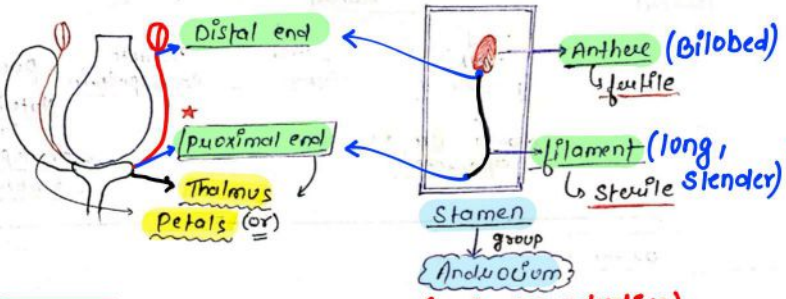
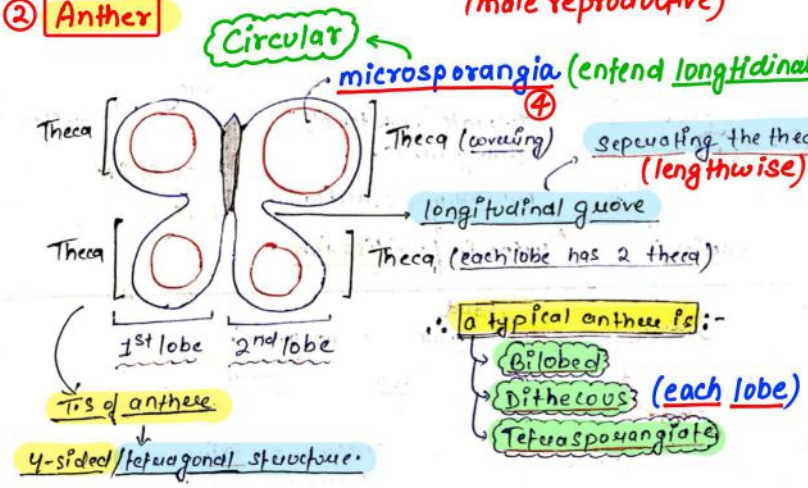
SEXUAL REPRODUCTION IN FLOWERING PLANTS

① Stamen



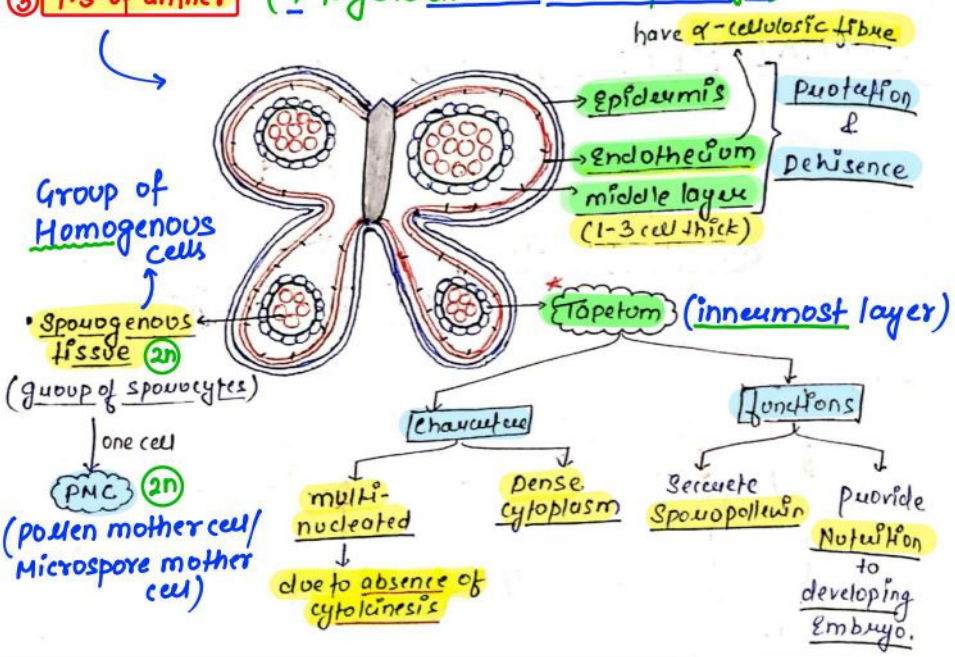
② Anther

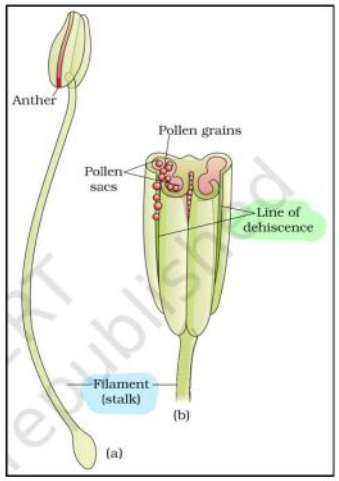


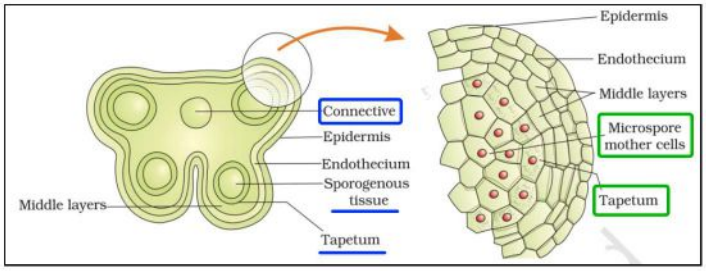
* Flowers are object of aesthetic, ornamental, social, religious & cultural value.
* Flowers are morphological & embryological marvels & site of sexual Reproduction
* several hormonal & structural changes initiated ↓ which lead to differentiation & further development of floral primordium

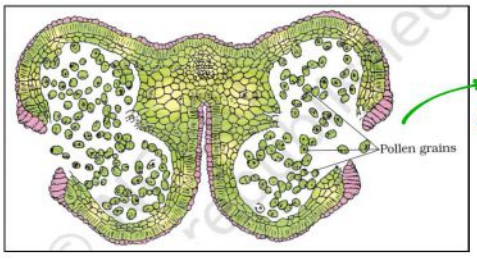
* Number & length of stamens are variable in flowers of diff species
* microsporangia → pollen sac (pollen grain)

③ T.S of anther (4-layers around microsporangia)

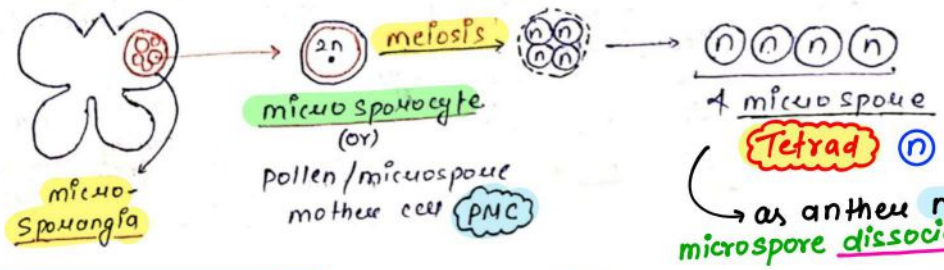








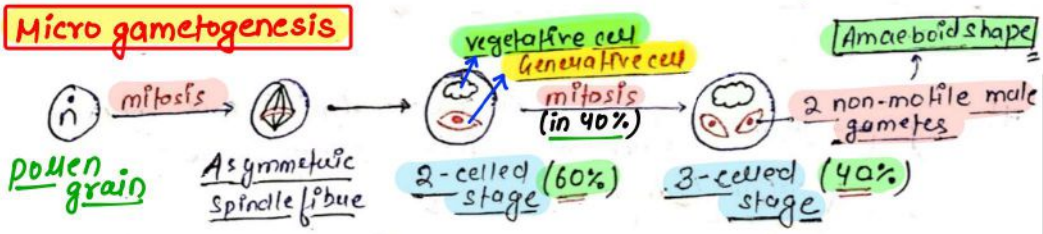
④ Micro sporogenesis (PMC —meiosis→ microspore)

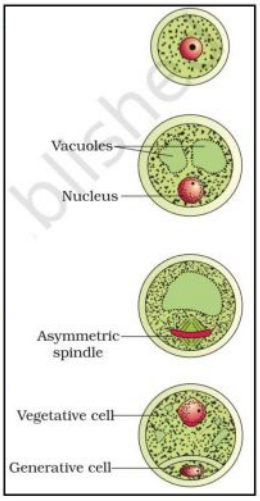


- Each cell of sporogenous tissue is capable to form microspore tetrad, ∴ each one is potential PMC

→ as anther mature & dehydrate microspore dissociate & develop into pollen grain.

⑤ Micro gametogenesis





mature pollen grain

- **Vegetative cell** (Tube cell) → Big cell → Abundant food reserve (Nutrition) → Irregular Nucleus (large)
- **Generative cell** (small) → Spindle shape → Dense cytoplasm → floates in cytoplasm of vegetative cell.

⑥ pollen grain (male gametophyte)

- **exine**: Hard, made of sporopollenin
- **inline**: Thin, contineous, cellulose & pectin
- **Germ pore** (prominent apertures) → pore present on exine where sporopollenin is absent. → pollen tube arise
- **Size**: 25-50 µm in diameter (spherical)

* pollen grains of different species have variety of architecture in → size, shapes, colours, design

⑦ Sporopollenin

- Secreated by Tapetum

* its deposition very specific in every species.

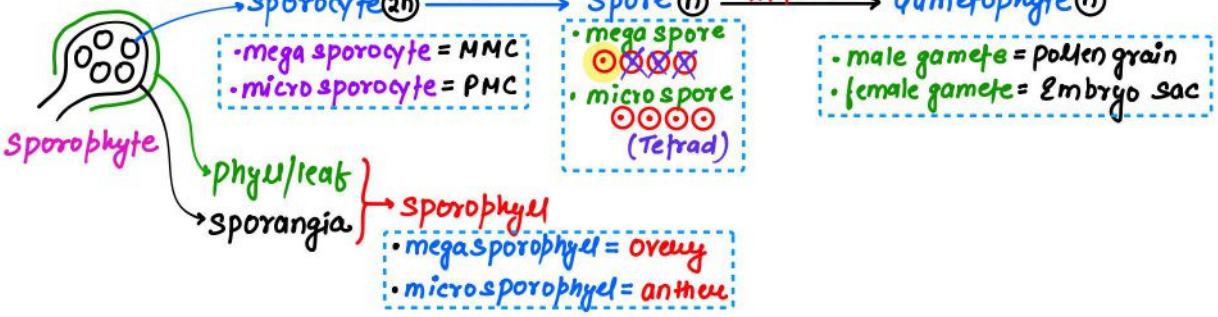
- most inert/resistant organic material → Tolerate high temp^{r}; strong acids. → No enzymatic action → * Helps in fossilisation

* It form exine → exhibits fascinating array of pattern & design → * helps in identification (Taxonomy)

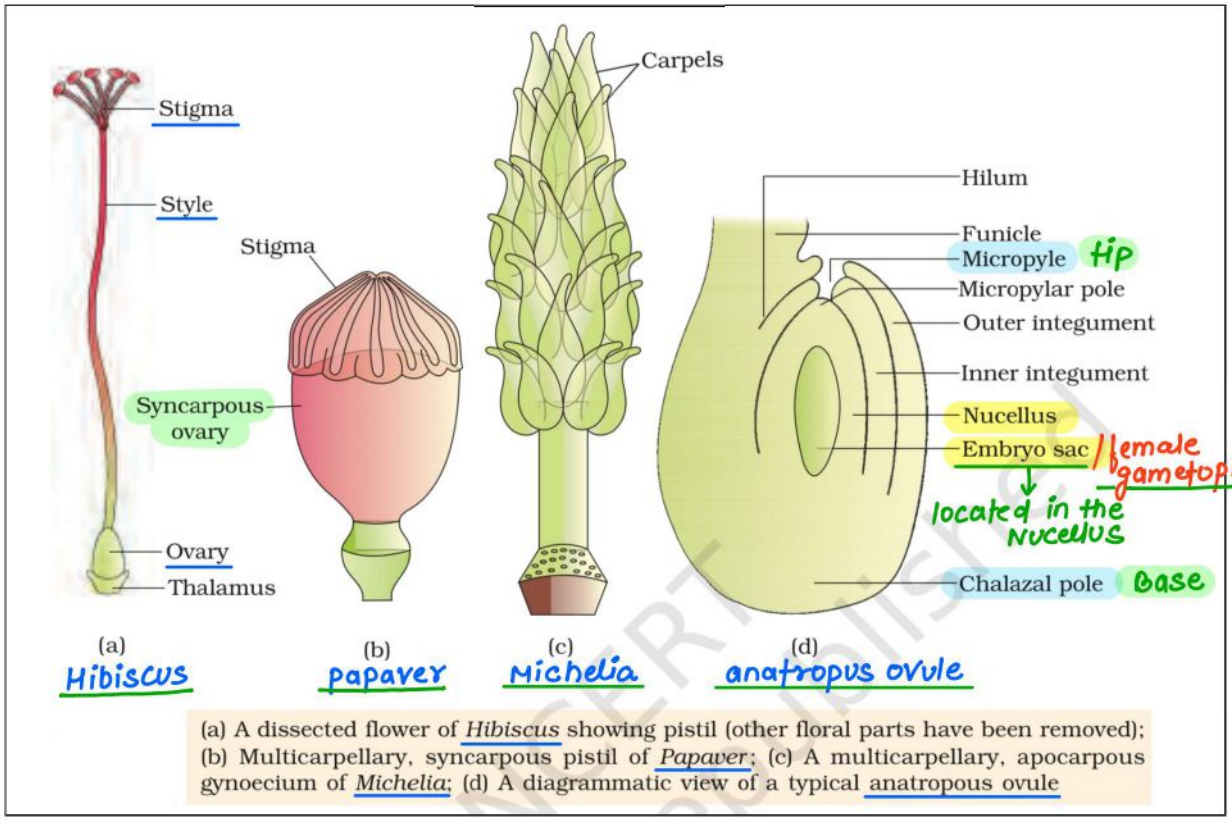
⑧

pollen Allergy	pollen Tablet	pollen viability	pollen bank
• air born pollen grain. → • allergies & bronchial affection → chronic Respiratory disorder → asthma, bronchitis • parthenium (carrot grass) → Imported with wheat.	• pollen rich in nutrients → used as tablet & syrup to increase efficiency of Race horse & Athletes • Bee pollen • Pollen jelly (in western countries mostly)	• period upto which pollen can germinate → variable, → Depend on temp & moisture. • Wheat, • Rice → 30 min (poaceae) • Leguminosae, • Rosaceae, • Solanaceae → months	• Storage of pollen in liquid nitrogen → at −196°C → used in • Crop breeding programme (called Cryopreservation)

★ **Imp points**



⑨ **Gynoecium** (female reproductive part, it is group of pistils)

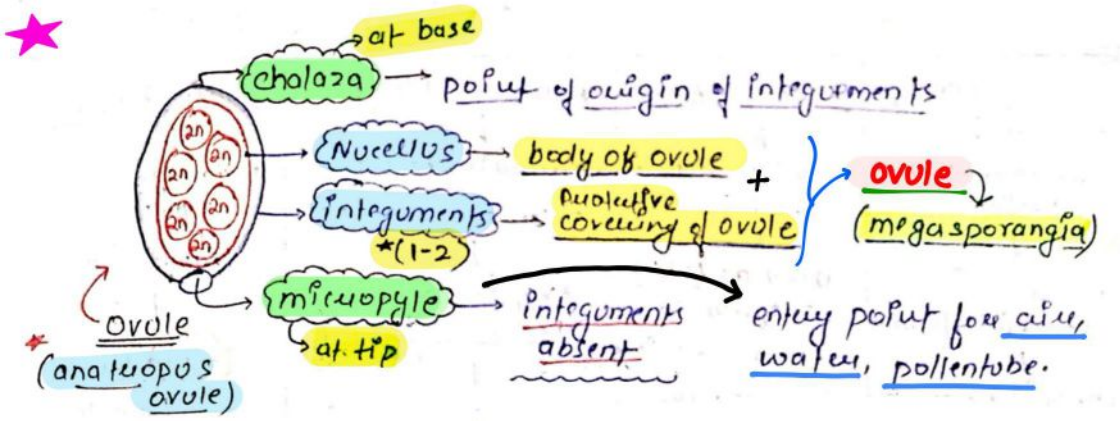


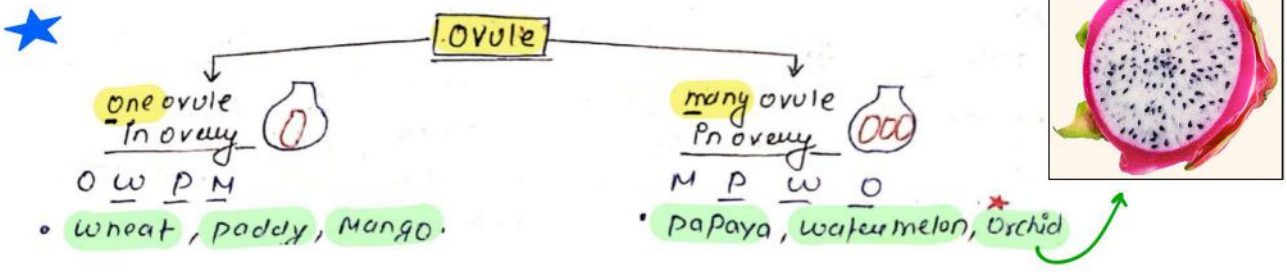
(a) A dissected flower of *Hibiscus* showing pistil (other floral parts have been removed); (b) Multicarpellary, syncarpous pistil of *Papaver*; (c) A multicarpellary, apocarpous gynoecium of *Michelia*; (d) A diagrammatic view of a typical anatropous ovule

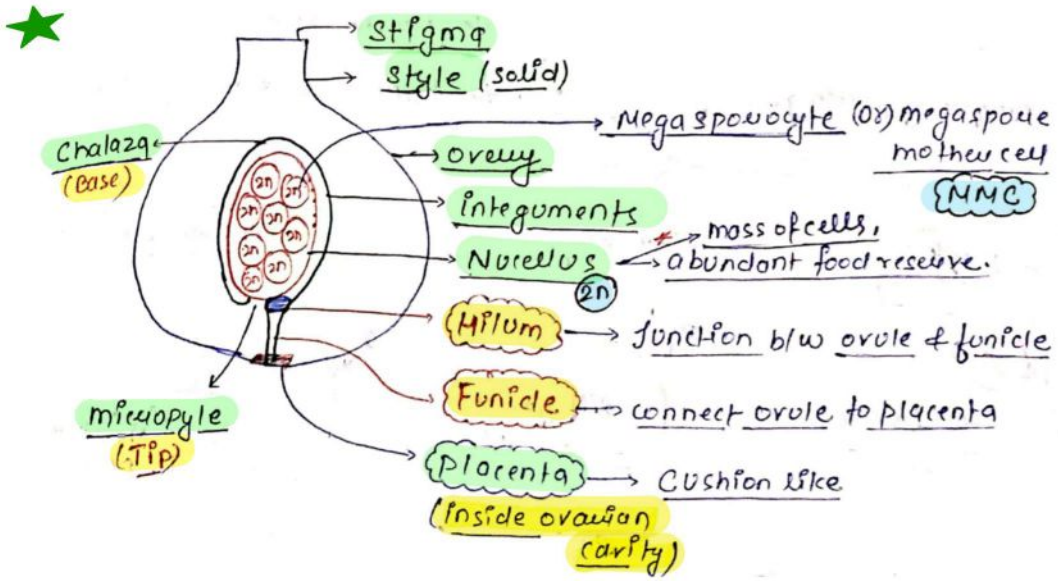
Hibiscus | papaver | Michelia | anatropus ovule

Micropyle → Hip
Chalazal pole → Base
Embryo sac / female gametophyte → located in the Nucellus

(10) Megasporangia / Ovule

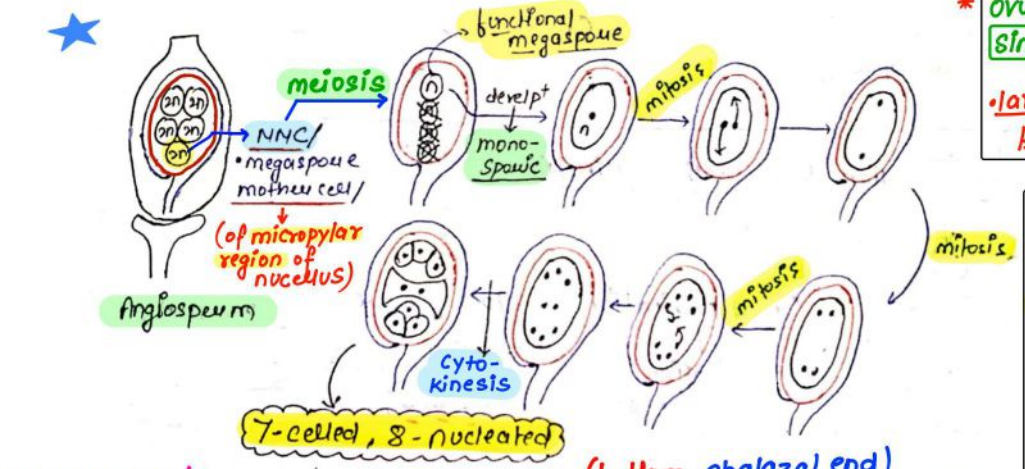






The ovule is a small structure attached to the placenta by means of a stalk called **funicle**. The body of the ovule fuses with funicle in the region called **hilum.** Thus, hilum represents the junction between ovule and funicle. Each ovule has one or two protective envelopes called **integuments.** Integuments encircle the nucellus except at the tip where a small opening called the **micropyle** is organised. Opposite the micropylar end, is the **chalaza**, representing the basal part of the ovule.

(II) Megasporogenesis (NMC (2n) —meiosis→ megaspore (n))



* ovule generally differentiate single NMC in micropylar region.
- large, dense cytoplasm, prominent nucleus

Functional megaspore
3-mitosis | monosporic development
Embryo sac / female gametophyte
(7-celled, 8-nucleated)

- Embryo sac/
- female gameto-phyde

(bottom, chalazal end)
- antipodal cells → degenerate after pollination
- central cells (middle)
- polar nucleus (n+n) → fuse prior to fertilization
- 1 egg cells, 2 Synergids → egg apparatus (top) → micropylar end
- filiform apparatus → secrete chemicals to attract pollen tube
- cellular thickenings of synergids

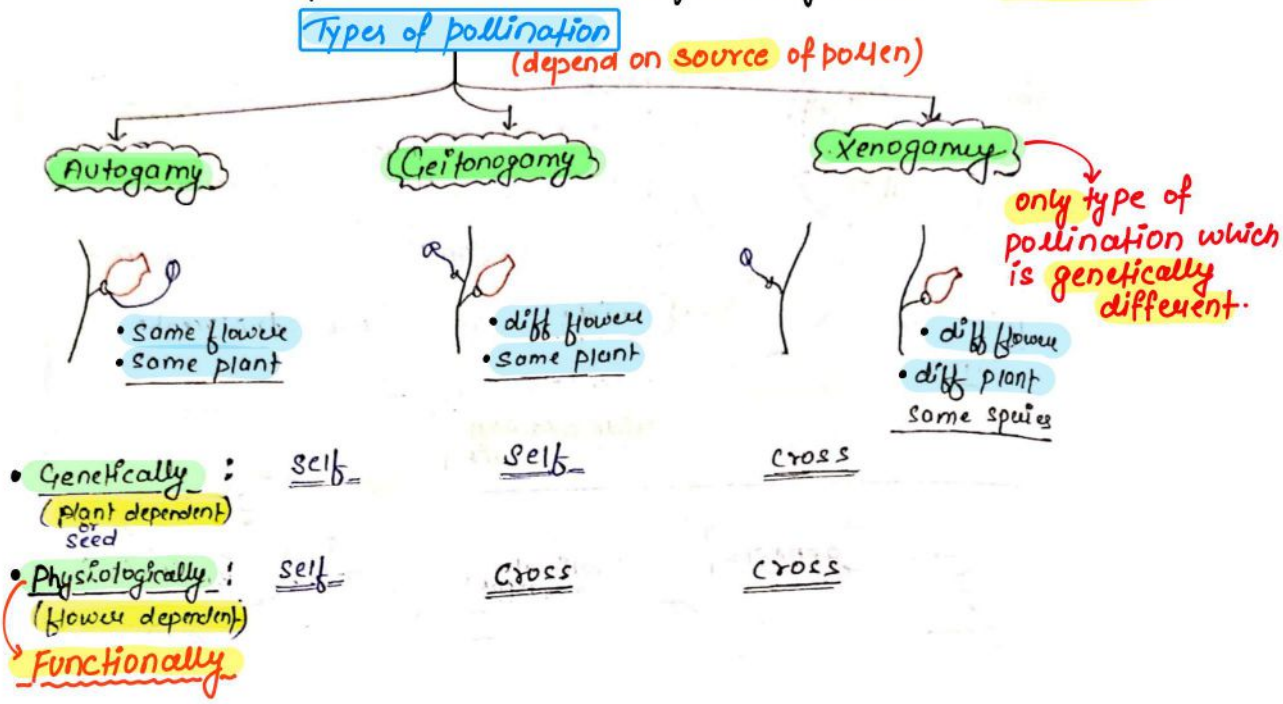
* Mitotic divisions are strictly free nuclear → i.e, nuclear division are not followed immediately by cell wall formation

(12) pollination

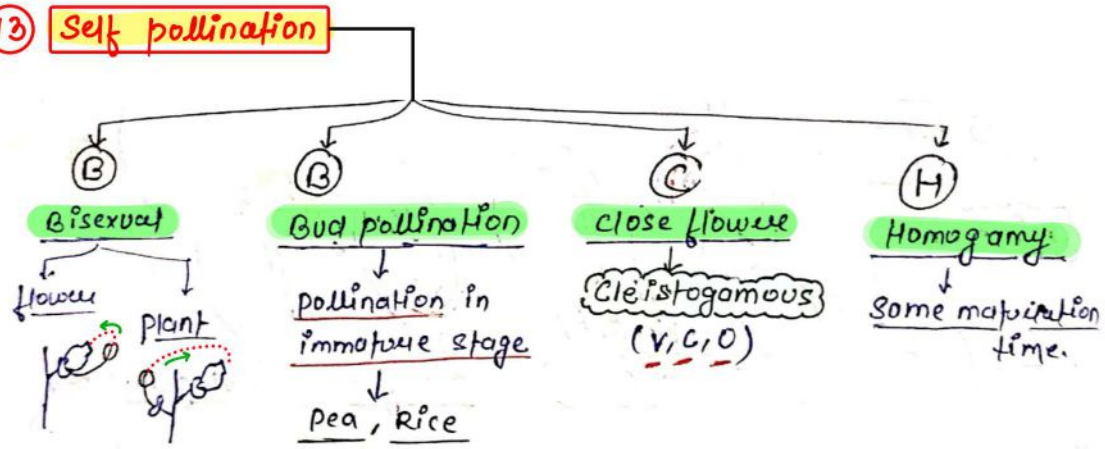
→ Transfer of pollen grain from anther to stigma of same species

→ pollination is required, b/c both male & female gamete are non-motile

Types of pollination (depend on source of pollen)



(13) Self pollination



★ IMP

- Viola
- Commelina
- Oxalis

(common pansy)

Close flower [Cleistogamous]
- Cross ⊗
- 100% self pollination ∴ NO need of pollinators.
- invariably autogamous
- No variation.

(!) No chances of cross pollination

Open flower [Chasmogamous] → Cross ✓

→ autogamy save fit req synchrony in pollen release & stigma receptivity

(14) Self pollination

- **advantage**
  - Economical
  - no need of fragence, nectous.
  - Assure seed formation
  - Produce pure line / Homozygous
- **disadvantage**
  - lack of variation
  - Inbreeding depression (accumulation of lethal gene)

(15) Outbreeding device

- Prevent → self pollination
- promote → Cross pollination
  - Unisexual
    - flower
    - plant
  - Bud pollination ⊗
  - open flower → Chasmogamous (V, C, O)
  - Hetero-gamy → have → Diff^n maturation time
  - Hetero style → Diff^n position of male & female flower
  - Self incompati-bility → genetic mechn → inhibit Pollen tube.

prevent Autogamy

(16) Sexuality

Monocious / Bisexual

- Bisexual plant
- unisexual flower
- Maize
- Castor
- diff flower
- same plant
- A: ✗
- G: ✓
- X: ✓

• prevent Autogamy, but not geitonogamy.

Diocious / unisexual

- Both flower & plant unisexual
- papaya
- diff flower
- diff plant
- A: ✗
- G: ✗
- X: ✓

• prevent both Autogamy & geitonogamy

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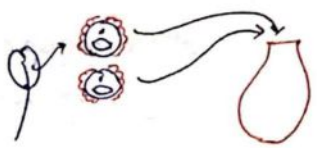
out breeding devices

Flowering plants have developed many devices to discourage self-pollination and to encourage cross-pollination. In some species, pollen release and stigma receptivity are not synchronised. Either the pollen is released before the stigma becomes receptive or stigma becomes receptive much before the release of pollen. In some other species, the anther and stigma are placed at different positions so that the pollen cannot come in contact with the stigma of the same flower. Both these devices prevent autogamy. The third device to prevent inbreeding is self-incompatibility. This is a genetic mechanism and prevents self-pollen (from the same flower or other flowers of the same plant) from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil. Another device to prevent self-pollination is the production of unisexual flowers. If both male and female flowers are present on the same plant such as castor and maize (monoecious), it prevents autogamy but not geitonogamy. In several species such as papaya, male and female flowers are present on different plants, that is each plant is either male or female (dioecy). This condition prevents both autogamy and geitonogamy.

→ diff^t Maturation time
→ diff^t position
→ self incompatibility
→ sexuality

(17) pollinating agent



pollen grains are non-motile
they need pollinating agent

- **Abiotic** (non-living) (small proportion)
  - **Wind/Air** [more common] → common in grasses
  - **Water** [Rare] → limited to ~30 genus → monocots
- **Biotic** (living) (majority)
  - insects (most common) → Honey bee
  - Birds
  - Bats
  - Lizard (reptile)
  - Primates (lemurs)
  - arboreal rodents (tree dwelling)

(a) Anemophilly → Air/wind

∵ directionless → ∴ wastage of pollen grain

pollen grain	male flower	female flower	ovule	example
• large no.	• well exposed stamens	• large & feathery stigma	single ovule	B → Bamboo
• light wt.	• (7) in group	• sticky stigma		M → Maize
• non sticky	• inflorescence (✓)	• Inflo (✓)		W → wheat
• non wettable		• colour, Nectar, fragrence (⊗)		S → Sugarcane
• winged pollen grain → Pinus				C → coconut, cashew
				G → grasses

- Stigma and style have Tassels (corn cob) which help to trap pollen grain

⑥ Hydrophilly → water

- pollen grain
  - light wt
  - large no
  - sticky
    - naked pollen
    - mucilage covering (sticky) → protect from wetting (non wettable)
- male flower
  - large no.
  - Boat shaped
- female flower
  - sticky stigma → twisted
  - long style
- ovule
  - any type
- example
  - EH
    - Hydrilla
    - vallisneria
  - HH
    - zostera (marine grass)

water is a regular mode of transport for the male gametes among the lower plant groups such as algae, bryophytes and pteridophytes. It is believed, particularly for some bryophytes and pteridophytes, that their distribution is limited because of the need for water for the transport of male gametes and fertilisation.

★ Hydrophilly types:

Epihydrophilly

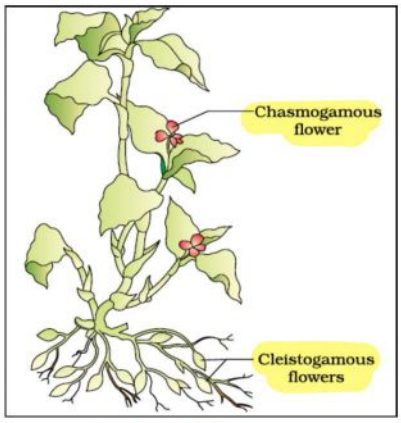
- Spherical pollen (carried passively by water current)
- male flower → surface
- female flower reaches to surface
- some male flower reaches to female flower
- long stalk
- female flower
- e.g. → vallisneria, Hydrilla

(diagram)

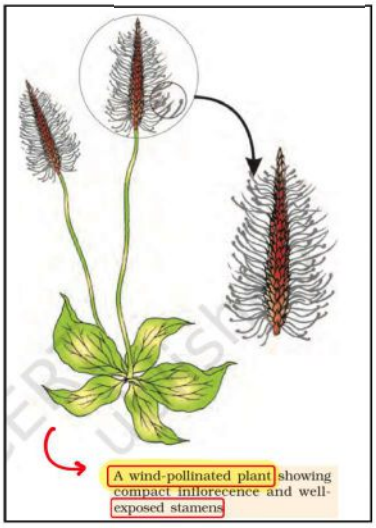
Hypohydrophilly

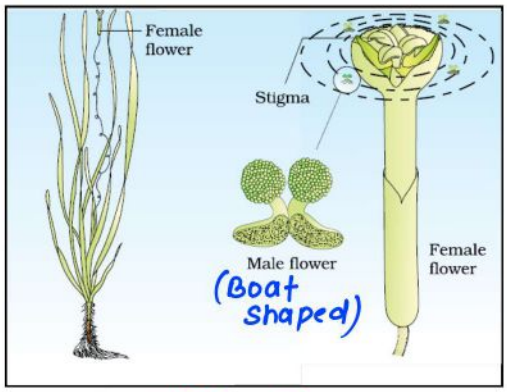
- pollen grain → long, spiral, ribbon shaped
- carried passively
- pollen grain released inside water
- female remain submerged in water
- e.g. → sea grasses (or) Zostera

* Most of aquatic plants pollinated by wind (insects → water hyacinth, water lily)
  - aquatic plants → those flowers emerge above the level of water



Commelina





Valisneria

EH

★ In *Vallisneria*, the female flower reach 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 some of them eventually reach the female flowers and the stigma.

HH

In another group of water pollinated plants such as seagrasses, female flowers remain submerged in water and the pollen grains are released inside the water. Pollen grains in many such species are long, ribbon like and they are carried passively inside the water; some of them reach the stigma and achieve pollination. In most of the water-pollinated species, pollen grains are protected from wetting by a mucilaginous covering.

© Entomophilly → insects (Honey bee most common)

- pollen grain
  - Heavy
  - sticky
- male flower
  - large
  - well exposed
  - ⑦ in group
- female flower
  - sticky stigma
  - large & well exposed
  - Inflorescence ✓
    - colourful ✓
    - fragrance ✓
    - Nectar ✓
- ovule
  - only type
- example
  - water Hyacinth
  - water lily
  - Many

(18) Some important points

★ Plants pollinated by flies & beetles → secrete foul smell.

★ Plants provide floral reward (Nectar & pollen grain)

- Figs & wasp
  - safe place for laying egg
  - pollinating agent.
- Yucca & moth
  - provide safe place for laying egg
  - pollinating agent
- Amorphophallous & insects
  - tallest tree (6 feet flower)
  - safe place to lay egg
  - pollinating agent

↓ Mutualism

★ Plants → requirement for agent:

Abiotic agent
- Pollen grain in large amt.
- colour, fragnance, nectar ⊗

Biotic agent
- Sticky, well exposed
- colour, fragnance, nectar ✓

(19) Pollen pistil intraction → Dynamic process, involve pollen recognition, then promotion/inhibition

- pollination does not guarentee transfer of correct pollen grain.
- pistil chemically evaluate pollen grain (chemical mediation)

Correct type PG (compatible) (pollen grain of same spp.) → Germination of pollen grain

Incorrect type PG (incompatable) → Germination prevent by Stigma / prevent by style

- post-fertilization event ✓
- inhibit pollen tube germ.

2-celled → mitosis in generative cell. → 3-celled → 2-male gamete

- Synergids will secrete chemical to stimulate/growth of pollen tube.

(20) Pollen tube

Growth of pollen tube

- Apical
- Chemotropic (in response to chemical secrete by synergids)

Entry of pollen tube

- enter into embryo sac via micropylar end, b/c synergids & egg are present.

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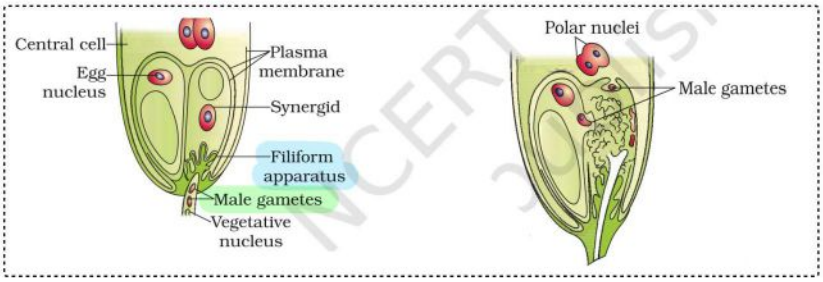
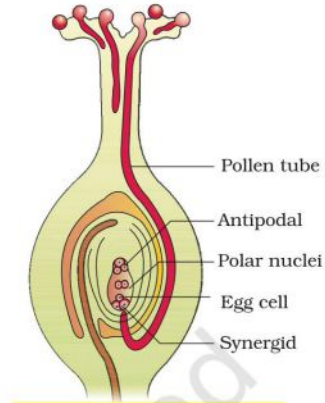
some plants, pollen grains are shed at two-celled condition (a vegetative cell and a generative cell). In such plants, the generative cell divides and forms the two male gametes during the growth of pollen tube in the stigma. In plants which shed pollen in the three-celled condition, pollen tubes carry the two male gametes from the beginning. Pollen tube, after reaching the ovary, enters the ovule through the micropyle and then enters one of the synergids through the filiform apparatus





Longitudinal section of a flower showing growth of pollen tube

(21) Artificial Hybridisation

- For same species / diff species
- Transfer of desired pollen grain on stigma
- used in crop improvement programme

Steps:

① Emasculation — Anther Removal
- Removal of immature anther from flower bud using forceps (To prevent self pollination / Autogamy)

② Bagging — butter paper
- covering of female flower with butter paper (To prevent unwanted cross pollination / xenogamy)

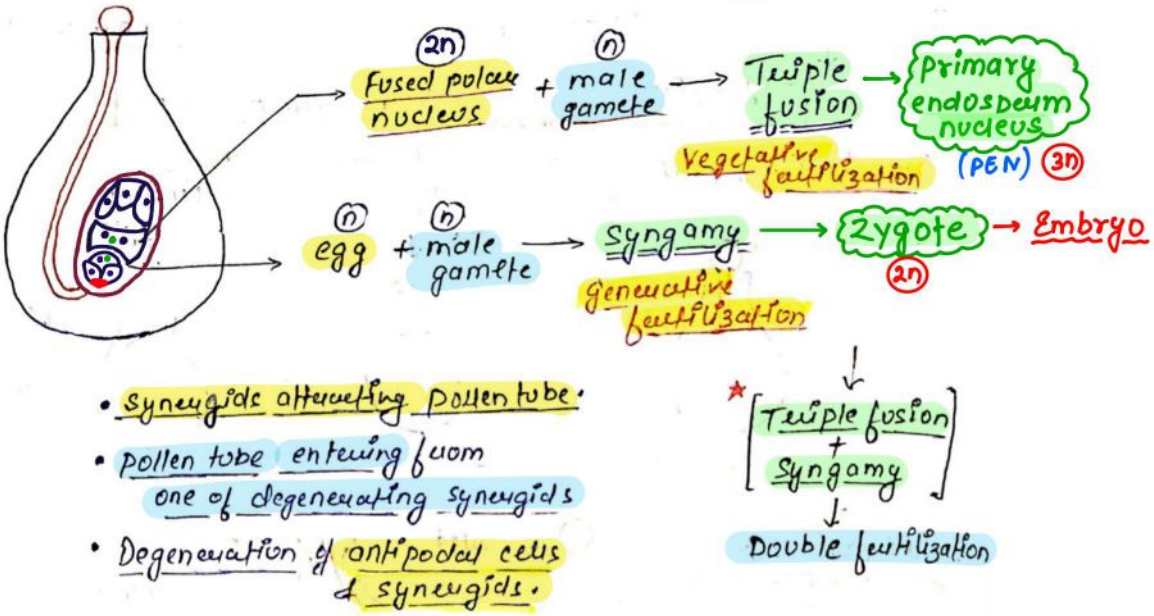
③ Dusting
- when stigma become receptive, then mature/desired pollen dusted on stigma

④ Re-bagging
- To prevent contamination (unwanted pollen)

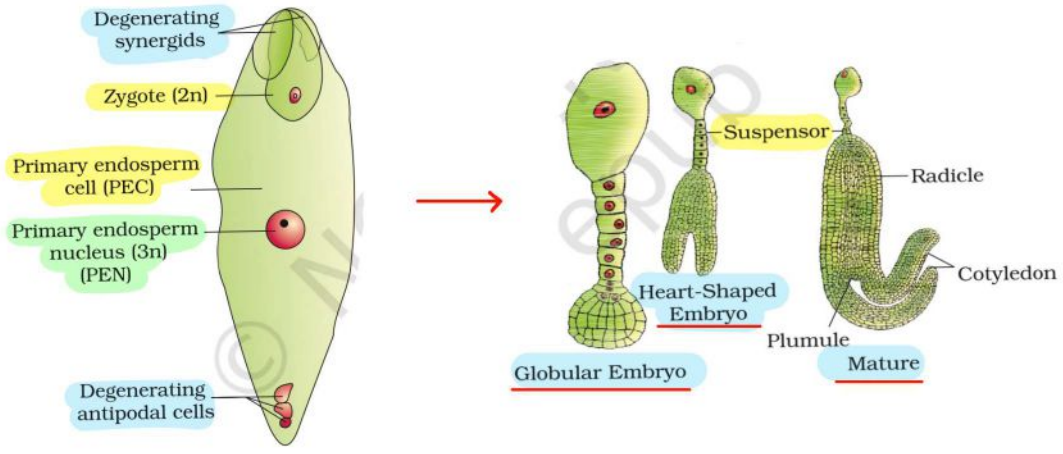
★ Bisexual flower: Emasculation (1st step) → Bagging → Dusting → Re-bagging

Unisexual flower: ~~Emasculation~~ → Bagging (1st step) → Dusting → Re-bagging

(22) Double fertilization (Characteristics of angiosperm)



After entering one of the synergids, the pollen tube releases 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 thus completing the **syngamy**. This results in the formation of a diploid cell, the **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 termed **triple fusion.** Since two types of fusions, syngamy and triple fusion take place in an embryo sac the phenomenon is termed **double fertilisation**, an event unique to flowering plants. The central cell after triple fusion becomes the **primary endosperm cell** (PEC) and develops into the **endosperm** while the zygote develops into an **embryo.**



(23) Post fertilization event

- primary endosperm cell (PEC)
- primary endosperm nucleus (PEN) (3n)
- Zygote (2n)

endosperm → provide Nutrition

Endosperm development
- precede embryo development

Endosperm development

- free nuclear endosperm (most common)
  - coconut water (liquid)
  - cotton
  - → syncitum condition (karyokinesis not followed by cytokinesis)
    - → multinucleated cond^n
- cellular endosperm
  - white kernal of coconut.

Post fertilization event
- Endosperm event
- Embryo devp.
- ovule → seed
- ovary → fruit

(24) Embryo development

During megasporogenesis

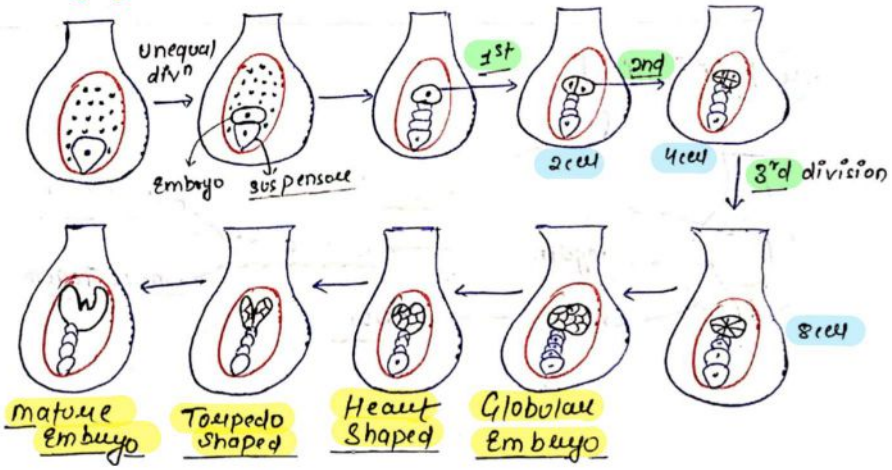
Endosperm completely consumed
- Non-endospermic seed
- ex/non-albuminous seed
  - B → Bean
  - G → Ground nut, Gram
  - P → Pea

Some amt of Endosperm remains (persistant Endosperm)
- Endospermic seed
- albuminous seed
  - B → Barley
  - M → maize
  - W → wheat
  - S → sunflower
  - C → castor, coconut
  - R → rice

nucellus remains (persistant nucellus) (2n)
- perispermic seed (2n)
  - Black pepper
  - Beet

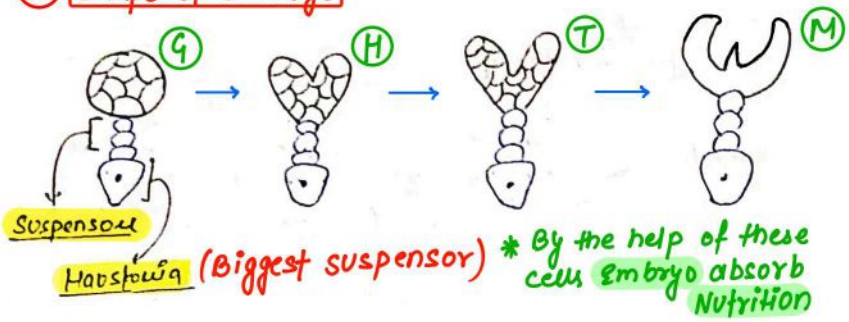
nucellus completely consumed
- non-perispermic seed

25 Embryogenesis

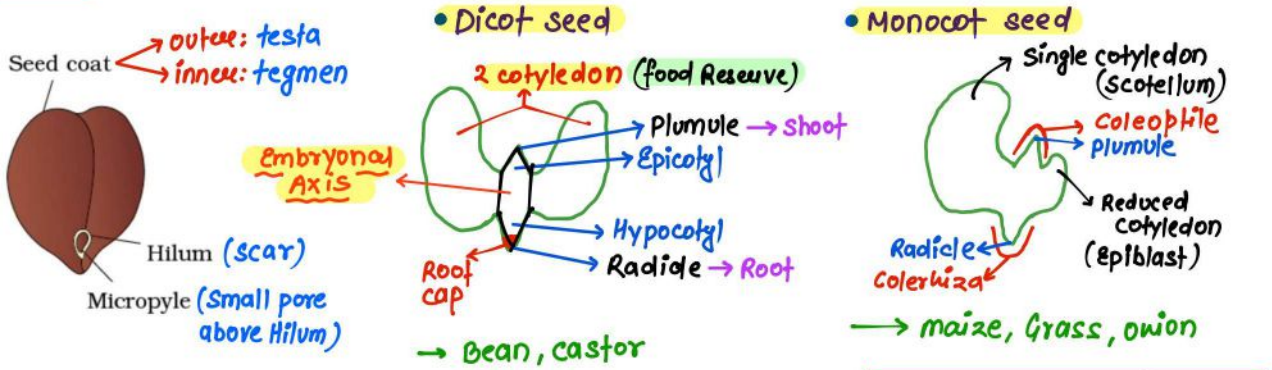


- Embryo develop at micropylar end.
- most zygote diride only after certain amt of endosperm formed to provide assured nutrition to the developing embryo.
- Early stage of embryo development similar in both monocot & Dicot.

26 Shape of Embryo



27 Seed



- Coleoptile : Hollow foliar str
- Coleorhiza : Undifferentiated Sheath.

NCERT

Integuments of ovules harden as tough protective seed coats The micropyle remains as a small pore in the seed coat. This facilitates entry of oxygen and water into the seed during germination. As the seed matures, its water content is reduced and seeds become relatively dry (10-15 per cent moisture by mass). The general metabolic activity of the embryo slows down. The embryo may enter a state of inactivity called **dormancy**, or if favourable conditions are available (adequate moisture, oxygen and suitable temperature), they germinate.

* Dehydration & dormancy is crucial for storage of seed & can be used as food and raise crop in next season.

(28) **Fruit** (fruit wall: pericarp)

- **True fruit** → develop from fertilised ovary
  - Mango
- **false fruit** → develop from other than ovary
  - Apple, Strawberry
  - cashew (edible thalmus)
- **parthenocarpic fruit** → develop without fertilization (seedless) — can induced via Growth hormone
  - Banana

★

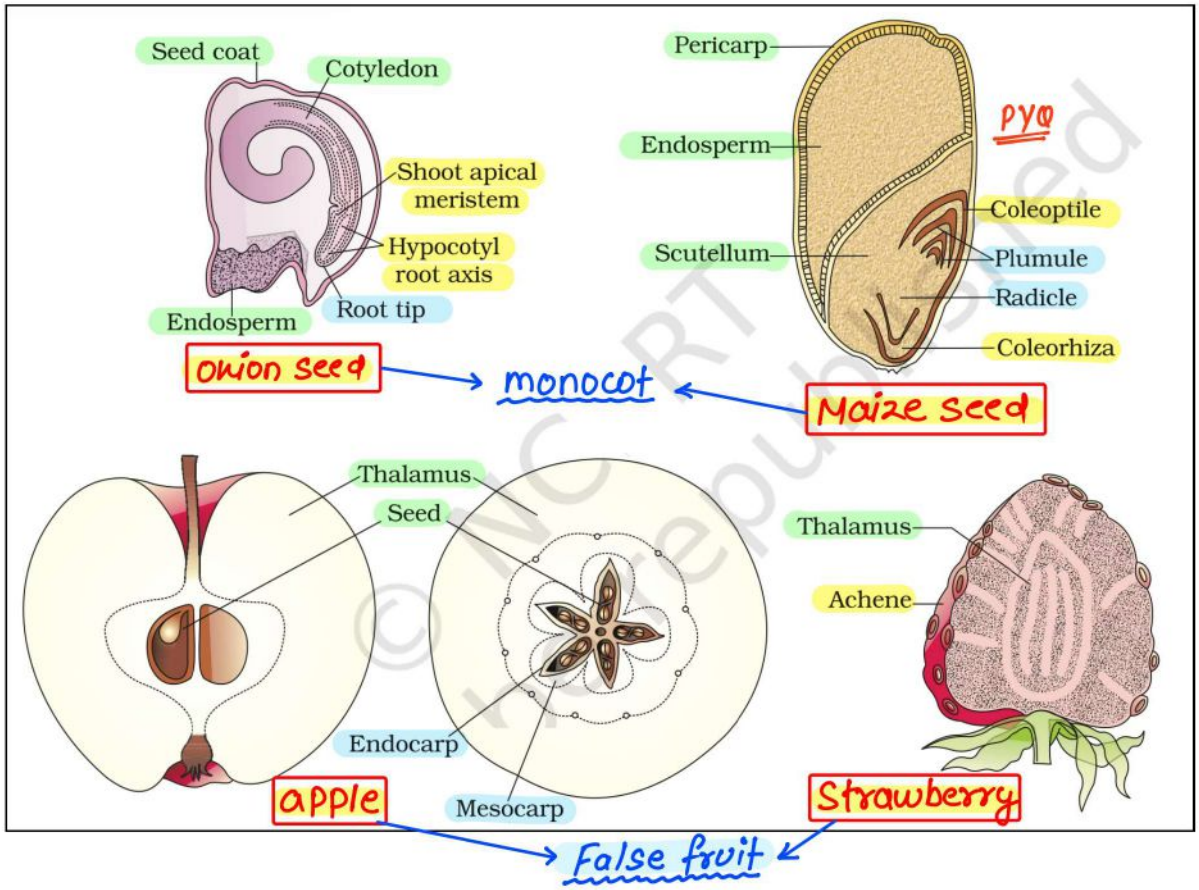
fleshy fruit	Dry fruit
• Guava, orange, mango	• Groundnut, mustard

(29) **Seed viability**

→ period upto which seed have power of germination

→ varies from species to species

eg:
- In few species (oxalis) → few month
- In large species → several years
- Date palm (phoenix dactylifera) → 2000 yrs (discovered at King Herod's palace near Dead sea)
- Lupine (lupinus arcticus) → 10,000 yrs (from arctic tundra) — oldest



(30) **Apomixis** (away fusion) (asexual) V/S **Amphimixis** (involve fusion)

- formation of seed without fertilization
- formation of seed with fert.ⁿ (sexual)

eg:- → Asteraceae family & some grasses

* Apomixis is a form asexual reproduction that mimics sexual reproduction.

(31) **polyembryony** (ovule contain many embryo)

- no. of embryo >> no. of seeds

→ diploid egg formed without Reduction division & develops into embryo without fertilization

eg:
- Citrus
- Mango
- Lemon
- orange

* fruits contain large no. of seeds.
  - orchids
  - orobanche
  - Striga

  → parasitic species

(32) **Hybrid seed**

Hybrid varieties of several of our food and vegetable crops are being extensively cultivated. Cultivation of hybrids has tremendously increased productivity. One of the problems of hybrids is that hybrid seeds have to be produced every year. If the seeds collected from hybrids are sown, the plants in the progeny will segregate and do not maintain hybrid characters. Production of hybrid seeds is costly and hence the cost of hybrid seeds become too expensive for the farmers. If these hybrids are made into apomicts, there is no segregation of characters in the hybrid progeny. Then the farmers can keep on using the hybrid seeds to raise new crop year after year and he does not have to buy hybrid seeds every year. Because of the importance of apomixis in hybrid seed industry, active research is going on in many laboratories around the world to understand the genetics of apomixis and to transfer apomictic genes into hybrid varieties.