REPRODUCTION IN PLANTS

What is meant by the term reproduction?

- It is the production of a new generation of individuals of the same species, during which there is transmission of genetic material from parents to their offspring to ensure continued survival of a species.
- OR: Formation of separately existing individuals of the same species by existing organisms

Types of reproduction: Sexual and Asexual

Distinguish between sexual and asexual reproduction

- **Asexual reproduction** is the production of offspring (new individuals) from a single organism without the formation of gametes. The offspring (referred to as **clone**) are genetically identical to each other and to their parent, except when and if mutation occurs.
  Cloning is the process by which an organism reproduces asexually to give individuals in a population genetically identical to each other and to their parent.

- **Sexual reproduction** is the production of offspring by the fusion of haploid male and female gametes (fertilization) to form a diploid zygote, which develops into the mature organism.
  Compare sexual and asexual reproduction Similarities:
- In both mitosis is involved
- Both produce offspring
- In both there is transmission of genetic material from parents to their offspring

Differences:

Sexual reproduction	Asexual reproduction
-Involves fertilization to form diploid zygote	-No zygote formation
-Offspring show genetic variability	-Offspring are usually identical to each other and to their parents; i.e. a clone
-Population numbers increase slowly	-Population numbers increase rapidly
-May involve one or two parents	-Always involves only one parent
-It is a less rapid process	- it occurs rapidly in favourable conditions
-Offspring mature slower	-Offspring mature faster
-Occurs among all living organisms -Male and female gametes produced by gametogenesis	-Occurs mainly among plants and simpler animals -No game formation

Give an account of the various forms of asexual reproduction

The five major ways by which asexual reproduction occurs are: **a)**
Fission:

It is the division of the cell by mitosis into two or more equal sized daughter cells identical to the parent cell. **Binary fission** ('splitting into two') occurs in bacteria, amoeba, paramecium while **multiple fission** (**schizogony**) - 'splitting into many' occurs in plasmodium (a malaria parasite) immediately after infection as the parasite (merozoites) enters the liver and again as they invade the red blood cells.

b) Sporulation (spore formation):

Is the formation of small unicellular bodies called spores by cell divisions in organisms, which detach from the parent plant and grow into new organisms under favourable conditions. It occurs in fungi e.g. *rhizopus*, bacteria, mosses, ferns, Liverworts, algae and amoeba.

What is a spore?

A haploid reproductive cell, usually unicellular, capable of developing into an adult without fusion with another cell.

c) Fragmentation:

This is the breaking of a single organism into two or more genetically identical pieces, each of which is capable of regenerating into a new individual. It occurs in sponges, spirogyra, cnidarians, flatworms.

d) Budding:

This involves the parent cell forming an out growth (a small bulge), which increases in size and finally drops off (detaches) to become an independent organism. It occurs in flat worms *e.g. tapeworms*, yeast, hydra, obelia, bryophyllum.

e) Vegetative propagation:

This is asexual reproduction in which a part of flowering plant other than the flower detaches itself to develop into a new individual plant. Parts of the plant such as root, stem, or leaf specialized to give rise to new individuals are called **propagules** and may also act as **organs of perennation.**

i)What are perennating organs?

ii) Explain the role played by perennating organs to the plants.

i) These are parts of flowering plants specialised for vegetative propagation as well as food storage, enabling plants bearing them to survive adverse (unfavourable) environmental conditions e.g. cold or dry periods. The food manufactured by photosynthesis in aerial green leaves is translocated and subsequently stored *as starch* in rhizomes, corms, stem and root tubers, *or as glucose* in onion bulb.

ii) During unfavourable conditions, the plant remains dormant but when conditions normalise, starch is hydrolysed to sugar and translocated to the young buds, enabling early growth, sprouting, and photosynthesis when there is little competition for nutrients from other species.

Distinguish between organs of vegetative propagation and organs of perennation in plants.

Organs of vegetative progation are the parts of the flowering plant other than the flower, such as root, stem, or leaf specialized for developing into new individuals when detached. Examples:

rhizomes *e.g. ginger, couch grass, canna lily and spear grass*; corms *e.g. coco-yam (mayuni), crocus and gladiolus*; stem tubers *e.g. Irish potato, yams*; root tubers *e.g. sweet potato, dahlia*; bulbs *e.g. onion, garlic, tulip*, swollen taproots *e.g. carrot, turnip*; stolons *e.g. blackberry*; runners *e.g. straw berry, oxalis*

Organs of perennation are plant parts specialised for storing the food used to develop into new individuals, enabling plants bearing them to survive adverse environmental conditions like drought. Examples: rhizomes, corms, stem and root tubers, bulbs, swollen tap roots.
Summarily, organs of perennation also double as organs of vegetative propagation, **but not all** *organs of vegetative propagation function as perennating organs.*

Specialised organs of vegetative propagation must have buds, which only occur on stems. Explain why root tubers (swollen adventitious roots) e.g. sweet potato, dahlia and cassava, and swollen taproots e.g. carrot and turnip are used as organs of vegetative propagation yet roots lack buds.
Root tubers and swollen taproots must bear a small part of old stem if they are to act as organs of vegetative propagation. The swollen root together with buds at the base of old stem form organs of vegetative propagation and perennation.

Artificial propagation methods in plants

- **Cutting:**

A piece of root *e.g. of lemon and tamarind*, or stem *e.g. sugarcane and cassava*, or a complete leaf is dipped in rooting mixture composed of plant hormones, and allowed to grow in a rooting composite or soil.

- **Layering:**

Involves pegging down of stem of runners *e.g. strawberry* into the soil to induce development of adventitious roots, after which the new daughter plants are detached from the parent plants by cutting.

- **Grafting and budding:**

It is the insertion of a stem or bud of one plant, the **scion** onto another closely related plant, the **stock,** ensuring that vascular tissues are in contact. It propagates lemons, apples, roses, hibiscus, and oranges.
Grafting in plants is not hampered by rejection, as is the case in animals.

Comparison of advantages and disadvantages of natural vegetative propagation

Advantages	Disadvantages

-It is a rapid means of reproduction and spread - Offspring are genetically identical, preserving good strains. -Perrenating organs enable survival in adverse conditions -Their dispersal and spread is independent of external agents hence the process is faster. - Plants are less affected by environmental factors - Females pass all of their genes to the offspring	-Leads to overcrowding and competition for nutrients, unless separated artificially. -New varieties cannot be produced, except by mutation resulting into reduced vigour & strength -Diseases typical of a species are rapidly transmitted and can decimate a crop -

Outline the process of sporulation in amoeba.

-It starts when the nucleus of a single cell of amoeba divides repeatedly and each unit is enclosed in a bit of cytoplasm, but all are encased by one cell membrane.

-Some residual cytoplasm may be left which is discarded.

-The new nuclei with cytoplasm are surrounded by spore case (cyst) to withstand unfavourable conditions

-The spores formed are released by bursting of the cell membrane.

What is parthenogenesis?

Parthenogenesis (“virgin origin”) is:

- The development of an embryo from an unfertilized egg or one in which the male and female nuclei fail to unite following fertilisation

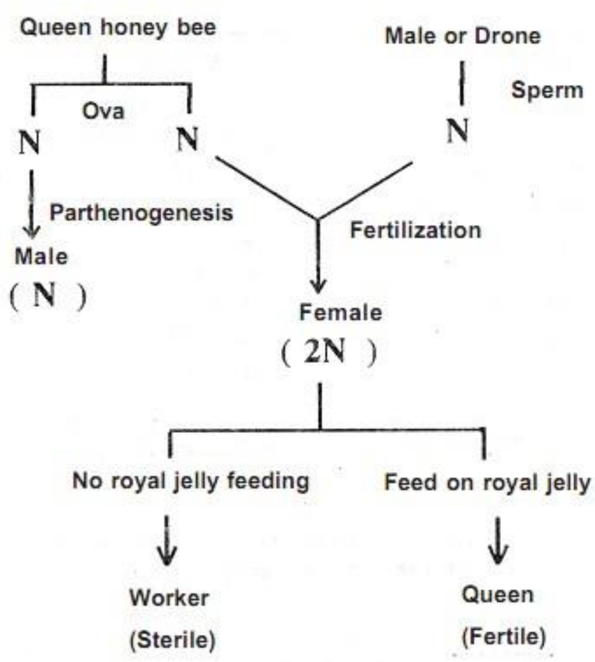
What is the exact meaning of the following? Give an example in each case. **a) Diploid parthenogenesis / ameoitic parthenogenesis:**

This is the development of embryo from unfertilized diploid eggs that formed by mitosis instead of meiosis, resulting into diploid offspring, which are clones of the parent. It occurs in Aphids, during which large numbers of wingless females are formed without necessitating the presence of males, in flatworms, rotifers, crustaceans.

b) Haploid parthenogenesis / meiotic parthenogenesis:

This is the development of embryo from unfertilized haploid eggs that formed by meiosis and may develop directly into haploid offspring. It occurs in honeybees, wasps, ants, whiptail lizards.

In honeybees, the queen bee can either fertilise the eggs as she lays them or allows them to pass unfertilised. Fertilised eggs become diploid females (fertile queens or sterile workers), and unfertilised eggs develop to become fertile haploid males (drones). In whiptail lizards of American southwest, meiosis is severely modified to yield a clone of only females **Summary of parthenogenesis in honeybees**



c) Apomixis:

It is the formation of plant embryo from an unfertilised haploid egg cell or from a diploid embryo sac mother cell or from a diploid cell in the ovule without fertilisation. It occurs in <u>potatoes</u> and <u>citruses</u>.

d) Parthenocarpy:

This is fruit development without fertilisation, usually induced by auxins e.g. in apples

Give the major advantages of parthenogenesis -
It avoids the problem in some animals of bringing together males and females at the right moment for successful fertilization.

- Produces a large number of organisms in a short time. *E.g. in whiptail lizards all the parthenogenetic offspring are females, which all produce eggs, yet only half of the bisexual population are egg-laying females.*
- It eliminates in each generation all lethal genes that thrive in homozygous state

Major disadvantage of parthenogenesis:

-During sudden environmental changes, parthenogenetic species have limited capacity to shift gene combinations to adapt to the new conditions

SEXUAL REPRODUCTION

The role of sexual reproduction compared

Advantages	Disadvantages

- Brings about genetic variability in a population by recombining parental characteristics, enabling a species to adapt to the changing environmental conditions -During the life cycle of the organism, resistant stages develop enabling survival of adverse conditions - The formation of spores, seeds or larvae, which may be used to disperse offspring and so, reduce intraspecific competition. -It leads to increased numbers of a population	- May result into lethal combination of genes - In some animals, it is difficult to bringing together males and females at the right moment for successful fertilization. - It relies so much on external agents hence reducing chances of occurrence -It is a slower method of reproduction. -There is wastage in production of males, many of which fail to reproduce & thus consume resources that could be applied in the production of females -Females only pass half of the genes to the offspring because the genome is halved at meiosis

Out line the ways through which variation can arise in a population

i) During fertilization when male and female gametes with different genotypes fuse to form a zygote. ii) Mutations during which there is alteration in gene structure and sequence.

iii) During meiosis by crossover during prophase I and also during random segregation of chromosomes on the metaphase plate iv) By the effects of the environment where the organisms live.

What are the main characteristics / features of sexual reproduction?

-It involves production of gametes by two separate parents, a process called gametogenesis. **Isogametes** are identical though dissimilar genetically, **Anisogametes** (heterogametes) differ slightly in size. Some species exhibit **oogamy**, the gametes greatly differ in size and activity - It involves fertilisation (syngamy), the union of male and female gametes -Bacteria reproduce by conjugation.

Define the term life cycle.

It is the progressive sequence of changes an organism goes through from fertilization till death.

What is meant by alternation of generations?

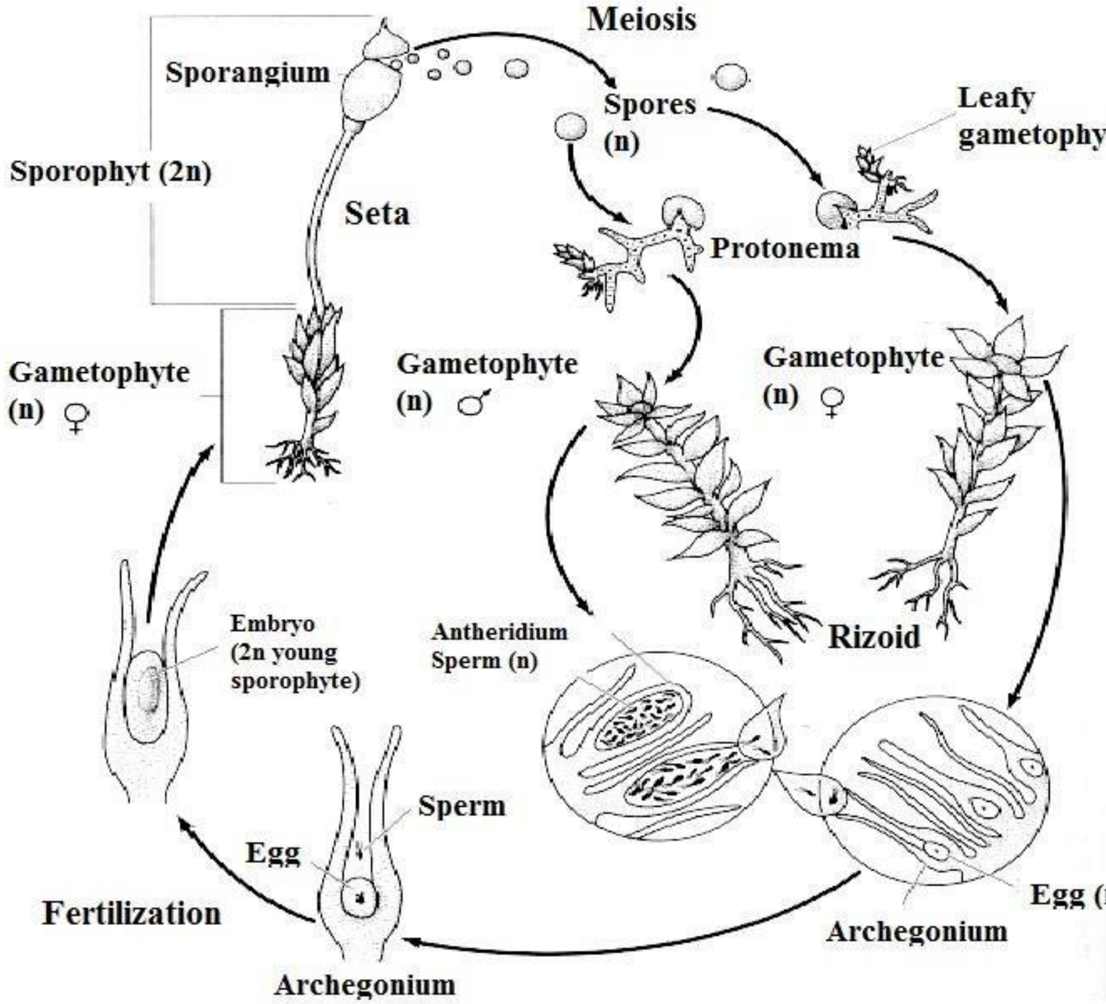
It is the occurrence within the life cycle of an organism two or more distinct forms (generations), a haploid gametophyte and diploid sporophyte generations, which differ from each other in appearance, method of reproduction and genetic constitution.

a) Give an account of alternation of generations in a named bryophyte or pteridophyte/Filicinophyte
b) Compare alternation of generations in a named bryophyte and pteridophyte.
c) Discuss the significance of alternation of generations to the life cycle of plants.

REPRODUCTION IN PLANTS

a) **Alternation of generations (lifecycle) of a moss e.g. *Funaria*** – a bryophyte:

- A moss e.g. *Funaria* consists of two distinct forms in its life cycle, the haploid gametophyte, which is the dominant and sexual stage, and the diploid sporophyte, which is the asexual and less conspicuous stage.
- A gametophyte may bear both sex organs, the antheridia (sperm producing) and archegonia (egg producing) or they may be borne on separate gametophyte plants.
- On maturing, the antheridia shed sperms, antherozoids that are aided by rain-splash to reach the open neck of archegonia, and the attracted by chemicals e.g. sucrose enables them to reach the archegonia.
- The haploid antherozoids fuse with the haploid eggs (ospheres) to form diploid zygotes (oospores).
- The zygotes develop into diploid sporophytes, which remain attached and surviving on the gametophytes.
- At maturity the sporophyte produces haploid spores by meiosis within a spore capsule, which splits open when dry and the spores are dispersed by wind.
- On landing on moist soil;, each spore germinates into a green filamentous protonema which produces buds that grow into new haploid gametophyte. *Lifecycle of Funaria*

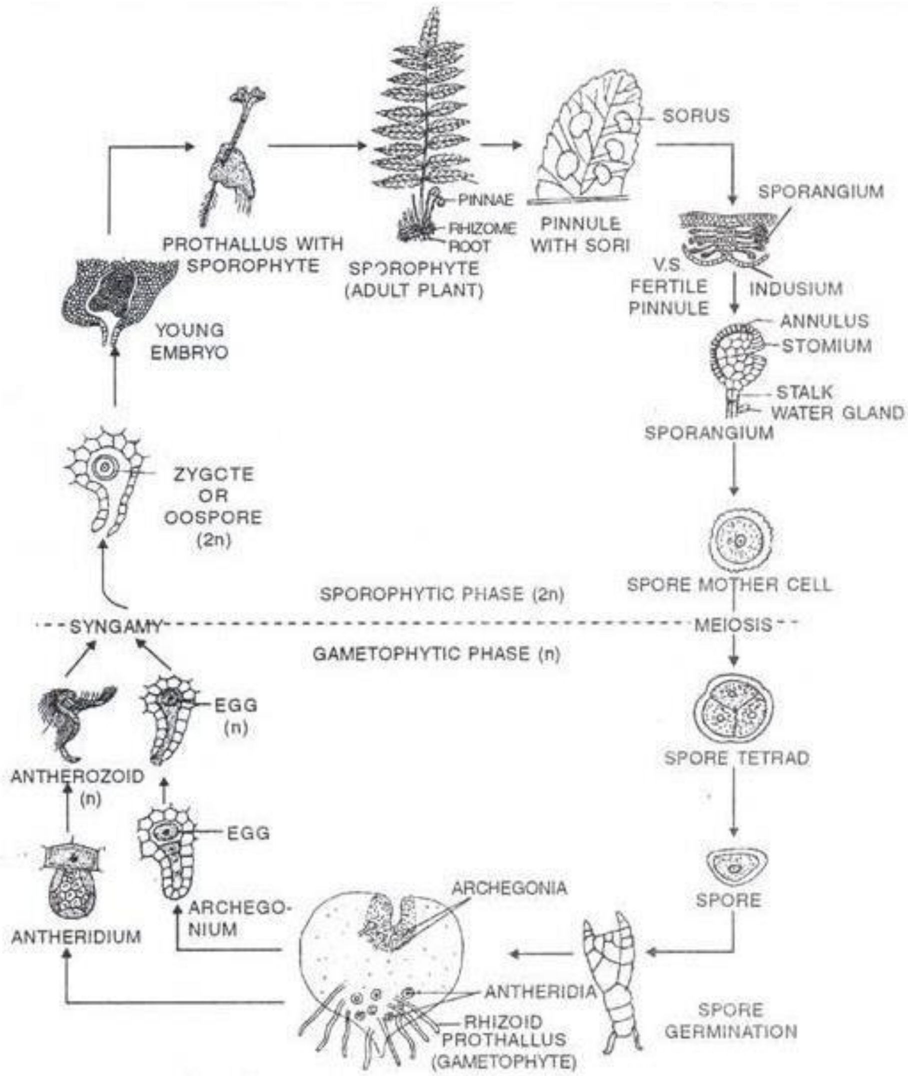


Alternation of generations (lifecycle) of a common fern - a Pteridophyte / Filicinophyte:

- A common fern (*Dryopteris)* consists of two distinct forms in its life cycle, the diploid sporophyte, which is the dominant and asexual stage, and the haploid gametophyte, which is the sexual and less conspicuous stage.
- Diploid spore mother cells inside sporangia divide by meiosis to produce haploid spores When mature, the protective covering (indusium) shrinks and the exposed sporangium wall begins to dry out.
- The walls rupture and the spores are discharged from the sporangium.
- If moisture is present, each spore germinates into heart-shaped prothallus (gametophyte), anchored to the soil by rhizoids.
- At the underside, the prothallus bears antheridia and archegonia that produce haploid sperms and eggs by mitosis respectively.

- After rupture of antheridia, the ciliated sperms swim through water to fertilise eggs at the base of archegonia, and the diploid zygotes formed grow into young sporophytes, which remain supported on the prothallus till self-supporting.

Lifecycle of Dryopteris



b) **Comparison of alternation of generations in a moss e.g. *Funaria* and common fern** <u>Similarities:</u>

In both:

-There is one dominant stage and the other stage is relatively inconspicuous.

-A moist or aquatic environment is required.

-Male gametes from the antheridia are brought into contact with eggs by some mechanisms.

-The gametophytes bear sperm producing antheridia and egg producing archegonia.

-Cases the spores are formed in specialized spore-bearing sporangia.

-There is a dispersal mechanism for scattering spores.

-Sporophytes are diploid and gametophytes are haploid. -Spores are produced by meiosis and gametes by mitosis

REPRODUCTION IN PLANTS

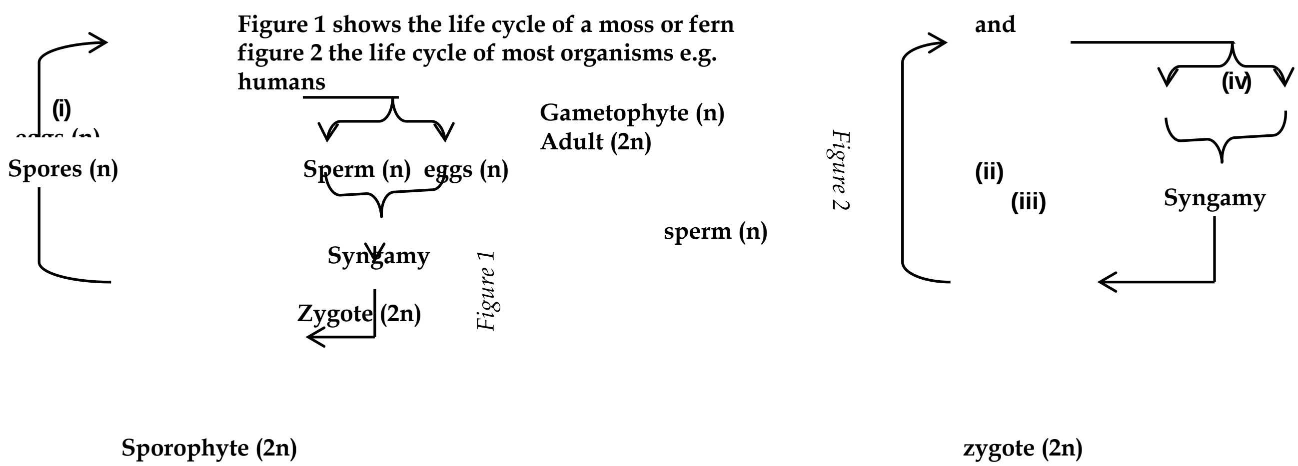
-There is sexual and asexual reproduction
-Male gametes are motile while eggs are non-motile

Differences between alternation of generations in a moss and common fern

Alternation of generations in a moss e.g. *Funaria*	Alternation of generations in a Common fern
- Sporophyte is dependent upon the gametophyte nutritionally -Each spore germinates first into protonema, which transforms into gametophyte - Gametophyte is the dominant generation - Both male and female reproductive organs may be borne on same or separate gametophyte plants -Majorly depends on water for plant growth, transference of sperms, support and spore dispersal and spore germination	- Sporophyte is a self supporting plant -Each spore germinates directly into gametophyte -Sporophyte is the dominant generation - Both male and female reproductive organs are borne on the same gametophyte (prothallus) - Dependence on water is less, mainly for swimming of sperms and germination of spores

c) ***The significance of alternation of generations to the life cycle of plants***

- It enable exploitation of different habitats in the ecosystem by the different generations
- Promotes rapid multiplication of species since spores are enormously produced
- Enables plants to cope better with adverse environmental conditions for survival
- It reduces chances of extinction of a species since the different generations are interdependent
- Brings abut genetic variability by meiosis during spore formation
- Mitosis during gamete formation maintains the plant genome by producing haploid gametes



Which processes shown by arrows represent meiosis in both cycles?

A. (i) and (iii)
B. (ii) and (iv)
C. (i) and (iv)
D. (ii) and (iii)

REPRODUCTION IN PLANTS

COMPARISON OF PLANT FEATURES IN DIFFERENT PHYLA

Features	Bryophyta	Pteridophyta	Gymnosperms	Angiosperms
Dominnant phase	Gametophyte	Sporophyte	Sporophyte	Sporophyte
Ploidy of main plant body	Haploid	Diploid	Diploid	Diploid
Differentiation of body	Thallus and rhizoids	Roots, stem and leaves	Roots , stem and leaves	Roots, stem and leaves
Vascular bundles	Absent	Present	Present	Present
Nature of spores	Homospores	Homospores or heterospores	Heterospores	Heterospore
Seed and its coverings	Seed absent	Seed absent	Seed naked without covering	Seed with coverings
Flower	Absent	Absent	Absent	Present

GENERALIZED DESCRIPTION OF THE ESSENTIAL ORGANS OF FLOWERS

Essential organs are those which directly take part in reproduction i.e. androecium and gynoecium while the **accessory/non-essential organs** are those which assist but do not directly take part in reproduction i.e. corolla and calyx.

a) Androecium: It is the collective name for the male sex organs of a flower, the stamens, each of which consists of the filament, a stalk supporting the anther head at the tip, and the connective, containing vascular strand. Various terms are used to describe stamens. i) Gynandrous – stamens attached to pistils

ii) Versatile – the filament is attached to the anther at the middle, so that the anther is loose and can oscillate *e.g. maize and most grasses*

iii) Adnate – anthers placed on filament along lengthwise direction of filament *e.g. michelia* iv) Basifixed – filament attached to the base of the anther e.g. radish

v) Dorsifixed – the tip of the filament is attached to the back of the anther (about the middle region) e.g. passionflower.

vi) Staminode - infertile / sterile stamens vii) Epipetalous – stamens attached on corolla

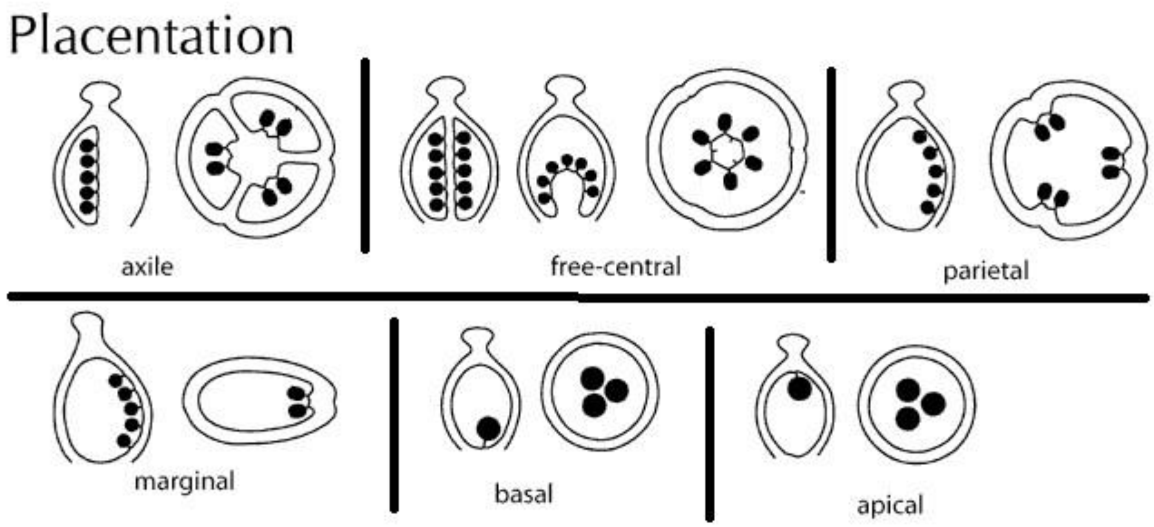
viii) Syngeneceous – a condition in which filaments free, but all anthers are fused ix) Synandrous – stamens are united completely by both filaments and anthers *e.g. cucumber* x) Adelphous – anthers free, filaments united

xi) Monoadelphous - anthers free, filaments united but in just one bundle *e.g. hibiscus* xii) Diadelphous - anthers free, filaments fused to form two bundles *e.g. sweet pea, bean* xiii) Polyadelphous - anthers free, filaments united to form many bundles.

Stigma may have one or more lobes, hairy, feathery, sticky, rough etc.

Internally, ovary may be monocarpellary (single carpel), bicarpellary (two carpels), pentacarpellary (five carpels), etc. depending on the number of mainly chambers observed when cut or stigma lobes.

Placentation (pattern of ovule arrangement) may be **marginal** *e.g. in beans*, **parietal** *e.g. in pawpaw, passion fruits and some cucumber*, axile *e.g. in oranges and lemons*, **free central/central** *e.g. in green pepper*, **basal** (at base) *e.g. in mango*, **Apical** (at apex) *e.g. avocado*



A carpel is described as:

i) Monocarpous – if it consists of only one carpel ii) Apocarpous – if there are many carpels that are entirely separate from one another e.g. in rose.

iii) Syncarpous – when all its carpels or at least their ovaries are fused e.g. in hibiscus.

With reference to plants, distinguish between the following, giving examples.
Monoecious, dioecious, and polygamous species
Dichogamy, Protandry and Protogyny
Heterostyly and self-sterility

Monoecious species: are species in which individual plants bear separate male and female flowers e.g. maize, oak, sycamore, coconut, date palms, castor oil, pumpkin

Dioecious species: are species in which individual plants bear either only male or only female flowers, so that there are different sexes of the plant e.g., pawpaw and asparagus.

REPRODUCTION IN PLANTS

Polygamous species: are species in which individual plants bear three types of flowers: bisexual, male and female e.g. mango

Dichogamy: failure of the stamens and pistil to ripen at the same time in a hermaphrodite flower. **Protandry:** it is the ripening of the stamens before the carpel in a hermaphrodite flower e.g. in sunflower, white deadnettle, salvia, and dandelion *(mainly insect pollinated flowers)*.

Protogyny: ripening of carpels earlier than the stamens e.g. in arum lilies, and wild varieties of: wheat, barley, and oats. *(Mainly wind pollinated flowers). NB: protandrous flowers are more common than protogynous ones.*

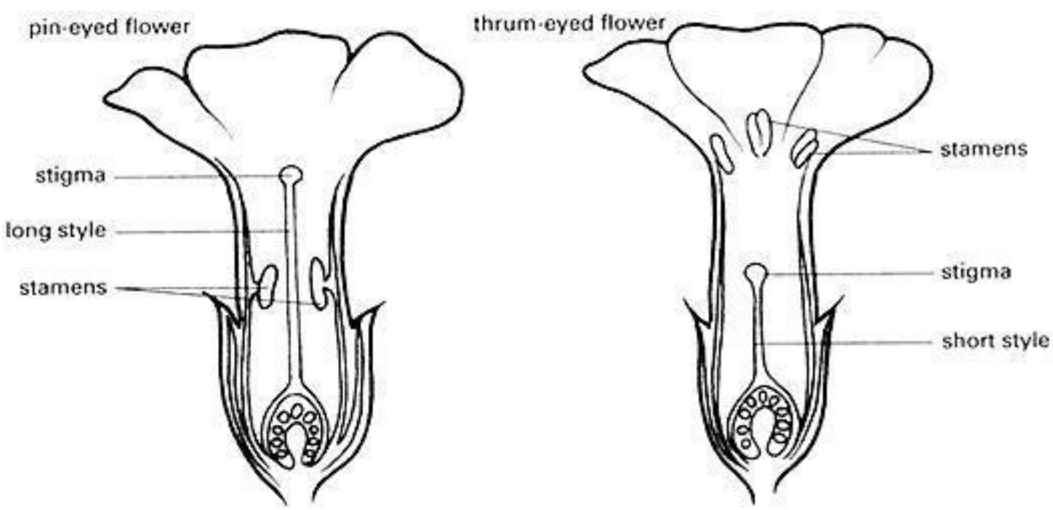
Heterostyly: it is a condition in which the style length is different in various flowers of an individual plant, so that pollen from a different flower only can bring about effective pollination. e.g. primrose, has two types of flowers that differ in length of style, with the pin-eyed flower having stamens situated below the stigma while in the thrum-eyed flower they are situated above.

Self-sterility/genetic self-incompatibility: a condition, which results when the pollen and stigma recognize each other as being genetically related and pollen tube growth is either blocked or retarded. e.g. in clover and pears.

Self-incompatibility is controlled by the *S* (self-incompatibility) locus, which bears many alleles e.g. S_1, S_2, S_3, that regulate recognition responses between the pollen and stigma.

In gametophytic self-incompatibility, if any of the *S* alleles in the stigma matches with any pollen *S* allele, then the growth of that particular pollen tube with the allele which matches stops before it reaches the embryo sac, but other pollen tubes with alleles that don't match continue growing. Gametophytic selfincompatibility is determined by the haploid pollen genotype e.g. in petunias.

In sporophytic self-incompatibility, if any allele in the stigma matches with either of the pollen parent *S* alleles, then not even a single haploid pollen germinates. Sporophytic self-incompatibility recognizes the genotype of the diploid pollen parent, not just the haploid pollen genotype e.g. in broccoli. **Drawings showing Heterostyly in primrose**



In a species, self-sterility is controlled by multiple alleles S_1, S_2 and S_3.

a) Assuming that self-sterility occurs if the pollen grain and the style tissue have an allele in common, what proportion of the pollen grains from a plant with the genotype S_1S_2 would be capable of

successfully germinating on a plant with: i) Genotype S_2S_3? ii) Genotype S_1S_2? Explain your answers in (i) and (ii) above.

b) What type of self-incompatibility is exhibited in (a) above?

c) Give three other factors which promote outcrossing in plants.

a) (i) Only ½ or 50% of the pollen grains (those with the allele S_1) would be capable of germinating A plant of genotype S_1S_2 produces ½ of its pollen with allele S_1 that does not match with either of the alleles S_2 and S_3 of the style tissue, hence would germinate, while the rest of pollen are of allele S_2 which matches with allele S_2 of the style tissue, germination would be inhibited.

ii) 0% or none of the pollen grains germinates. Both alleles S_1 and S_2 would match with those of the style tissue and germination would be inhibited.

c) Dioeciousness (Dioecism), Monoeciousness (Monoecism), Dichogamy and Heterostyly

a) State the physiological adaptations of flowers to pollination

b) Explain the mechanisms which limit inbreeding / promote outcrossing in plants

c) What are the consequences of self pollination and cross pollination

Pollination is the transfer of pollen grains from the anthers to the stigma of the flower.

Self-pollination – pollen from the anthers is transferred to the stigma of the flower on the same plant. Cross-pollination - pollen from the anthers is transferred to the stigma of another flower on a different plant but of the same species. Based on agents, wind pollination is categorized as follows:

i) Anemophily (wind pollination). Anemophilous flowers exhibit many features (check page 12) **ii) Entomophily** (insect pollination). Characteristics of entomophilous flowers are given on page 12. **iii) Hydrophily** (water pollination). In hydrophilous flowers, pollen grains have same specific gravity as that of water to enable floating in water at any depth.

iv) Ornithophily (bird pollination). Ornithophilous flowers are tubular shaped, brightly coloured, with plenty of nectar, and generally odourless.

v) Chiropterophily (bat pollination). Chiropterophilous flowers emit strong scent and open after dusk, have long stalks and produce large quantities of nectar. ***a) Adaptations of flowers to self-pollination:***

Physiological	Morphological
-Stamens and carpels mature at the same time -Hermaphrodite flowers may not open petals -Hermaphrodite flowers may remain under ground -Pollen is released onto the stigma by matured anthers before the petal opens. -Pollen is compatible with the tissues of style, thus allowing for their germination	-Flowers are reduced and inconspicuous -Stamens are situated above the stigma or the anther is close to the stigma -stigma often coiled to touch ripe anthers -Style and filaments coil on one another -Flowers failing to open e.g. in commelina

Adaptations of flowers to cross-pollination:

Physiological	Morphological

-Stamens ripen before carpel (protandry *e.g. in salvia, deadnettle and dandelion*) or carpel ripens earlier (protogyny) -Self incompatibility due to chemicals prevents germinating of pollen on the stigma of the same flower (self-sterility) -It is genetically controlled by self-incompatibility genes e.g. in pears pollen only becomes functional if the stigma surface on which it is has a different genetic composition.	-Dioecious flowers have either stamens or pistil -Stamens situated below the stigma . -Hermaphrodite (bisexual) flower containing both sex organs. -Production of nectar to attract insects. -Hanging of stamens or whole flower downwards so that falling pollen drops clear of that plant.

b) ***Mechanisms which limit inbreeding (self-pollination) in plants***

- Dioeciousness, all flowers on the plant being either male or female e.g. pawpaw
- Monoeciousness, having separate male and female flowers on the same hermaphrodite plant.
- Heterostyly (differing style length), structure of the flower e.g. when a stigma is protected from coming into contact with its own pollen or stigma being taller than the anthers.
- Dichogamy, Stamens ripening before carpel (protandry) or carpel ripening earlier (protogyny).
- Self incompatibility due to chemicals prevents germinating of pollen on the stigma of the same flower

c) ***Consequences/effects of self-pollination (inbreeding) and cross-pollination (out breeding)***

Consequences of self-pollination (inbreeding)	*Consequences of cross-pollination (out breeding)*
It promotes homozygosity i.e. transmission of genotype in the population, resulting into decreased fertility, reduced resistance to disease, thereby reducing evolutionary potential of the species in the long run.	It promotes genetic diversity, resulting into hybrid vigour, causing increased resistance to diseases, high yield, and earlier maturity, thereby providing greater evolutionary potential.

Comparison of the advantages and disadvantages of self and cross pollination:

Advantages	*Type of pollination*	*Disadvantages*
-It is reliable especially where members of a species are rare and far apart -It is the only means where pollinating agents are unreliable e.g. mountain tops lack insects, and during harsh climate. -It is not wasteful of pollen grains	*Self-pollination*	It promotes homozygosity i.e. transmission of genotype in the population, resulting into decreased fertility and reduced resistance to disease
It encourages genetic variation, increasing the hybrid vigour	*Cross-pollination*	It is wasteful of pollen grains since pollinating agents are not very efficient

a) Give one ecological importance of each of the following structural arrangements in plants. i) Monoeciousness

-It allows self-fertilization for continuity of species where plants of that species are few or separated by long distance **ii) Dioeciousness**

- It encourages genetic variation, thereby increasing the hybrid vigour since it allows crosspollination

b) Explain why

i) ***In dioecious plants, male plants are usually associated with dry soils while female plants are associated with moist soils.***

-Pollen production does not require much water, while seed formation and fruit ripening require much water.

ii) Nearly all dioecious plants are wind pollinated

It may not be possible to have animal pollinators bring in pollen from the same plant species, which would reduce chances of fertilization.

OR: It is therefore much easier for wind to bring in pollen from same plant species to increase chances of fertlisation

c) Suggest two reasons why dioecious plants (those with separate sexes)are rarer than monoecious plants, despite the advantages of cross-pollination.

-Half of the individuals in dioecious plants do not produce seeds, whereas all individuals in monoecious plants bear seeds.

-A lot of pollen is wasted in dioecious plants because the male and female plants are not necessarily together.

d) Why is dioecism (separate sexes) common in animals than in plants?

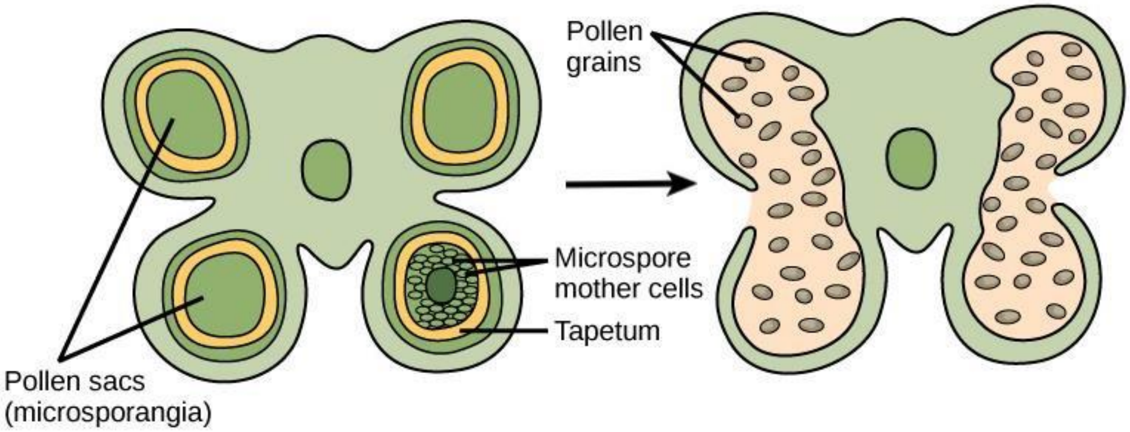
-There is less wastage of gametes in animals than in plants because males and females can move about.

Comparison of wind pollinated (anemophilous) and insect pollinated (entomophilous) flowers

Wind pollinated flowers e.g. guinea grass, maize, rice	*Insect pollinated flowers e.g. crotalaria, sunflower, coffee, etc*
-Inconspicuous flowers, small and reduced in size. Petals may be absent or dull coloured if present. -No nectar and not scented -Pollen produced in large quantity, light, smooth, small and may have wing-like extensions. -Anthers are large and versatilily attached to filament. -Stamens hang outside the flower to release pollen. -stigmas are large, feathery or branched to trap pollen. -Stigmas hang out side the flower. -Flowers often unisexual, having male and female reproductive parts on separate flowers.	-Conspicuous flowers, large with brightly coloured petals, and often held in inflorescence if they are tiny and inconspicuous. -Produce nectar and or scent to attract insects. -Less in quantity, sticky, relatively heavy, and large pollen is produced. -Anthers are small and basifixedly or dorsifixedly attached to filament. -Stamens are confined within the flower. -Stigma relatively small, glandular, and sticky. -Stigma lies inside the corolla. -Flowers bisexual, enclosing reproductive organs e.g. stamens and carpels.

REPRODUCTION IN PLANTS

Transverse section of male gamete producing organs in flowering plants

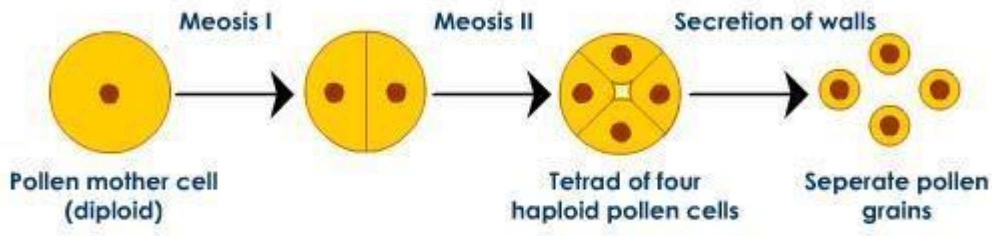


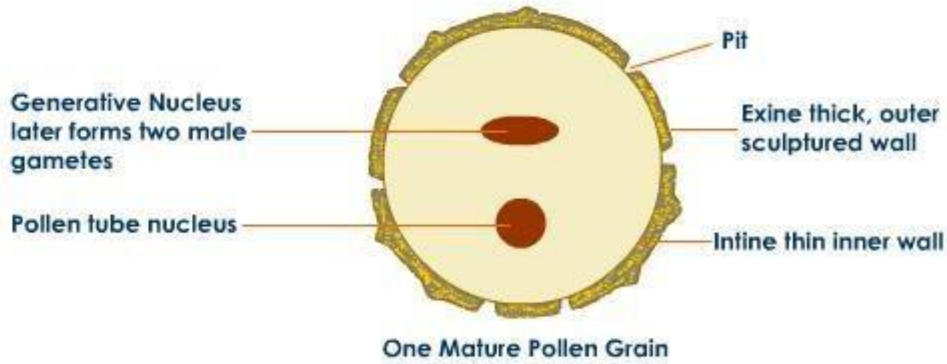
Describe the significant events that lead to the production and release of gametes in flowering plants.

- Gamete formation in plants occurs in the anther (male gametes) and ovary (female gametes).
- The pollen grains, formed in the anthers, contain and transport the male gamete while the ovules, formed in the ovary contain the female gamete (egg/ovum).

Production and release of male gametes:

- Repeated mitotic divisions occur within the sporogenous tissue, producing a mass of swollen cells, the microspore mother cells.
- Mitosis stops and each micro spore mother cell divides by meiosis to form a tetrad of haploid microspores, each of which gives rise to a pollen grain.
- Each pollen grain develops a hard resistant, sculptured outer wall, the exine and an inner cellulose wall, the intine.
- The single haploid pollen grain nucleus divides by mitosis form a pollen tube nucleus and the generative nucleus.
- When the pollen grains mature, the walls between each pair of pollen sacs breakdown and the anther lobe rupture longitudinally along the line of weakness to release pollen grains. ***Diagrams illustrating the production of male gametes in plants***



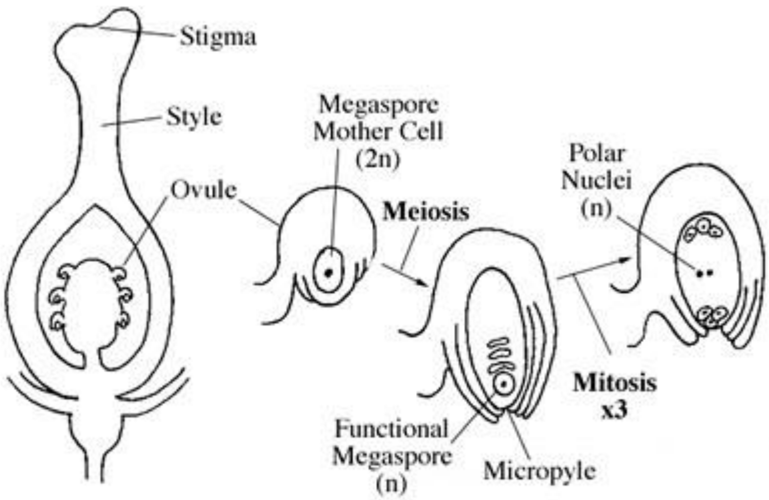


Production of female gametes:

- Each ovary develops one or more ovules, which contain a mass of cells, the nucellus, which is completely surrounded by two integuments, except at a small pore called micropyle.
- One cell of the nucellus develops into a diploid embryo sac mother cell.
- The embryo sac mother cell divides meiotically to give four haploid megaspore cells, only one of which develops to form the embryo sac while the three degenerate. *(In terms of development, the embryo sac is the equivalent to the pollen grain of the male)*
- The embryo sac nucleus divides mitotically to form two nuclei, which migrate to opposite poles, from where each divides mitotically to form four haploid nuclei at each pole.
- One nucleus from either end of the sac move to the centre and fuse to form a diploid primary endosperm nucleus.
- The remaining six nuclei each gets enclosed in a thin cell wall, and one of the three nuclei near the micropyle becomes the female gamete (egg nucleus).
- The remaining two nuclei near the micropyle, the synergids disintegrate while the three nuclei at the opposite end to the micropyle become the antipodal cells.
- Thus, a mature embryo sac contains a total of 7 nuclei, comprised of: two synergids, three antipodal cells, and diploid primary endosperm nucleus.

Diagrams illustrating the production of female gametes in plants

REPRODUCTION IN PLANTS



State the main features of embryo sac development in flowering plants

 Mitosis occurs three times

- There is formation of diploid nucleus by fusion of two male nuclei
- Produces six haploid cells
- Forms antipodal, synergid and egg cells.

a) Describe the events, which occur in the flower from pollination to fertilization.
b) What are the results of fertilization in a flower?
c) Explain what is meant by double fertilisation in relation to flowers.

a) -When a ripe pollen grain lands on the right stigma, it absorbs water, the outer wall (exine) breaks open and the inner wall (intine) germinates to form a pollen tube.

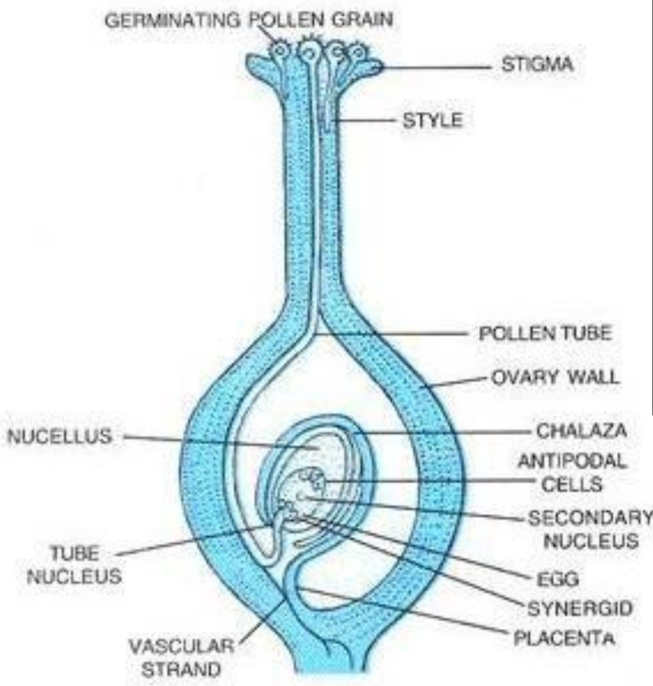
-The tube nucleus is positioned at the tip of the growing pollen tube controlling growth while the 2 male nuclei (2 sperms) formed by mitosis from the generative nucleus follow closely behind. -The pollen tube tip pierces the stigmatic surface and penetrates the style tissue via intercellular spaces.

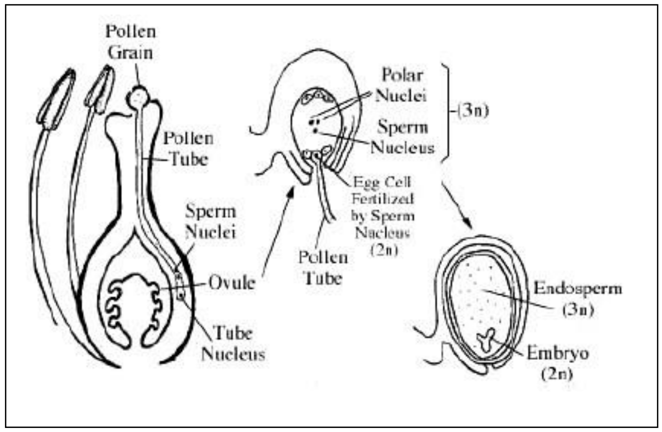
-Chemical substances in the style and embryo sac enable the unidirectional rapid growth of the pollen tube towards the ovary.

-After reaching the ovary, the pollen tube grows towards the ovule and usually enters through the micropyle, chalaza, or integuments.

-The pollen tube then penetrates the embryo sac, bursts open and the tube nucleus degenerates. -The <u>first fertilization</u> occurs when one sperm fuses with the egg to form a <u>diploid zygote</u>, while the second fertilization occurs when another sperm fuses with the diploid secondary nucleus to form a triploid primary endosperm nucleus. This double fertilization is unique to only flowering plants.

Diagrams illustrating fertilisation in flowering plants





b) Summary of the results of fertilization in a flowering plant

Before fertilisation	*After fertilisation the parts become*	*Function of part formed after fertilisation*
Zygote	Embryo	
Ovule	Seed	Protects embryo
Ovary	Fruit	Protects seeds and enables their dispersal
Integuments: (a) outer (b) inner	Testa/seed coat Tegmen	Offer protection to the seed
Ovary wall	Fruit wall/pericarp	Offers protection to fruit contents
Triploid primary endosperm nucleus	Endosperm	Acts as food store in some seeds e.g. cereals like maize, wheat, castor oil
Micropyle	Micropyle	For entry of water and oxygen at germination
Nucellus	Disappears	
Calyx	Wither away or may persist	
Petals, stigma, style & stamens	They dry and fall off	

c) Double fertilization: is a unique process occurring only in flowering plants in which one male nucleus fuses with the functional egg nucleus to form a diploid zygote while another male nucleus fuses with the diploid secondary nucleus to form a triploid primary endosperm nucleus simultaneously.

a) What are the advantages and disadvantages of propagation by seed?
b) Explain how the science of palynology (pollen analysis) can provide information about past climate and human activities of a particular period of time.

a) Advantages:
- Enable plants to be better adapted for land environment since water is less required for sexual reproduction
- Embryo is protected within the seed
- There is food reserve for embryo growth in the cotyledon or endosperm
- Seeds are easy to store
- Seeds are easy to disperse and transport
- Allows for mixing of genes which increases the hybrid vigour
- There is increased resistance to diseases
- Plants mature early
- There is tolerance to unfavourable conditions **Disadvantages:**
- Seeds are easily destroyed by pests
- Seeds have limited food reserves
- Requires selection of suitable seeds
- Needs technical knowing
- Initial inputs are expensive
- Dispersal may not be easy because of the large size of seeds usually

b) -The highly sculptured pattern of the exine (outer wall) of pollen grain is specific to plant species or genus.
-Since the exine has a waterproof lining resistant to decay, pollen grains last for a longtime in the sediments.
-The pollen from successive layers of sediments can be extracted and analysed by radiocarbon dating to establish the climatic history e.g. past temperature. Human interference with the natural vegetation is also reflected in the pollen record e.g. absence of pollen from trees in some areas would indicate forest clearance.