AS-2317

Department of Forestry, Wildlife and Environmental Sciences
Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.)

Paper III: Reproductive Biology in Forest Trees

Time: 3 hours Max.marks: 60

Note: Section A is compulsory. Attempts any Four question in section B

SECTION –A

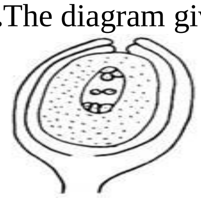
Q1 A. Multi Choice Question
[1×1]

1.Maturation of male and female sex organ at different time is known as:
(a) Herkogamy (b) Dichogamy
(c) Polygamy (d)Apogamy
Ans. (b) Dichogamy

2.Cross pollination is prefered over self pollination because it :
(a) Produce better offspring (b)Induce parthenogenesis
(c) Form new verities (d) Economical

Ans. (c) Form new verities

3.The diagram given by the side represents the sectional view of



(a) Campylotropous ovule (b) Anatropous ovule
(c) Orthotropous ovule (d) Amphitropous ovule
Ans.(c)Orthotropous ovule

4.Fibrous thickenings of hygroscopic nature are found in this part of the anther wall:
(a) Endothecium (b)Tapetum
(c) Epidermis (d) Middle layer
Ans.A

5.Which one of the following is surrounded by a callose wall?
(a) Pollen grain (b) Microspore mother cell
(c) Egg (d) Male gamete
Ans. (b) Microspore mother cell

Q1(B). Fill in the blanks: **[1×1]**
1 Orchidaceae is the largest Angiosperm family having 24, 000 species Orchids

2.Primitive fossils of 125-million-year-old angiosperms **Magnoliophyta**
3.The key adaptations in the evolution of angiosperms are **flowers and fruits**..
4.Flower of *Aristolochia* shows **Fly trap mechanism**.
5.Phenomena of formation of more than one embryo is **Polyembryony.**

Q1.(C) Write short notes any Five on the following question **(5 X 2 = 10)**

a. Pollinium- is a coherent mass of pollen grains in a plant.They are the product of only one anther, but are transferred, during pollination, as a single unit. This is regularly seen in plants such as orchids. Most orchids have **waxy** pollinia. These are connected to one or two elongate stipes, which in turn are attached to the sticky **viscidium**.

b. Fission- is a form of asexual reproduction when a cell (or body, population, or species) divides into two or more parts and the regeneration of those parts into *separate* cells (bodies, populations, or species).**Binary fission** produces *two* separate cells, populations, species, etc. used by all prokaryotes, (bacteria and archaebacteria), whereas **Multiple fission** at the cellular level occurs in many protists, e.g. sporozoans and algae.

c. Chasmogamous Flower- A chasmogamous flower opens at maturity, exposing stamens and style to allow fetilization. The style receives pollen from another individual. Chasmogamous flowers also provide pollen to other plants. Chasmogamous flowers are structured to maximize the receipt of pollen; they are generally larger and showier with markings such as nectar guides to facilitate the entrance of pollinators such as insects.[1] They produce nectar, the reward sought by pollinating organisms, and are sometimes scented to attract them. The petals of a chasmogamous flower can be attractive to pollinators; Chasmogamy is a mechanism that can increase fitness via the exchange of genes between individuals.

d. Zoophily- is a form of pollination whereby pollen is transferred by vertebrates, particularly by hummingbirds and other birds, and bats, but also by monkeys,marsupials, lemurs, bears, rabbits, deer, rodents, lizards and other animals. Zoomophilous species, evolve mechanisms to make themselves more appealing to the particular type of pollinator, e.g. brightly colored or scented flowers, nectar, and appealing shapes and patterns. These plant animal relationships are often mutually beneficial because of the food source provided in exchange for pollination. Zoophilous species include *Arctium*, *Acaena*, and *Galium aparine*.

e. Clone- A cell, group of cells, or organism that is descended from and genetically identical to a single common ancestor, such as a bacterial colony whose members arose from a single original cell.**Cloning** is the process of producing similar populations of genetically identical individuals that occurs in nature when organisms such as bacteria, insects or plants reproduce asexually. A DNA sequence, such as a gene, that is transferred from one organism to another and replicated by genetic engineering techniques. Cloning refers to processes used to create copies of DNA fragments (molecular cloning), cells (cell cloning).

f. Ephydrophilly- Pollination by by water. The pollen may be transported on the water surface, as in Vessisneria,Spiralis.Both male and female organs are horizontal ,small cup shaped depression is formed in female flower and male flower floats and come close to the female flower and trumble down in to depression.

SECTION-B **[1×10]**

Q2. Write in detail the reproductive biology of *De*lbergia sisso.

Ans. *Dalbergia sissoo* is distributed throughout the sub Himalayan tract usually up to 900m but sometimes ascending to about 1500m.It has been cultivated or self sown in the most parts of Indo-Pakistan sub continent for a long time. *D. sissoo* is a native of Indo-Gangetic basins and grows naturally in parts of Bhutan, Nepal, India and Pakistan. The tree has been introduced into many other countries like Java, Nigeria, Mauritius, Srilanka, Kenya etc. It is very likely that sissoo is indigenous to only the sub-Himalayan tract and has been introduced by man elsewhere.

In the natural habitat of sissoo maximum shade temperature varies from 39ºc to 49ºc and minimum from 4ºc to 6ºc. The normal rainfall varies from 760-4570mm.

In its natural state, Dalbergia sissoo grows most typically on alluvial ground either in the beds of river or mostly on the sand or gravel along the banks of rivers often very gregariously. Its preference is to a porous well irrigated soils with adequate moisture has been its characteristics feature wherever its growth has been a marked success. The tree is capable of existing in very poor soils, on hilly cliffs. It does not tolerate water logging. It is moisture-loving species

D. sissoo is recognised as an important multipurpose tree species. Its timber is used for making cabinets, veneers, bent wood articles like furniture, superior quality felloes for wheels, in gun carriage, in ordnance factories etc. It is also used for boat building, brush backs and to a small extent for unshielded bobbins. Considerable use in the sports equipments such as croquet, mallet heads and balls, as frames of tennis racquets cannot be disparaged. Sissoo wood is an excellent fuel, Seed oil and powdered wood is used for leprosy and skin disease treatment. Its wood is hard, heavy, strong, double elastic, seasons well and is decay resistant .

Sissoo is a deciduous tree often with crooked trunk and light crown. It fixes atmospheric nitrogen to ameliorate the site.

Morphological variations

A survey revealed that there exits a wide variation in the phenotypic characters of individuals selected for study. This variability has been categorised into different parameters as below.

Phenological variations in fruit and seed variability.

Trees of D. sissoo largely varied for flowering intensity. Trees with very dense flowering and very thin flowering were also identified. Some differences in the flowering period of the trees was also observed. Some trees flowered earlier than others which can be due to change of environmental factors at different sites. Due to large variation in flower bearing capacity of trees, large variation in pod setting of trees was also observed. Trees which bear less flowers produced very less pods or even bears no pods and tree with very heavy flowering shows very heavy pod setting. Pods could be collected having 1 to 4 seeds.

Reproductive biology

Phenology. Tree is leafless in December- January.The leaflets fall separately and before falling they turn brown. In the month of March-April, flowering starts along with the appearance of leaves.Flowering is influenced by temperature. High temperature hastens flowering. The whole process was completed in 15-20 days from bud initiation to flower opening. It takes 7-8 months from bud initiation to fully ripened pods. It was also seen that buds and flowers occur at the same time in different stages of development, even on the same branch of the tree.

Flowering behaviour

Initiation 2^{nd} week of March
Peak 1^{st} week of April
Decline 4^{th} week of April

Floral Biology

Inflorescence

It is observed that the inflorescence of D. sissoo is an axilliary panicle, composed of several short spikes with sessile to sub sessile flowers ranging from 7-14 in number per inflorescence. Length of inflorescence is recorded to be 3-8cms. Flowers Flowers of D. sissoo tree are small pea shaped, slightly fragrant with a fine toothed calyx ,five petals (including two narrow wings and a narrow keel) and are yellowish white in colour. Flower colour changed from yellowish white to orange after pollination. Androecium is composed of nine stamens that are united into a broad stalk, monoadelphous, stamens are in two sizes 5 large and 4 small. Length of all floral organs stamen, ovary, petals & sepal were measured to understand the pollination mechanism. It was found that average length of flower petals was 0. 9 ± 0.07 cm and lengths of stamens (0.79 ± 0.2cm) were slightly less than hairy pistil, which was measured to be (0.85± 0.06cm). The stalked hairy pistil has a narrow ovary containing 5-6 ovules, a short style and a dotlike stigma. In the bud stage the ovary is in bent form and surrounded by anthers. Anthesis Data on flower opening was recorded and it was found that maximum number of flower opening takes places between 10.00 hrs to 14.00 hrs with a peak between 11.30-13.30 hrs. It was also found that dehiscence of anthers also takes place in morning hours in the bud stage, just before flower opens.

Receptivity

Study shows in opened flowers and unopened flowers, it was found that stigma becomes receptive few hours before flower opening and it was also noted that it remains receptive for few hours even after flowers opening. The stigma, which shows shiny and sticky surface, was considered as receptive.

Pollen structure

Pollen grains were 3 zonocolpate, thin walled, spherical in shape having size 10.2um± 0.11um.

Pollen viability Viability of pollen grains was measured by the acetocarmine test. 2% acetocarmine solution was used to stain pollen grains on slides. Viability of pollen grains was studied at different stages of flower development. Maximum pollen viability 100% was found at bud stage before flowers opening which decreases considerably with storage.. This gives important information about the pollination pattern of the species. When the viability of the pollen grains was checked from the already opened flowers it was recorded to be quite low i.e., 56%. This highlights that the chances of the pollen to effect the fertilization are considerably low after the opening of the flowers.

Mode of Pollination

To know about the mode of pollination the trees of the species were kept under constant observations for the visit of the insects and birds. It was seen that birds and insects do visit the flowers but do not participate in the pollination as they were found, when pollination had already taken place and flowers were in the stage of withering.

Pollination pattern

Self pollination. Under this experiment single bud inflorescence was selected before opening on each tree. 100 buds were bagged for selfing and data was recorded on pod setting. It was found that 16.25% pod setting occurs under controlled self-pollination. Some inflorescences were selected and tagged after counting the buds for recording pod setting percentage in nature, it was found that 35% pod setting takes place. Less pod setting under controlled self pollination with bagging is due to covering the buds with bags, which leads to the changed environment of the bud. Effective pollination is found to take place in the bud condition.

Artificial crossing

For this study young buds in which just corolla become visible were selected on the marked trees. These selected buds were emasculated early in the morning before 8.00 hrs. This process exposed the gynoeciums. After emasculation each bud was bagged to prevent contamination. On the same day at 11.00 to 12.00 hr the emasculated buds were pollinated with the pollens from other trees and again bagged. Data on pod setting was recorded and found that only 5-7% pod setting takes place.

Fruit Biology Pods mature in November-December. Pods were light brown and flat in shape. It has been seen that flowering and fruiting occurs simultaneously as young pods can be seen along with flowers on the inflorescences .

Number of pods per inflorescence

In natural pollinated inflorescences the number of pods/inflorescence ranged from 4-7.5 with a mean of 6.01 while in selfed ones it ranged from 3.2-4.5 with mean of 4.0.It is seen that the pods take about 6-7 months for complete maturity. The difference for mean number of pods per inflorescence between natural and self-pollinated inflorescence was significant.

Pod length

The average pod length in natural pollinated inflorescence was 5.132 cm while in self-pollinated inflorescence it was 4.542 cm . The differences between and within the natural and self-pollinated tree for pod length were found to be significant.

Fruit and seed development

Pod is indehiscent in nature and remains on the tree for months together even after attaining the maturity. While this pod development is taking place, simultaneously seed development also occur inside the pod. There are 5-6 ovules/ovary . Thus depending upon the number of ovules fertilized the corresponding number of seeds develop inside the pod. The number is usually 1 to 4 seeds per pod . It is observed that the size of pod with one seed is smaller than the pod with 3 or 4 seeds. The seeds are initially green and the cotyledons are fully endospermic, they have the funicle attached to the pod wall. As they attain maturity the testa becomes hard and brown in colour and the dehydration of the seed takes place..

Seed Biology - Seeds of D. sissoo were observed to be light brown in colour flat and thin reniform in shape.

Seed Length - The mean length of one seed was observed to be 0.83 cm in natural pollination trees and 0.82 in self pollinated individuals, however, these differences were found to be insignificant..

Seed breadth - The mean seed breadth of one seed was recorded 0.42 cm in self as well as naturally pollinated individuals.

Seed weight - A sample of hundred seeds was taken to measure the seed weight. The average hundred seed weight of D. sissoo was recorded as 1.53 gms in the individuals which were self pollinated or naturally pollinated.

Seed germination - It is seen that there is no problem/ barrier i.e dormancy in seed germination and the germination percentage is very high in the fresh seeds i.e., up to 83.6 per cent in some trees. However, the mean seed germination percentage in naturally pollinated individuals is found to 73.68 per cent and in self pollinated individuals the value is 73.99 per cent. Following peculiar features of D. sissoo was observed-

- Factors favoring self pollination in the species
- Ovary in the bud stage is enclosed in the whorls of stamen.
- Dehiscence of anthers takes place at the bud stage
- Anthesis takes place after the dehiscence's of the anthers
- Receptivity takes place inside the bud
- Pollen fertility to be very high in the bud stage
- Controlled pollination experiments leading to good amount of pod formation. Very few significant differences were found among the pod characteristics of the self pollinated and naturally pollinated individuals.
- As for the seed characteristics are concerned no significant differences could be found. There is apparently no difference in the seed germination behavior of the self pollinated and naturally pollinated individuals.
- Factors favoring cross pollination in the species.
- Receptivity of the style persisting even after the opening of the flowers. Viability of the pollen grains though decreased but still exists even after the opening of the flowers such that they can effect the pollination.
- Though the role of insects and birds acting as agents in dispersal of the pollen grains has no been found in the present studies but chances of anemophily in the species cannot be ruled out.
- Ovary coming out of the whorls of stamen in receptive stage after the opening of flower may increase the chances of cross pollination as there is no hindrance of other floral organs and chances of any pollen grains in the air can effect the pollination.
- Though very less, but still there is formation of pods on artificial cross pollination.

Q3. Why is reproduction essential for organism. Which is better mode of reproduction sexual or asexual and why.

Ans. Plant reproduction is the production of new individuals or offspring in plants, which can be accomplished by sexual or asexual reproduction. Sexual reproduction produces offspring by the fusion of gametes, resulting in offspring genetically different from the parent or parents. Asexual reproduction produces new individuals without the fusion of gametes, genetically identical to the parent plants and each other, except when mutations occur. In seed plants, the offspring can be packaged in a protective seed, which is used as an agent of dispersal.

Asexual Reproduction -New plants are obtained without production of seeds or spores.

- **Vegetative Propagation**

It is a type of asexual reproduction in which new plants are produced from the vegetative parts of the plant.Example - **Rose**

- **Budding**

Small bulb like projection coming out from some single celled organism that gradually grows and gets detached from parent cell and forms a new organism.Example - **Yeast**

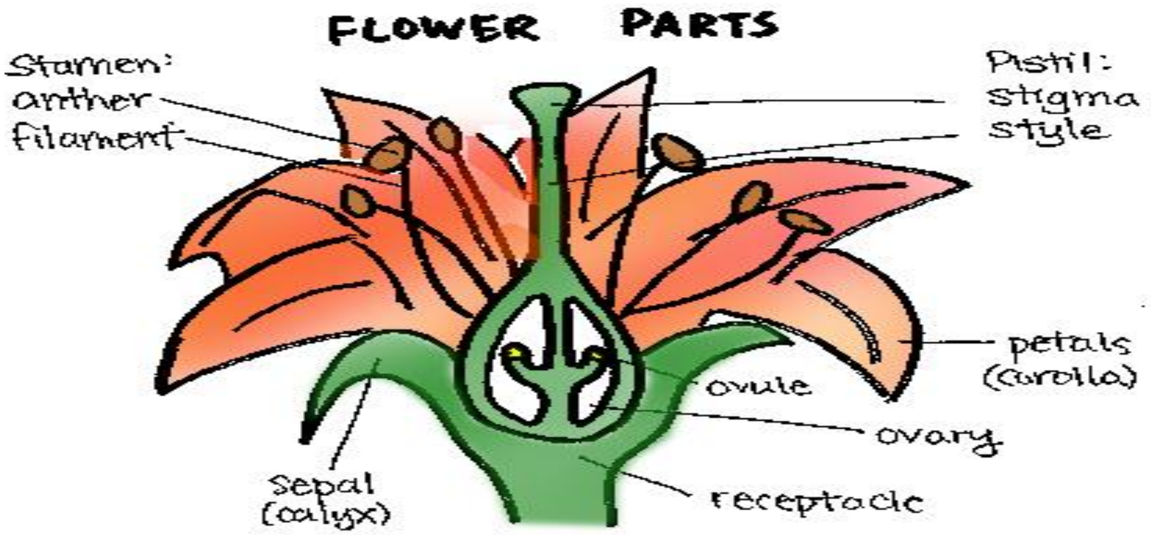
- **Fragmentation**

During fragmentation an Organism breaks up into fragments and these fragments or pieces grow into new individuals.Example – **Spirogyra**

- **Spore Formation**

The spores are asexual reproductive bodies. Under favourable conditions, spore germinates and develops into a new individual.Example - **Fungus**

Asexual Reproduction -Reproduction with the help of sex organs are called sexual reproduction.Flowers are the reproductive parts of a plant .



- **Pollination**

Transfer of pollen grains from anther to stigma of a flower is called pollination

- ***Self Pollination***

The transfer of pollengrains from anther to stigma of the same flower is called self pollination

- ***Cross Pollination***

Transfer of anther to stigma of the flower in the different plant or different flower in the same plant is cross pollination.

- **Fertilisation**

Fusion of male and female gamete is called Fertilisation and the cell which results after it is called a **Zygote**

<u>Comparison Between Asexual and Sexual Reproduction</u>

	Asexual Reproduction	**Sexual Reproduction**

	Asexual Reproduction	Sexual Reproduction
Number of organisms involved	One parent needed	Two parents are required to mate
Cell division	Cells divide by Fission, budding , or regeneration	Cells divide by Meiosis
Types	Budding, vegetative reproduction, fragmentation, spore formation	Syngamy and conjugation
Advantages	Time Efficient; no need to search for mate, requires less energy	Variation, Unique., organism is more protected
Disadvantages	No variation - if the parent has a genetic disease, offspring does too.	Requires two organisms, requires more energy
Evolution	There is very little chance of variation with asexual reproduction. Mutations in DNA can still occur but not nearly as frequently as sexual reproduction.	Sexual reproduction leads to genetic variation in new generations of offspring. This is fundamental to evolution.
Involvement of Sex cells	no formation or fusion of gametes(sex cell)	formation or fusion of gametes(sex cell) occurs
Found in	lower organisms	higher invertebrates and all vertebrates
Unit of reproduction	may be whole parent body or a bud or a fragment or a single somatic cell	gamete
Time period	Less	more
Number of offsprings produced	two(minimum) or more than two	one(minimum) or more than one

The sexual reproduction has many advantages over asexual reproduction. In asexual reproduction, off-springs are almost identical to their parent because they have the same genes as their parent. So, mud genetic variation is not possible in asexual reproduction. This is a disadvantage of asexual reproduction because it inhibits the further evolution of the organism.

In sexual reproduction the off-springs, although similar to their parents, are not identical to them or to one another. This is because the off-springs receive some genes from the mother and some from the father. Because of the mixing of genes of mother and father in various different combinations, all the off-springs have genetic variations.

In this way, sexual reproduction leads to a greater variety in population. This means that a species (animal or plant) can adapt more quickly to changes in its surroundings (or environment). This is because there are always likely to be some individuals who are more suited to the changes than others, and these individuals will survive and reproduce themselves. Sexual reproduction plays an important role in the origin of new species having different characteristics. This genetic variation leads to the continuous evolution of various species to form better and still better organisms. All this is not possible in the case of asexual reproduction.

Q4.Define pollination. How pollination take place in anemophilous and hydrophilous plants give with suitable digramme.

Ans. Pollination is the process by which pollen is transferred in the reproduction of plants, thereby enabling fertilization and sexual reproduction. The transfer of pollen from the anthers of a flower to the stigma of the same flower or of another flower. Pollination is a prerequisite for fertilization: the fusion of nuclei from the pollen grain with nuclei in the ovule. Fertilization allows the flower to develop seeds. Some flowers will develop seeds as a result of self-pollination, when pollen and pistil are from the same plant, often (but not always) from the same flower. Other plants require cross-pollination: pollen and pistil must be from different plants.

Most plants need help moving pollen from one flower to the pistil of another. Wind moves the pollen for some plants such as grasses like corn. Animal pollinators move pollen for many other flowering plants.

Types

1.1 Abiotic- Abiotic pollination refers to situations where pollination is mediated without the involvement of other organisms. Only 10% of flowering plants are pollinated without animal assistance. The most common form of abiotic pollination, anemophily, is pollination by wind. This form of pollination is predominant in grasses, most conifers, and many deciduous trees. Hydrophilyis pollination by water, and occurs in aquatic plants which release their pollen directly into the surrounding water.

1.2 Biotic-About 80% of all plant pollination is biotic. In gymnosperms, biotic pollination is generally incidental when it occurs, though some gymnosperms and their pollinators are mutually adapted for pollination. More commonly, the process of pollination requires pollinators: organisms that carry or move the pollen grains from the anther to the receptive part of the carpel or pistil. This is biotic pollination. The various flower traits that differentially attract one type of pollinator or another are known as pollination syndromes. Roughly 200,000 varieties of animal pollinators are in the wild, most of which are insects.

Entomophily, pollination by insects, often occurs on plants that have developed colored petals and a strong scent to attract insects such as, bees, wasps and occasionally ants

(Hymenoptera), beetles (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). In zoophily, pollination is performed by vertebrates such as birds and bats, particularly, hummingbirds, sunbirds, spiderhunters, honeyeaters, and fruit bats. Plants adapted to using bats or moths as pollinators typically have white petals and a strong scent, whereas plants that use birds as pollinators tend to develop red petals and rarely develop a scent (few birds rely on a sense of smell to find plant-based food).

Anthropophily pollination by humans, often artificial pollination used in hybridization techniques.

Insect pollinators such as honeybees (*Apis mellifera*),bumblebees (*Bombus terrestris*),and butterflies (*Thymelicus flavus*)have been observed to engage in flower constancy, which means they are more likely to transfer pollen to other conspecific plants.This can be beneficial for the pollinators, as flower constancy prevents the loss of pollen during interspecific flights and pollinators from clogging stigmas with pollen of other flower species. It also improves the probability that the pollinator will find productive flowers easily accessible and recognizable by familiar clues.

2 Mechanics- Pollination can be accomplished by **cross-pollination** or by **self-pollination** :

- **Cross-pollination,** also called ***allogamy*-** occurs only when pollen is delivered to a flower from a different plant. Plants adapted to outcross or cross-pollinate often have taller stamens than carpels or use other mechanisms to better ensure the spread of pollen to other plants' flowers.

A European honey bee collects nectar, while pollen collects on its body.

A hummingbird feeding

- **Self-pollination** -occurs when pollen from one flower pollinates the same flower or other flowers of the same individual. It is thought to have evolved under conditions when pollinators were not reliable vectors for pollen transport, and is most often seen in short-lived annual species and plants that colonize new locations. Self-pollination may include *autogamy*, where pollen moves to the female part of the same flower; or*geitonogamy*, when pollen is transferred to another flower on the same plant. Plants adapted to self-fertilize often have similar stamen and carpel lengths. Plants that can pollinate themselves and produce viable offspring are called self-fertile. Plants that cannot fertilize themselves are called self-sterile, a condition which mandates cross pollination for the production of offspring.

- ***Cleistogamy***- *It* is self-pollination that occurs before the flower opens. The pollen is released from the anther within the flower or the pollen on the anther grows a tube down the style to the ovules. It is a type of sexual breeding, in contrast to asexual systems such as apomixis. Some *cleistogamous* flowers never open, in contrast to *chasmogamous* flowers that open and are then pollinated. Cleistogamous flowers by necessity are self-compatible or self-fertile plants.[12] Many plants are self-incompatible, and these two conditions are end points on a continuum.

Pollinator: An animal that moves pollen from the anthers to the stigmas of flowers, thus effecting pollination. Animals that are known to be good pollinators of flowers include bees, butterflies, hummingbirds, moths, some flies, some wasps, and nectar feeding bats.

2.1Pollen vectors-

Biotic **pollen vectors** are animals, usually insects, but also reptiles, birds, mammals, and sundry others, that routinely transport pollen and play a role in pollination. This is usually as a result of their activities when visiting plants for feeding, breeding or shelter. The pollen adheres to the vector's body parts such as face, legs, mouthparts, hair, feathers, and moist spots; depending on the particular vector. Such transport is vital to the pollination of many plant species.

Any kind of animal that often visits or encounters flowers is likely to be a pollen vector to some extent. For example, a crab spider that stops at one flower for a time and then moves on, might carry pollen incidentally, but most pollen vectors of significant interest are those that routinely visit the flowers for some functional activity. They might feed on pollen, or plant organs, or on plant secretions such as nectar, and carry out acts of pollination on the way. Many plants bear flowers that favour certain types of pollinator over all others.

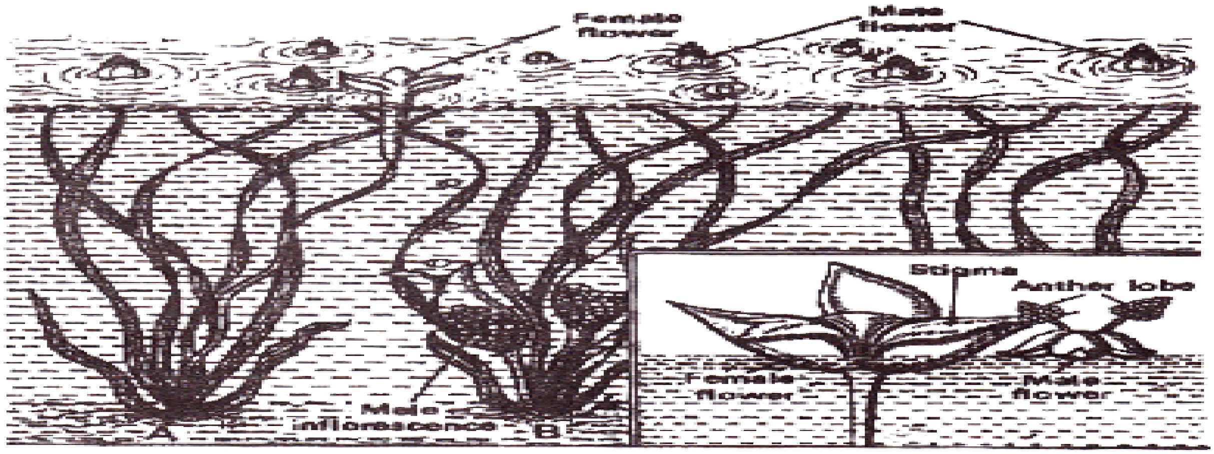
Most species of lizards in the families that seem to be significant in pollination seem to carry pollen only incidentally, especially the larger species such as Varanidae and Iguanidae, but especially several species of the Gekkonidae are active pollinators, and so is at least one species of the Lacertidae, *Podarcis lilfordi*, which pollinates various species, but in particular is the major pollinator of *Euphorbia dendroides* on various Mediterranean islands.

Mammals are not generally thought of as pollinators, but some rodents, bats and marsupials are significant pollinators and some even specialise in such activities. In South Africa certain species of *Protea* (in particular *Protea humiflora*, *P. amplexicaulis*, P. subulifolia, P. decurrens and P. cordata) are adapted to pollination by rodents (particularly Cape Spiny Mouse, *Acomys subspinosus*) and elephant shrews (*Elephantulus* species).

Anemophily or **wind pollination** – It is a form of pollination whereby pollen is distributed by wind.Almost all gymnosperms are anemophilous, as are many plants in the order Poales, including grasses, sedges and rushes.Other common anemophilous plants are oaks, sweet chestnuts, alders and members of the family Juglandaceae

Hydrophily –It is a fairly uncommon form of pollination whereby pollen is distributed by the flow of waters, particularly in rivers and streams. Hydrophilous species fall into two categories: those that distribute their pollen to the surface of water, and those that distribute it beneath the surface.

Surface pollination is rare, and appears to be a transitional phase between wind pollination and true hydrophily. Surface hydrophily has been observed in several species of *Potamogeton* as well as some marine species.



Q5. a. Explain the role of tapetum in the formation of pollen grains.

Ans. The **tapetum** is a layer of nutritive cells found within the sporangium, particularly within the anther, of flowering plants.

Tapetum is important for the development of pollen grains. The cells are usually bigger and normally have more than one nucleus per cell. As the sporogenous cells undergo mitosis, the nuclei of tapetal cells also divide. Sometimes, this mitosis is not normal due to which many cells of mature tapetum become multinucleate. Sometimes polyploidy and polyteny can also be seen. The unusually large nuclear constitution of the tapetum helps it in providing nutrients and regulatory molecules to the forming pollen grains. The following processes are responsible for this:

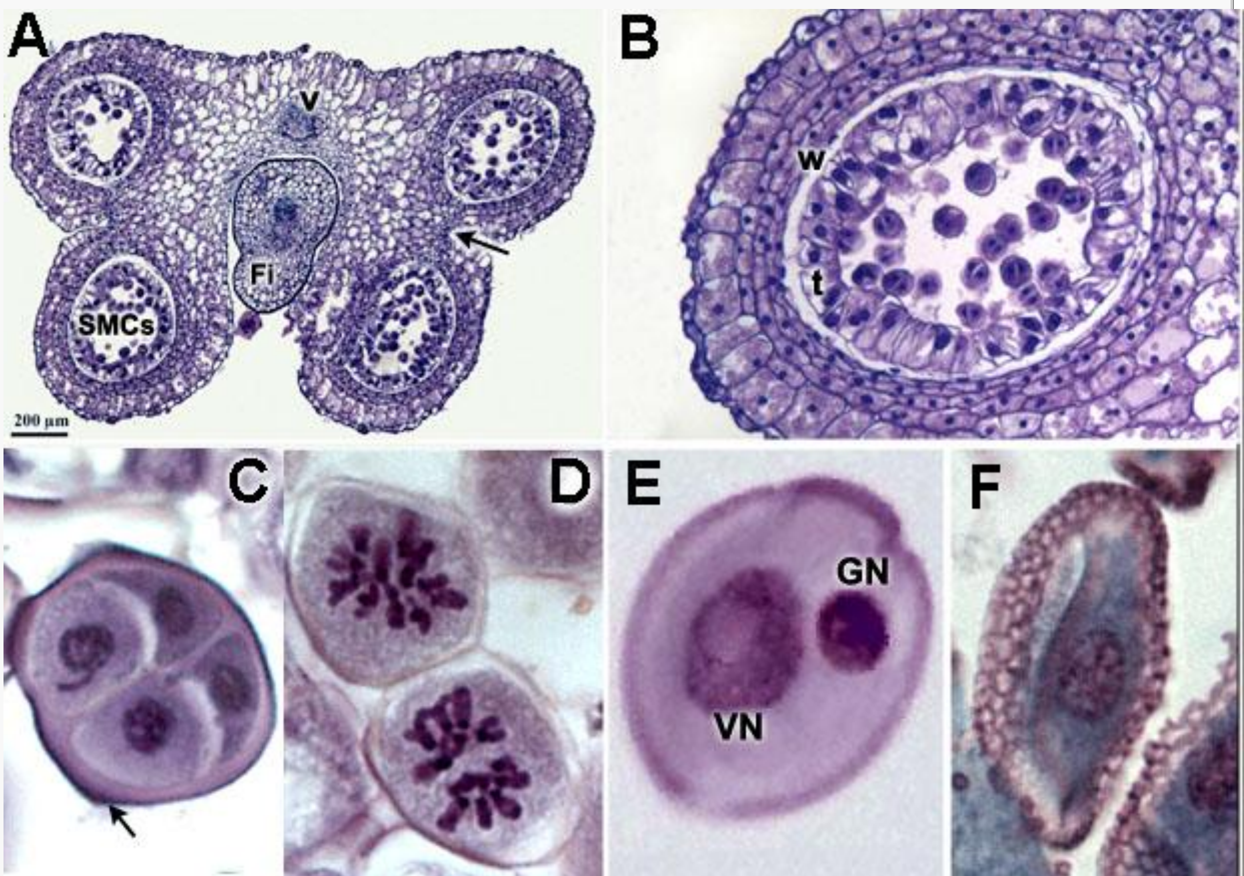
- Endomitosis
- Normal mitosis not followed by cytokinesis
- Formation of restitution nuclei
- Endoreduplication

Tapetum helps in pollenwall formation, transportation of nutrients to inner side of anther, synthesis of callase enzyme for separation of microspore tetrads.

The tapetum is the innermost layer of the microsporangium. It is also known as nourishing layer. It nourishes the developing pollen grains and helps in formation of wall of pollen grains. It secrets Ubisch bodies (made up of sporopollenin) for exine formation.

Pollen grains develop in the anthers of the staminae. In the anthers (figure A and detailed view D) mostly four, but sometimes only two loculi are present. In the loculi sporogenic tissue can be found from which pollen develop. At the inner side of each loculus a layer of large, rectangular cells, the tapetum (from the Greek tapes = carpet; t in figure D) can be found. The tapetum serves for the nutrition of the developing pollen, the deposition of cell wall material in the outer part of the pollen grain and other compounds in and over the wall. First, free pollenmothercells (PMC) are formed, which become spores by a meiotic division (see example of a meiotic stage in figure B). The meiosis involves two divisions, which lead to the formation of four daughter cells, the spores. Those four cells are originally still interconnected and are called tetrads (Greek Tetra = four; figure C). Later they come apart and the tapetum deposits the outer wall or exine (more on the pollen wall in pollen morphology). The exine protects the spore against dessication, mechanical pressure and ultraviolet radiation (figure F). Sometimes the exine layer is covered by sticky substances (pollenkitt, tryphine, elastoviscin and sporopollenin viscin threads), which are also produced by the tapetum. Thisadhesive material facilitates the attachment of pollen grains to insects, and in this way also zoophilic pollination. It also plays an important role in the adhesion of pollen grains to the female stigma and in the recognition between pollen and pistil. Also substances responsible for pollen allergy are often products originating from the tapetum.

Pollen development in the anthers



A. Cross-section through an anther of Lilie (*Lilium*)sp.) with on the left and the right side two loculi each. In the loculi sporemothercells (SMCs) can be seen from which the four spores develop through meiosis I and II. Inbetween the loculi of each pair a thin layer of cells (arrow) is visible along which the loculus can burst open at maturity and release the pollen grains. In the middle the cross-sectioned filament (Fi) to which the anther is attached is indicated. In the upper part the vascular bundle (v) of the loculus can be distinguished.

B. Loculus. The lumen contains developing pollen. On the inner wall (w) of the loculus a layer constituted of block-shaped single cells is present, the tapetum (t). The tapetum feeds the developing spore and -later- pollen.

C. Tetrad stage during pollen development. After the two meiotic divisions the four daughter cells are still interconnected and form a tetrad. They are still surrounded by the wall (arrow) of the original cell, the microspore mothercell (MMC).

D. Mitotic division in the spore leading to the formation of a microgametophyte or pollen. Only the metaphase is shown here. The chromosomes lay in the equatorial plane of the cell.

E. Nearly ripe pollen grain: visible are a vegetative cell with nucleus (VN), which later will form the pollen tube, and a generative cell with its own nucleus (GN), which later will divide into two sperm cells.

F. Ripe pollen grain in which the texture of the outer cell wall, the exine, can be recognized. The grainy dark purple structure in the middle of the pollen grain is the vegetative nucleus.

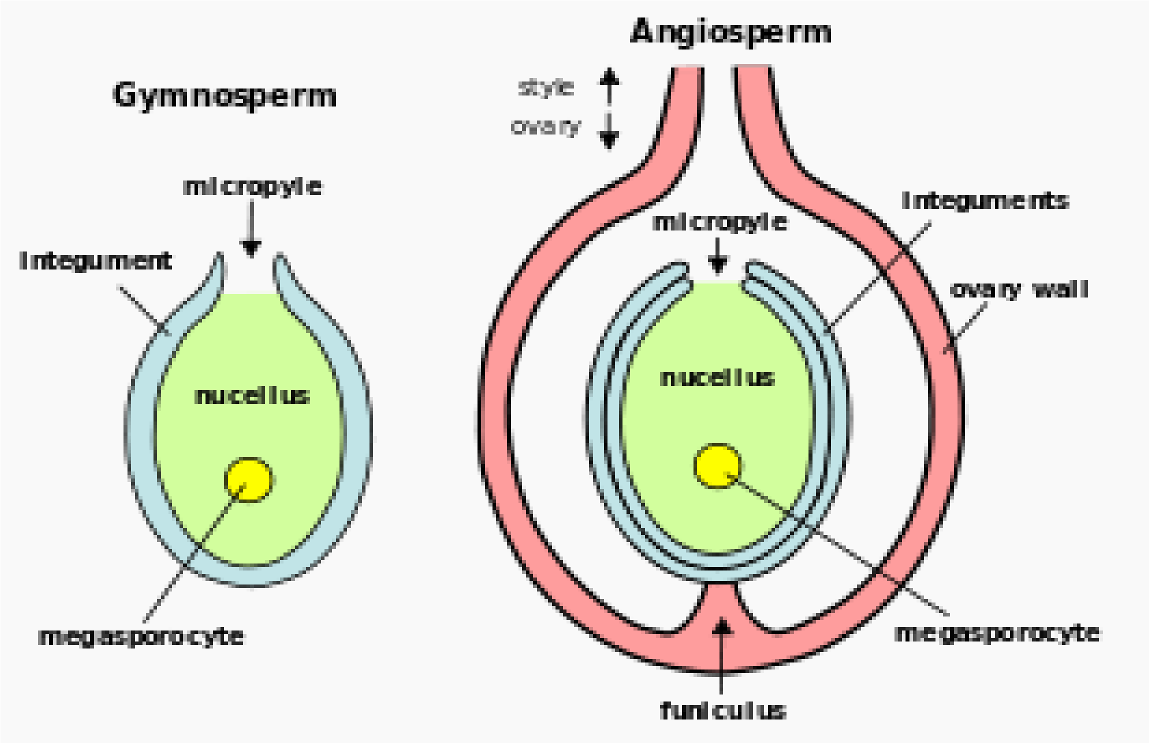
G. Diagram in 3 parts: Ripe pollen grain consisting of the vegetative cell (VC) and therein the smaller generative cell (GC). After landing on the stigma (St) the pollen grain germinates and forms a pollen tube. In the pollen tube the generative cell divides into two sperm cells (SC). The pollen tube grows to the embryo sac (ES) and delivers the two sperm cells that are involved in double fertilization.

Q.5(b). Make suitable digramme to describe the parts of typical angiospermic ovule and its importance in seed development.

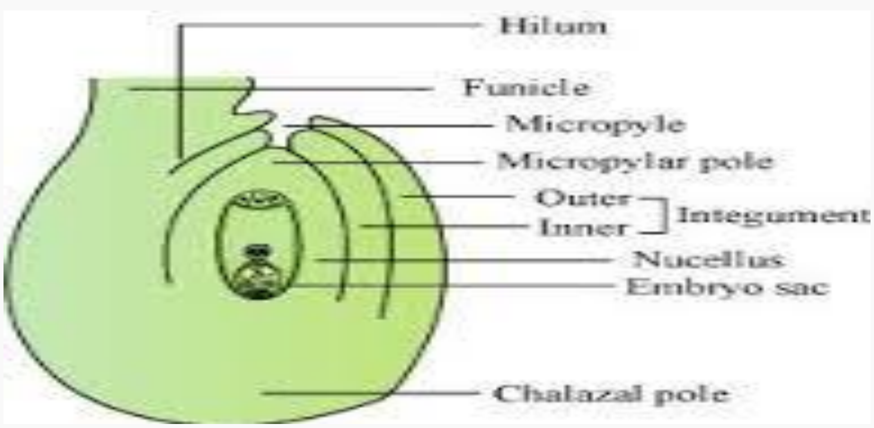
Ans. Ovule means "small egg". In seed plants, the ovule is the structure that gives rise to and contains the female reproductive cells. It consists of three parts: The **integument(s)** forming its outer layer(s), the **nucellus** (or remnant of the mega sporangium), and the megaspore-derived female gametophyte (or **mega gametophyte**) in its center. The mega gametophyte (also called **embryo sac** in flowering plants) produces an egg cell (or several egg cells in some groups) for fertilization. After fertilization, the ovule develops into a seed. In flowering plants, the ovule is typically located inside the portion of the flower called the gynoecium. The ovary of the gynoecium produces one or more ovules and ultimately becomes the fruit wall. Ovules are attached to placenta in the ovary through a stalk-like structure known as a funiculus. Different patterns of ovule attachment, or placentation, can be found among plant

In gymnosperms such as conifers, ovules are typically borne on the surface of an ovuliferous (ovule-bearing) scale, usually within an ovulate cone (also called megastrobilus). Boy In some extinct plants (e.g. Pteridosperms), megasporangia and perhaps ovules were borne on the surface of leaves. In other extinct taxa, a cupule (a modified leaf or part of a leaf) surrounds the ovule (e.g. *Caytonia* or *Glossopteris*).

<u>Ovule parts and development</u>



Plant ovules:

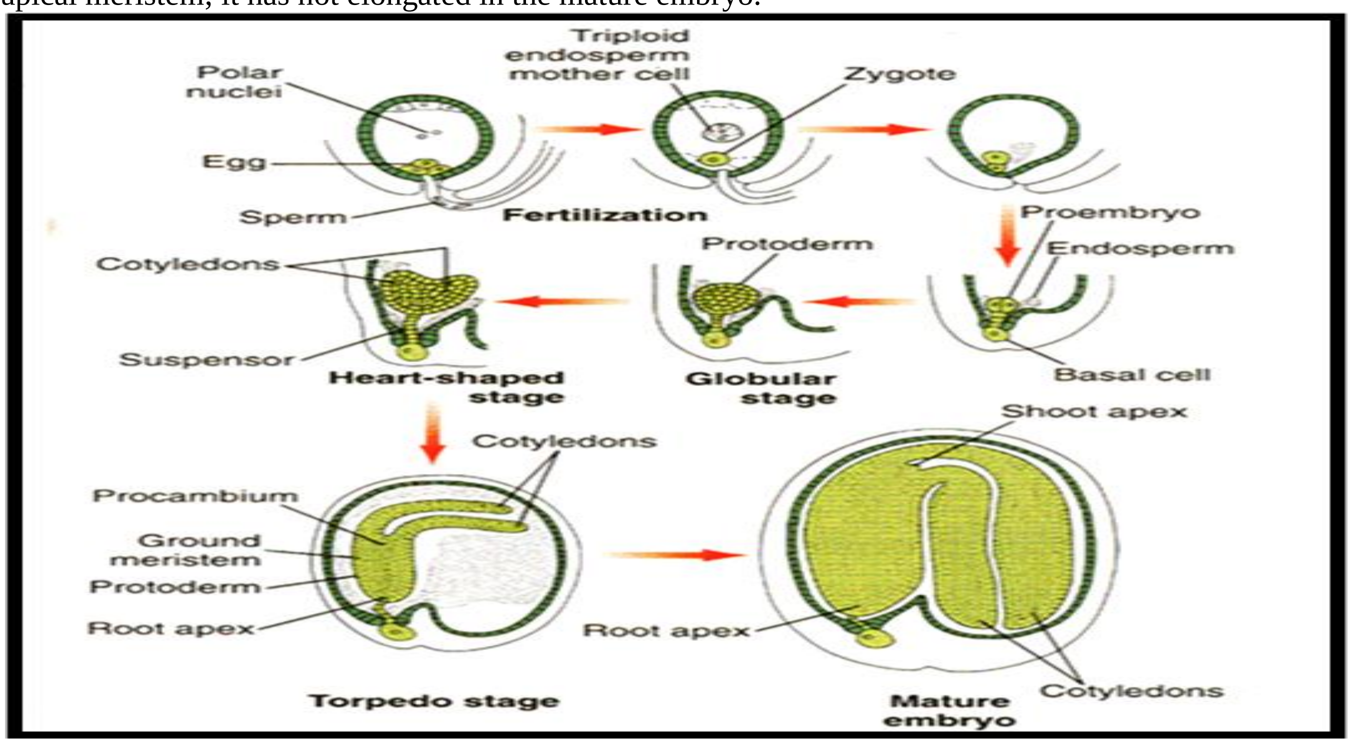


The ovule appears to be a megasporangium with integuments surrounding it. Ovules are initially composed of diploid maternal tissue, which includes a megasporocyte (a cell that will undergo meiosis to produce megaspores). Megaspores remain inside the ovule and divide by mitosis to produce the haploid female gametophyte or megagametophyte, which also remains inside the ovule. The remnants of the megasporangium tissue (the nucellus) surround the megagametophyte. Megagametophytes produce archegonia (lost in some groups such as flowering plants), which produce egg cells. After fertilization, the ovule contains a diploid zygote and then, after cell division begins, an embryo of the next sporophyte generation. In flowering plants, a second sperm nucleus fuses with other nuclei in the megagametophyte forming a typically polyploid (often triploid)endosperm tissue, which serves as nourishment for the young sporophyte.

A seed is a mature ovule that includes a seed coat, a food supply, and an embryo. The developing embryo grows, absorbs the endosperm, and stores those nutrients in "seed leaves" called **cotyledons**.

Development includes the following stages:

- **Proembryo stage** –. Initially the embryo consists of a **basal cell, suspensor**, and a two celled proembryo. The suspensor is the column of cells that pushes the embryo into the **endosperm**. Note that the endosperm is extensive but is being digested.
- **Globular stage** – A stage that is radially symmetrical and has little internal cellular organization.
- **Heart-shaped stage** – Differential division produces bilateral symmetry and two ctyledons forming the hear-shaped embryo. The enlarging cotyledons store digested food from the endosperm. Tissue differentiation begins, and root and shoot meristems soon appear.
- **Torpedo stage** – the cotyledons and root axis soon elongate to produce an elongated torpedo-stage embryo. Procambial tissue appears and will later develop into vascular tissue.
- **Mature embryo** – has large, bent cotyledons on either side of the **stem apical meristem**. The radicle, later to form the root, is differentiated toward the suspensor. The **radicle** has a **root apical meristem** and **root cap**. The **hypocotyl** is the region between the apical meristem and the radicle. The endosperm is depleted and food is stored in the cotyledons. The **epicotyl** is the region between the attachment of cotyledons and stem apical meristem; it has not elongated in the mature embryo.

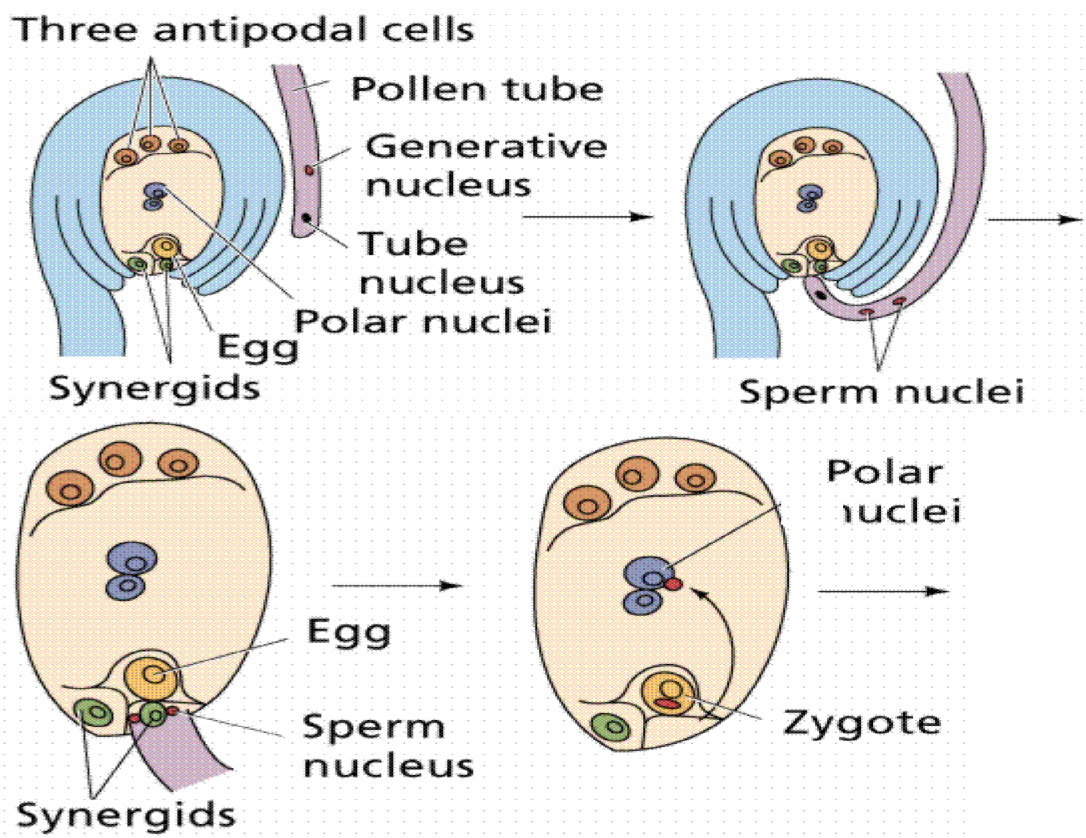


Q6.Why the process of fertilization in a flowering plant referred as double fertilization. Explain.

Ans. Double fertilization is a complex fertilization mechanism of flowering plants (angiosperms). This process involves the joining of a female gametophyte (megagametophyte, also called the embryo sac) with two male gametes (sperm). It begins when a pollen grain adheres to the stigma of the carpel, the female reproductive structure of a flower. The pollen grain then takes in moisture and begins to germinate, forming a pollen tube that extends down toward the ovary through the style. The tip of the pollen tube then enters the ovary and penetrates through the micropyle opening in the ovule. The pollen tube proceeds to release the two sperm in the megagametophyte.

One sperm fertilizes the egg cell and the other sperm combines with the two polar nuclei of the large central cell of the mega-gametophyte. The haploid sperm and haploid egg combine to form a diploid zygote, while the other sperm and the two haploid polar nuclei of the large central cell of the mega-gametophyte form a triploid nucleus (some plants may form polyploidy nuclei). The large cell of the gametophyte will then develop into the endosperm, a nutrient-rich tissue which provides nourishment to the developing embryo. The ovary, surrounding the ovules, develops into the fruit, which protects the seeds and may function to disperse them.[1]

The two central cell maternal nuclei (polar nuclei) that contribute to the endosperm, arise by mitosis from the same single meiotic product that gave rise to the egg. The maternal contribution to the genetic constitution of the triploid endosperm is double that of the embryo.



Q7. **a. Write in brief the role of out crossing to maintain genetic diversity. Discuss various strategies have evolved to promote out crossing.**

Ans. Outcrossing is the practice of introducing unrelated genetic material into a breeding line. It increases genetic diversity, thus reducing the probability of all individuals being subject to disease or reducing genetic abnormalities.

It is used in line-breeding to restore vigor or size and fertility to a breeding line. "Line breeding", is where animals carry a common ancestor in their pedigrees and are bred together, should be considered distinct from the term "in-breeding" which is the production of offspring by parents more closely related than the average.

With recessives, outcrossing allows for the recessive traits to migrate across a population. The outcrossing breeder then may have individuals that have many deleterious genes that are expressed by placing their animals against a similarly outcrossed individual. There is now a gamut of deleterious genes within each individual in many breeds. However one may increase the variance of genes within the gene pool by outcrossing, protecting against extinction by a single stressor from the environment.

Breeders inbreed within their genetic pool, attempting to maintain desirable traits and to cull those traits that are undesirable. When undesirable traits begin to appear, mates are selected to determine if a trait is recessive or dominant. Removal is accomplished by breeding two individuals of known genetic status, usually they are related.

In nature, where breeding is not managed, outcrossing rates may be estimated by genetic analysis, by employing mathematical models of mating systems such as the mixed mating model or the effective selfing model. This allows calculation of the amount of genetic exchange between populations, and thus provides insights into the biogeography and phytogeography of species.

Gregor Mendel used outcrossing in his experiments with flowers for his breeding stock. He then used the resulting offspring to chart inheritance patterns, using the crossing of siblings, and backcrossing to parents to determine how inheritance functioned.

Q7. b. Gene Flow and its importance.

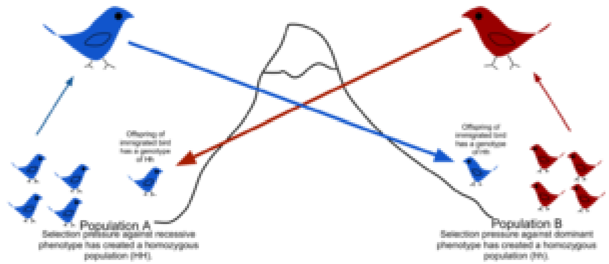
Ans. Gene flow is the transfer of alleles from one population to another population through immigration of individuals. In this example, one of the birds from population Aim migrates to population B, which has less of the dominant alleles, and through mating incorporates its alleles in into the other population.

Migration into or out of a population may be responsible for a marked change in allele frequencies (the proportion of members carrying a particular variant of a gene). Immigration may also result in the addition of new genetic variants to the establishedgene pool of a particular species or population.

There are a number of factors that affect the rate of gene flow between different populations. One of the most significant factors is mobility, as greater mobility of an individual tends to give it greater migratory potential. Animals tend to be more mobile than plants, although pollen and seeds may be carried great distances by animals or wind.

Maintained gene flow between two populations can also lead to a combination of the two gene pools, reducing the genetic variation between the two groups. It is for this reason that gene flow strongly acts against speciation, by recombining the gene pools of the groups, and thus, repairing the developing differences in genetic variation that would have led to full speciation and creation of daughter species.

For example, if a species of grass grows on both sides of a highway, pollen is likely to be transported from one side to the other and vice versa. If this pollen is able to fertilize the plant where it ends up and produce viable offspring, then the alleles in the pollen have effectively been able to move from the population on one side of the highway to the other.



Barriers to gene flow

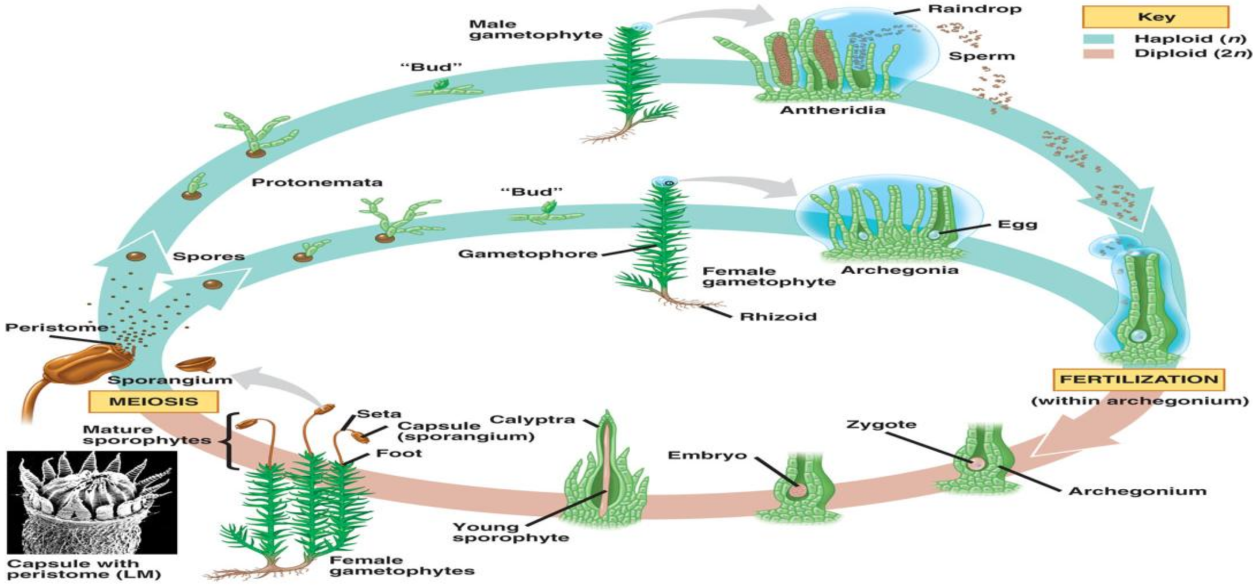
Physical barriers to gene flow are usually, but not always, natural. They may include impassable mountain ranges, oceans, or vast deserts. In some cases, they can be artificial, man-made barriers, such as the Great Wall of China, which has hindered the gene flow of native plant populations.One of these native plants, *Ulmus pumila*, demonstrated a lower prevalence of genetic differentiation than the plants *Vitex negundo*, *Ziziphus jujuba*, *Heteropappus hispidus*, and *Prunus armeniaca* whose habitat is located on the opposite side of the Great Wall of China where *Ulmus pumila* grows.This is because *Ulmus pumila* has wind-pollination as its primary means of propagation and the latter-plants carry out pollination through insects.Samples of the same species which grow on either side have been shown to have developed genetic differences, because there is little to no gene flow to provide recombination of the gene pools.
Barriers to gene flow need not always be physical. Species can live in the same environment, yet show very limited gene flow due to limited hybridization or hybridization yielding unfit hybrids.Female choice can also play a role in hindering gene flow.

Q8. Write in detail the origin and diversification of angiosperms with suitable example.

Ans. The Plantae evolved from green algae, most likely a group called the charophytes.
Water is a supportive medium, air is not. Algae are surrounded by a medium that contains water and minerals and can take in their requirements across the whole body.To survive on land a plant must:

- Avoid drying out.
- Be able to hold itself up.
- Possess differentiated tissues because air and soil differ in composition and resources. Exploiting these different media requires specializedtissues.
- Solve the problem of reproducing outside water.

Transition to land-It is believed that ancestral charophytes lived in shallow water that sometimes dried out (as do modern charophytes).Selection would have favored adaptations in these charophytes to resist drying out such as waxy cuticles and protecting developing embryos within layers of tissue. These *preadaptations* facilitated the transition onto land.Moving onto land required the development of new forms of reproduction.Algae shed their gametes into the water, but on land gametes must be protected against desiccation.Plants produce gametes within gametangia (protective layers of tissue that prevent gametes from drying out).Egg is fertilized within female gametangium (called the archegonium) and embryo develops for some time inside archegonium.



Embryophytes-Retention of the developing embryo by plants is a fundamental difference from algae. Because this difference is so basic, plants are sometimes described as embryophytes.The ancestor of modern plants once established on land had enormous opportunities. No competition for sunlight or minerals and no herbivores.Selection rapidly led to a massive diversification of plants.

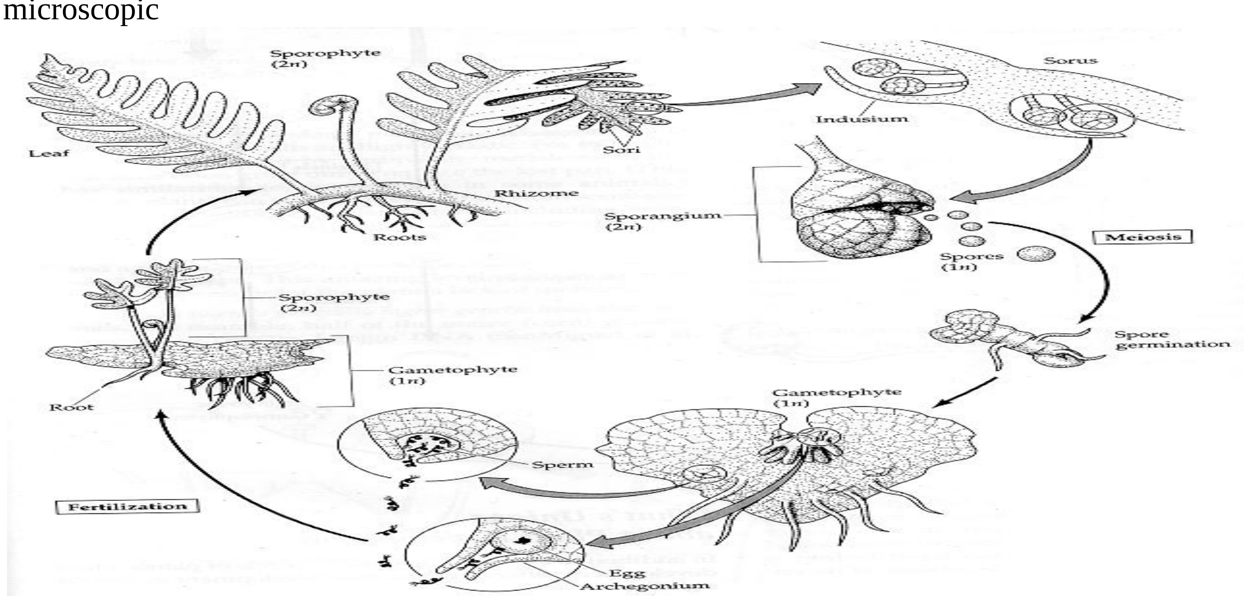
Rise of Vascular plants-The first land plants lacked vascular tissue (as is true of most mosses today) so they could not transport water, sugars or minerals around the plant.Lack of vascular tissue also, of course, limited the size of plants.Once the first plants moved onto land, selection quickly led to the development of specialized roots and shoots.Roots and shoots required the development of a vascular system to move water and other essentials around the plant and by about 400mya early vascular plants had begun to diversify. Large ferns and other seedless plants came to dominate the land in the Carboniferous Period.

Transition from homospory to heterospory

Homospory means spores are the same size and heterospory that microspores (male) and megaspores (female) differ in size.Microspores develop into male gametophytes and megaspores into female gametophytes.Mosses and most ferns are homosporous. Conifers and flowering plants are heterosporous.Homosporous plants produce spores that develop into bisexual gametophytes that produce both sperm and eggs.For successful fertilization, homosporous plants need water in the form of rainfall when gametes are mature. Some homosporous plants evolved heterospory.With heterospory in which the female gametophyte is enclosed and protected and there is no need for water to ensure fertilization.Heterospory led to the evolution of seeds.

Evolution of the seed-

In mosses the life cycle is dominated by the gametophyte generation.In ferns the sporophyte generation is dominant and the gametophyte is reduced, but still visible to the naked eye.In seed plants the gametophyte generation is so reduced that in most cases it is microscopic



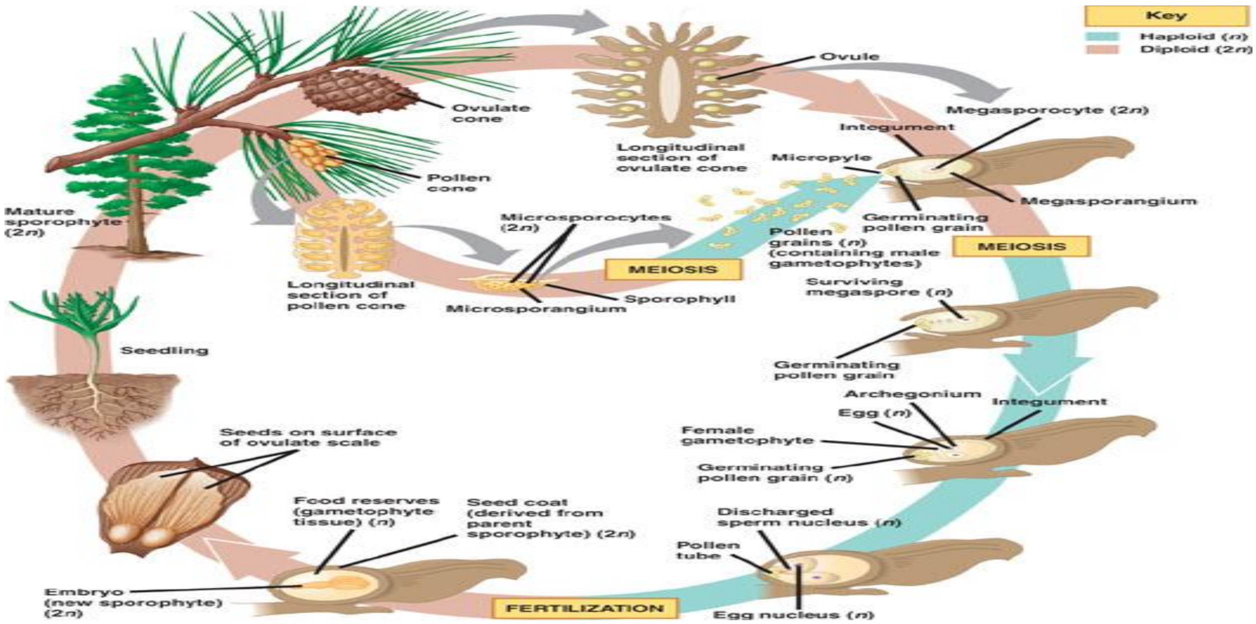
Alternation of Generations-

The reduction of size of the female gametophyte has meant that it can be enclosed and protected within sporophyte tissue (the ovule).The female gametophyte is not dispersed and is protected from drying out and other hazards.The male gametophyte is what is dispersed in seed plants. It is also protected by sporophyte tissue, the pollen grain.Pollen lands on the ovule and eventually fertilizes egg produced by the female gametophyte. Embryo (sporophyte 2n) then develops.

The Gymnosperms

The seed plants evolved from fern-like non-seed ancestors. Several changes occurred to make this novelty possible. First, two types of spores, large megaspores and small microspores, appeared. This change is illustrated in *Selaginella* and some aquatic ferns. In both, the gametophytes are reduced in size, developing within the spore walls. The male **gametophyte** developing within the microspore wall became the **pollen**. The female gametophyte developed within the spore wall, and the spore was retained within the **megasporangium**. For fertilization to occur pollen was carried by wind to the megasporangium, the grains germinated as a tube and the male gametes moved to the egg cell. After fertilization, the embryo developed inside of the megasporangium, now called the **ovule**. The fertilized ovule then became a **seed**, with an **embryo** inside.

This new life cycle had several advantages. First, the protected pollen grain was blown by wind to the site of germination, reducing the requirement for water and permitting these plants to sexually reproduce in much drier conditions. Secondly, the development of the seed provided a means of protecting the embryo against dessication and the storing of the embryo in dormancy until ideal conditions would trigger germination. Finally, modifications of the seed promoted dispersal by wind or animals.

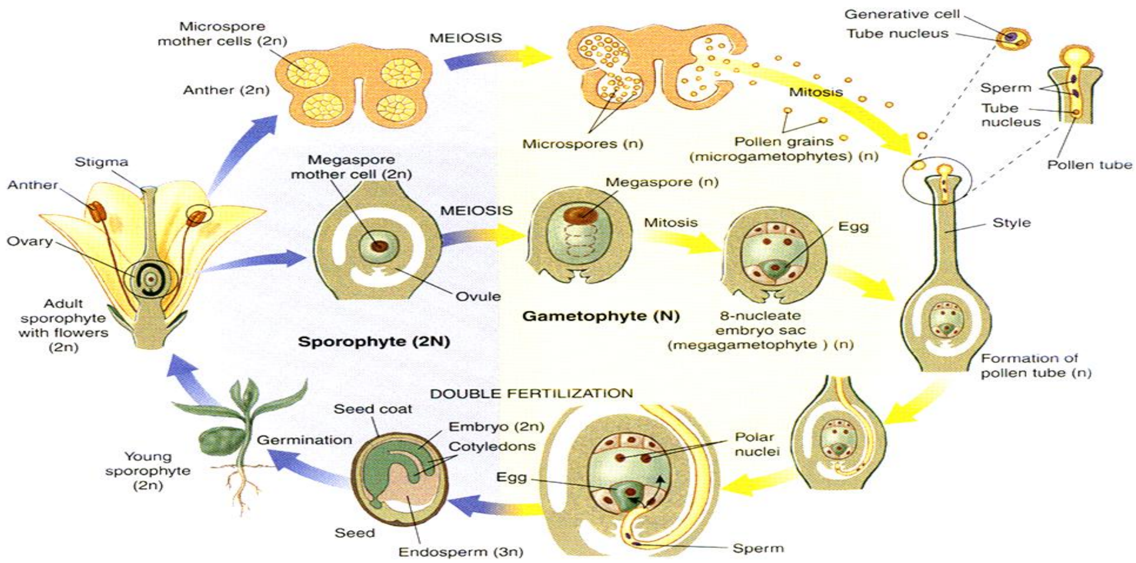


Angiosperms Plants-The angiosperms have been enormously successful. There are now about 235,000 species in comparison to just over 700 gymnosperms. The key to the success of the Angiosperms has been that they have evolved flowers and fruit.

Fruit protects the seeds and aids in their dispersal.The fruit is a bribe. Animals eat the fruit and spread the seeds.

Flowers and pollination –A major advantage of flowers is that they have allowed angiosperms to use other organisms to move their pollen about.Bees, bats, birds and others all transport pollen. They are attracted to flowers by the nectar and pollen [bribes] provided by the plant and when they visit multiple flowers they move pollen from one to the next

Angiosperm life cycle- Eggs from within the embryo sac inside the ovules, which, in turn, are enclosed in the carpels. The pollen grains, meanwhile, form within the sporangia of the anthers and are shed. Fertilization is a **double process**. A sperm and egg come together, producing a zygote; at the same time, another sperm fuses with thepolar nuclei to produce the endosperm. The endosperm is the tissue, unique to angiosperms, that nourishes the embryo and young plant.



Advantages of seeds -

Provides protection and nourishment for developing embryo.

- Dispersal: seeds can be dispersed more widely than spores by enclosing them in a bribe (fruit) and having animals move them.
- Dormancy: the developing embryo is protected and can wait a long time to germinate when conditions are good.

Angiosperm diversification-

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