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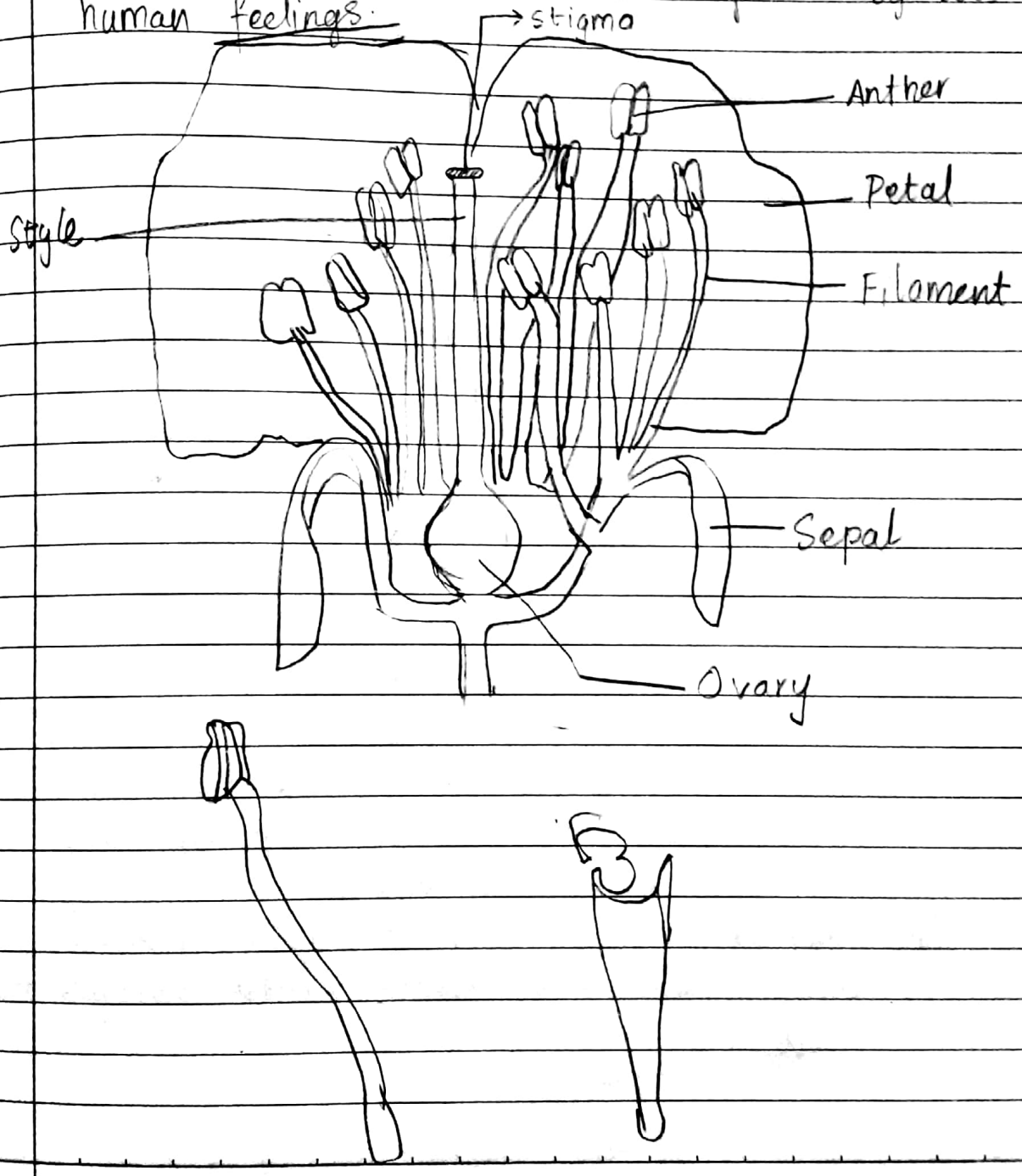
2] Sexual Reproduction in Flowering plants

★Flower is object of aesthetic, ornamental, social, religious and cultural value. They are symbols of human feelings.



Pre-fertilisation :- Structures & Events

⇒ Stamen, Microsporangium & Pollen Grain

Stamen → long, slender stalk called filament and terminal bilobed structure called anther.
No. & length of stamen is variable.

Anther → Bilobed & each lobe has 2 theca i.e. they are dithecous.
Longitudinal groove seperates theca
Anther is tetragonal structure having four microsporangia, at corners, 2 in each lobe.
Microsporangia → Pollen grains.
↳ Has 4 wall layers :-

(i) Epidermis
↓
→ outermost
→ Protection

(ii) Endothecium
↓
→ Dehiscence of anther
→ Have α-cellulosic fibrous bands

(iii) Middle layers
↓
→ Reserve food for developing pollen.

(iv) Tapetum :- Innermost layer. Nourishes the developing pollen grain. Have dense cytoplasm and more than 1 nucleus.

In young anther, a group of compactly packed homogeneous cells is at centre called sporogenous tissue.

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* As anther develops, cells of sporogeneous tissue undergo meiotic division to form microspore tetrad. Hence, each is a potential pollen or microspore mother cell.

The process of formation microspores from pollen mother cells through meiosis is called Microsporogenesis.

Microspores develop into Pollen grains, eventually.

● Pollen Grain → Represent Male gametophyte.
→ Spherical shape & 25-50 micrometers in diameter.
→ Outer Wall → Exine → made of sporopollenin which is most resistant organic material known, can withstand high temperatures and cannot be degraded by any enzyme.
→ Inner wall → Intine → Thin and continous layer made up of cellulose and pectin.
→ Cytoplasm of pollen is surrounded by plasma membrane.

When pollen grain is Mature it has 2 cells
① Vegetative cell :- Big, abundant food reserve, irregularly shaped nucleus.
② Generative cell :- small, splindle shape, floats in vegetative cells cytoplasm, dense cytoplasm & nucleus present.

Pollen grain is shed at 2 celled stage in 60%.

In remaining, Generative cell undergoes mitosis to form 2 male gametes & 3 celled stage.

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★ Pollen grains also causes ~~allergy~~ allergies & bronchial afflictions.
Egs:- Parthenium, Amaranthus, Chenopodium cause pollen allergy.

★ Pollen grains are rich in nutrient and used as food supplements. Pollen consumption increases performance of athletes and horses.

★ The period for which pollen remain viable is highly variable & depends on temp. & humidity.

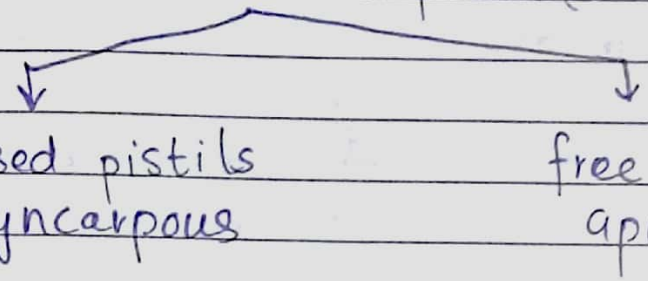
Rice, Wheat - viability 30 mins
Rosaceae, Leguminoseae, Solanaceae - viability months

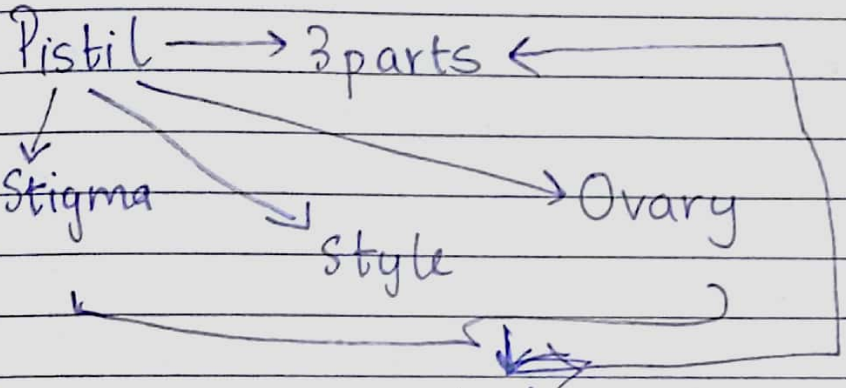
★ Storage of pollen grains of large number of species in pollen banks for years in liquid nitrogen ~~at~~ (at -196°C) is called cryopreservation.

→ Pistil, Megasporangium & Embryo Sac

Gynoecium → female reproductive part.

Pistil → Single pistil (mono carpellary)
↳ More than one pistil (multicarpellary)





Stigma → landing platform for pollen grains
Style → Elongated slender part
Ovary → Basal bulged part.
↳ Inside ovary → ovarian cavity (locule)
↳ inside it → placenta.
From placenta → Megasporangia/Ovules arise.

Megasporangium :-

Ovule is attached to placenta by a stalk called funicle. Body of ovule fuses with funicle in the region called hilum. Thus, hilum is junction b/w Ovule and funicle. Each ovule has 2 protective envelops that encircle ovule, called Integuments. The ovule is uncovered

by integuments at tip, where a small opening called micropyle is present. Opposite to micropylar end is the chalazal end or chalaza → basal part of ovule. Enclosed inside integuments is mass of cells called nucellus. Nucellus cells have abundant reserve food material. Inside nucellus embryo sac or female gametophyte is present.

Megaspore —Reductional division→ Embryo Sac.

Megasporogenesis :- It is the process of formation of megaspores from megaspore mother cell.

Female Gametophyte :-
In most flowering plants, out of the four megaspores only one is functional and other 3 degenerate. The functional megaspore develops into embryo sac. Method of formation of embryo sac from single megaspore is Monosporic development.
Formⁿ of Embryo Sac :-

Nucleus of ~~embryo sac undergoes~~ functional megaspore undergoes 3 sequential mitotic divisions to form 2-nucleate, 4 nucleate & then 8-nucleate stages of embryo sac. This mitosis is free nuclear. After 8 nucleate stage cell walls are laid down leading to formation of typical female gametophyte or embryo sac.

Distribution inside Embryo Sac:-

→ 6 out of 8 nuclei and surrounded by cell walls.
→ 2 nuclei which do not have cell wall, are called polar nuclei and situated below egg apparatus in central cell
→ 3 cells are grouped together at micropylar end and constitute egg apparatus → one egg cell, 2 synergids. Synergids have special thickenings at micropylar tip called filiform apparatus, which plays role of guiding pollen to synergids.
→ 3 cells are grouped at chalazal end and called antipodal cells.

This is 8 nucleate, 7 celled stage of embryo sac.

⇒ Pollination:-

Pollination is a mechanism for transfer of pollen grain from anther to stigma of a pistil.

Types:-

1) Autogamy:-
Transfer of pollen from anther to stigma of same flower. Eg:- Oxalis, Viola, Commelina produce 2 types of flowers:-

i) Chasmogamous flowers are those which are similar to flowers of other species with exposed anther's & stigma.

2) Cleistogamous flowers are those which do not open at all. Anther & Stigma lie close to each other. As soon as pollen dehice, they go and stick to stigma. Cross pollination not possible.

II] Geitonogamy :- Transfer of pollen from anther to stigma of another flower on same plant.
Functionally → Cross pollination
Genetically → self pollination

III] Xenogamy :- Transfer of pollen from anther to stigma of another flower on a different plant.

Agents of Pollination :-

1) Wind Pollination :- Pollen grains are light/non-sticky. Also, such plants possess well exposed stamens and large feather stigma to easily trap air borne pollen grains. Single ovule & flowers packed into inflorescence (corn cob)
Egs :- Maize, Grasses, Wheat, Sugarcane, Bamboo.

2) Water Pollination :-
Very rare only in some 30 monocot genera
Pollen grains are light, unwettable and generally covered by mucilagenous covering to avoid wetting.
Long stick unwettable stigma.
If it occurs at water surface (epihydrophily) then female flower has a very long pedicel to reach surface of water. Male flowers undergo breakage to reach surface. Pollens released on surface of water and carried passively by water currents.
Ego :- Vallisneria.
If it occurs beneath the surface, pollens are long ribbon like and carried passively to submerged flower.
Egs :- Zostera.

Biotic Agents :- Most flowers use animals like Bees, butterflies, flies, beetles, wasps, ants, moths, birds & bat for pollination.
Also animals like insects*, primates (lemurs), tree dwelling (arboreals), rodents, or reptiles like lizards.

3) Insect Pollinated :-
Flowers are large, colourful, fragnant and rich in nectar.
Small sized flowers are clustered into inflorescence.
* Flowers pollinated by flies & beetles emit foul odour.
Flowers also provide floral rewards like
* Nectar
* Place for laying eggs. Eg:- Amorphallus.
* Moth species lays its egg in locule of ovary & in return it pollinates the Yucca plant. The larvae of moth come out of eggs as seed develops.

⇒ Outbreeding Devices :-
These are devices of features of plant that discourage self pollination (as it leads to inbreeding depression) and encourages cross pollination.
Prevents Autogamy
1) In some species pollen release & stigma receptivity is not synchronised i.e. both take place at different times.
Eg:- Sunflower, cotton, Ficus.
2) Also, sometimes anther and stigma are placed at different positions so that pollen cannot come in contact.
3) Self incompatibility is genetic mechanism that prevents self pollen (from same flower or diff. flower from same plant) from fertilising ovule by preventing pollen germination on pistil.

→ Forⁿ of unisexual flowers.

Monoecious

4) If both male and female flowers are on same plant it prevents autogamy only. eg Castor, Maize.

Dioecious → If both male & female flower are on diff. plants it prevents alltogamy & geitonogamy. eg Vallisneria, Papaya

⇒ Pollen-Pistil Interaction :-

If pistil recognises pollen to be compatible it promotes fertilisation & post fertilisation events, but if pollen is incompatible pistil rejects it by preventing pollen germination. The ability of pistil to accept is due to dialogue b/w pollen and pistil which is mediated by their chemical components.

- ★ If pollen is compatible pollen germinates on stigma to produce pollen tube through germ pores. The contents of pollen move into the tube.
- ★ Pollen tube grows through tissues of style & stigma & reaches ovary. During this growth generative cell divides to form 2 male gametes, if pollen was shed at 2-celled stage.
- ★ Pollen tube after reaching ovary enters ovary through micropylar end, into one of the synergid. Filiform apparatus guides the tube during this.

✳ Artificial Hybridisation :- It is process of crossing different species and often genera to combine desirable characters and produce commercially 'superior' varieties. To avoid unwanted pollen on stigma we use 2 methods, emasculation & bagging.

If female bears bisexual flowers, the anthers are removed before they dehice. This is emasculation.

Emasculated flowers are then covered with bag of butter paper, to prevent unwanted pollen. This is called Bagging. When Stigma becomes receptive bag is removed, collected pollens are dusted and then rebagged until fruit development.
If flower is unisexual, emasculation is not required. Other process of bagging, dusting and rebagging are same.

⇒ Double Fertilisation :-

After entering synergids, 2 male gametes are released;

1st gamete fuses with egg to give → Zygote. (Diploid)
This is syngamy.

2nd gamete moves towards polar nuclei fuse with them to give → Primary Endosperm Nucleus (Triploid)
This is Triple fusion.

Then, Zygote → Embryo
PEN → Primary endosperm cell (PEC) → Endosperm.

2 fusions take place i.e. syngamy & triple fusion, hence called "Double Fertilisation"

⇒ Post Fertilisation — Structures :-

★ Endosperm :-

The primary endosperm cell divide repeatedly and forms triploid endosperm tissue. This tissue has cells having reserve food material for nutrition of developing embryo.

Endosperm development :- The PEN undergoes successive nuclear divisions to form free nuclear endosperm. Then, cell wall formation occurs and endosperm becomes cellular.

Coconut → Water → Free nuclear endosperm
↳ White Kernel → Cellular endosperm.

Endosperm is either completely consumed by embryo (eg. pea, groundnut, beans) before seed maturation or it may persist in mature seed (e.g. castor, coconut) and be used by during seed germination.

★ Embryo :-

Develop at micropylar end. Zygote gives rise to proembryo and then, globular, heartshaped and mature embryo.

Embryogeny → Stages of Embryo development.

Typical dicot Embryo → Embryonal axis & 2 cotyledons.

Portion of embryonal axis above cotyledons is epicotyl and terminates into plumule or stem tip. Portion below

cotyledons is hypocotyl and terminates into its lower end called radicle or root tip (covered by root cap).

Monocotyledons ——→ One cotyledon only.
Grass family cotyledon is called scutellum & is situated along lateral side of embryonal axis. On lower end embryonal axis has radicle & root cap in a undifferentiated sheath called coleorrhiza. Portion above e.a of scutellum is epicotyl which has a shoot apex & leaf primordia enclosed in hollow foliar structure called coleoptile.

⇒ Seed:- → fertilised ovule

Seed is final product of sexual reproduction.

Seed → seed coats
→ cotyledons. } components
→ Embryo axis

Seeds → Albuminous → retain a part of endosperm as it is not completely used during embryo development e.g.:- wheat, maize

Non-Albuminous
→ No residual endosperm as it is consumed during embryo development eg:- pea, groundnut

Some seeds nucellus also persists
This residual nucellus is perisperm
Eg:- Black pepper & Beet.

Seed → Integuments form protective seed coat
↳ Micropyle present for entry of O_2 & H_2O in seed during germination.
↳ As it matures, water content does, becomes dry general metabolic activity of embryo slows down & may enter inactive stage → Dormancy
↳ If favourable conditions present they germinate.

Ovule ——→ Seeds
Ovary ——→ Fruit
↳ Wall of ovary ——→ Wall of fruit → Pericarp.
↳ eg:- Apple, cashew, strawberry.

★ False fruits → Thalamus contributes to food formation.
★ True fruits → Fruits develop from ovary
★ Parthenocarpic fruits → Fruits develop without fertilisation
Eg:- Banana

★ Advantages of Seed to Angiosperms :-
→ Have adaptive strategies for dispersal to new habitat.
→ Sufficient reserve food for young seedlings.
→ Protection to young embryo by seed coat.
→ New genetic combination.

★ Seeds show dehydration and dormancy which makes them important for agriculture as they can be stored for food and for next crop.

★ Period for which seeds retain their power of germination is called seed viability.
Oldest viable seed → Of Lupine, Lupinus → 10,000 yrs ago → Arctic tundra
Phoenix dactylifera → 2000 yrs old seed of date palm.

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⇒ Apomixis :- It is process to produce seeds without fertilisation. It is asexual method that mimics sexual one.

* It can be done in following ways:-
- Diploid egg cell is formed without reduction division and develops into embryo without fertilisation.
- In some Citrus & Mango variaties nucellar cells around embryo sac start dividing, protrude in embryo sac and develop into embryo.

Such species have more than one embryo in ovule. This is polyembryony.

↳ Occurence of more than one embryo in seed.