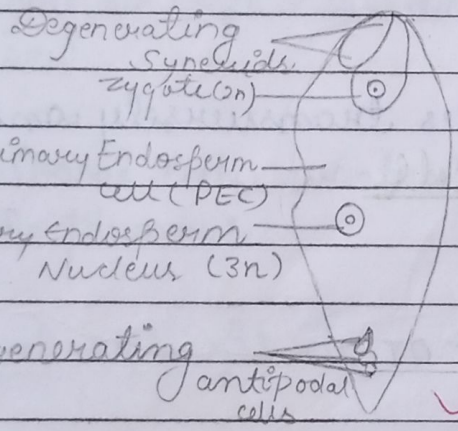


Fig - Fertilised embryo sac showing Zygote and primary endosperm nucleus.

Note → Main functions of an endosperm is that provide nutrition of the developing embryo.

Date: _____ Page: 35

DEVELOPMENT OF AN EMBRYO

→ Development of zygote gives rise to an embryo, that has the potentiality to form a complete plant called embryogeny.

→ small daughter cell, with dense cytoplasm situated towards chalazal pole side called terminal cell or apical cell or embryonal cell.

→ Comparatively large daughter cell situated towards the micropylar cell called Basal cell

→ This basal cell divides transversely and give rise to Suspensor cell

* EMBRYOGENY IN DICOT

- In a typical dicot the zygote elongates & then divides by a transverse wall into two unequal cells, the larger basal cell is K/a Suspensor cell which has a large central vacuole.
- The smaller denser terminal cell toward the antipodal end is termed as embryo cell.

- The suspenser cell divides transversely a few times to produce a ~~fle~~ filamentous suspensor of 6-10 cells. The suspensor cell help in pushing the embryo ~~it~~ into the suspensor.
- The first cell of the suspensor towards the micropylar end and termed as haustorium.
- The cell of the suspensor cell at the adjacent end to the embryo is known as hypophysis. which formed radical and root cap
- Embryo cell undergoes two vertical divisions and one transverse division to form 8 cells arranged in two tier i.e. epibasal and hypobasal (near the Susfensor)
- The epibasal cells eventually form the two cotyledons and the plumule.
- Hypobasal cells produce the hypoptyl except its tip.
- Initially the embryo is globular and undifferentiated with radial symmetry known as proembryo.
- It is transferred into embryo with development of radicle (root), Plumule (shoot) & cotyledons.
- Two coteyledons differentiates from the sides with a faint plumule in the centre. at this time the embryo becomes heat shaped.

Date: Page:

- **Structure of Dicot Embryo :-**

- A typical dicot has an embryonal axis and two cotyledons.

- The part of the embryonal axis above the level of cotyledon is known as epicotyl. It terminates in the stem tip known as Plumule.

- The part below the level of cotyledon is known as hypocotyl which terminates into the root cap known as Radicle

- Root tip is covered with a root cap.
  e.g- Mango, Apple, rose & radish etc.

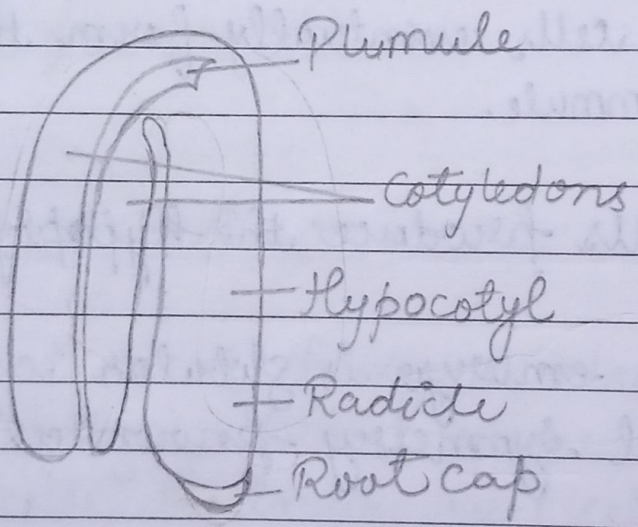


Fig- A typical dicot embryo.

NOTE→ In monocot embryogeny cotyeledon is a Paper like thin substance having negligible amount of food and nutrients so it take nutrition of food & from starchy endosperm present in seed For ex- Maize

• EMBRYOGENY IN MONOCOT

- Zygote elongates and divides transversely to form basal and terminal cell. Basal cell produces a large swollen vasicular suspensor cell.
- The terminal cell divides by another transverse wall to form two cell.
- The top cell after a series division from Plumule & a single cotyledon known as Scutellum
- The cotyledon rapidly grows and pushes the terminal plumule to one side. The plumule comes to lie in a depression.
- The middle cell after many divisions forms hypocotyl and epicotyl. It also have a small suspensor cells.
- In some cereals plumule and radicle get covered by a sheath develop from scutellum known as coleoptile and coleorhiza. eg- Grass, palm etc.

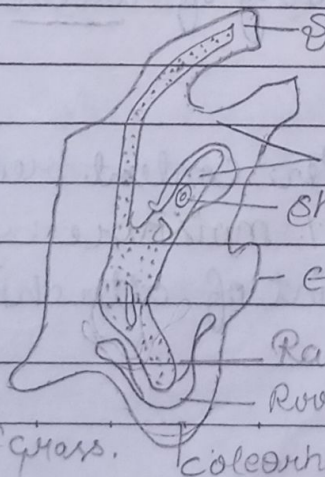


Fig- Monocot Embryo of grass.

DEVELOPMENT OF A SEED

Double fertilisation in angiosperms triggers the transformation of ovule into a seed.

* Seeds are formed inside the fruits.

Structure of a Seed

- Seed consists of a seed coat, cotyledon & an embryonal axis.

- Seed coat often double layered formed by integuments.
  - outer seed coat known as testa (hard)
  - Inner seed coat known as tegmen.

- Cotyledons are thick swollen with food materials.
  - These are 1-2 in number
  - And rich in reserve food material

- Microfyle small opening found in seed coat used for entry of water & oxygen into seed.

- Seed matures water content reduced & seeds become dry. (10-15% moisture by mass)
  Hilum marks point of attachment to the stalk.

- Note → General metabolic activity of embryo slow down & may enter into inactive state called dormancy.

→ Seeds germinate into plants when conditions are favourable.

TYPES OF SEED

- Albuminous
- Non-albuminous.

→ Depending upon presence or absence of endosperm Seeds having copious amount of endosperm tissue are ~~or~~ called Albuminous. e.g. Onion

→ Seeds in which endosperm is used up are Non-albuminous. e.g. Pea.

[→ DEPENDING upon the number of cotyledons, Seeds can be Monocot or Dicot.]

Advantage of Seeds.

i) Stored food in seed support the growth of seed till they become nutritionally independent

ii) Seeds are good for seed dispersal to form new plants colony

iii) Stored for long time as food source.

iv) Seeds are product of sexual reproduction, they show genetic recombination.

FORMATION OF A FROIT

Fruit is formed after fertilisation as a result of cell division & differentiation in the ovary.

→ wall of ovary develops into the fruit wall called Pericarp

→ which may be Fleshy e.g- guava, tomato

→ Pericarp protect seeds & helps in their dispersal.

→ e.g- of leathery & dry pericarp is- pea, beem

Significance of Fruit Formation

i) Fruits protects seed from injury.

ii) Fleshy fruits provide food to animals who also act as dispersal agent of their seeds.

iii) Fruits are a source of nutrition to human

TYPES OF FRUITS

- TRUE FRUITS
- FALSE FRUITS

i) Fruit derived from ovary of a flower is called True Fruits (not associated with accessory floral part)
e.g- Mango, Tomato etc.

ii) Fruit derived from ovary along with other accessory floral part is called False Fruits
e.g- Apple, cashewnut ~~or~~ etc.

PARTHENOCARPY
- Vegetative cell seedless fruit can develop even without stimulus of pollination e.g- Pear.
- Stimulative stimulus of pollination is required without actual process of fertilisation e.g- Grapes

- Their is a false fruit which is produced by parthenocary without the sexual intercource between male & female gametes in plants.
eg. Banana.

Note → It can be induced through the application of growth hormones.
And they are seedless.

Special Mechanisms of Reproduction

Plants have envolved a special mechanism to produce seeds or to develop many embryos from single fertilised egg.

Date: Page:

APOMIXIS

→ In apomixis female gametes self-develop and forms seeds without fertilisation.

→ It is a an asexual reproduction but it mimics like sexual reproduction

e.g- Poaceae

POLYEMBRYONY

→ Many embryo forms inside a fruit due to multiple embryogenesis.

OR

Development of two or more embryo from a single fertilised egg.

e.g- Orange, Lemon