

Concept of Flower as a Modified Shoot

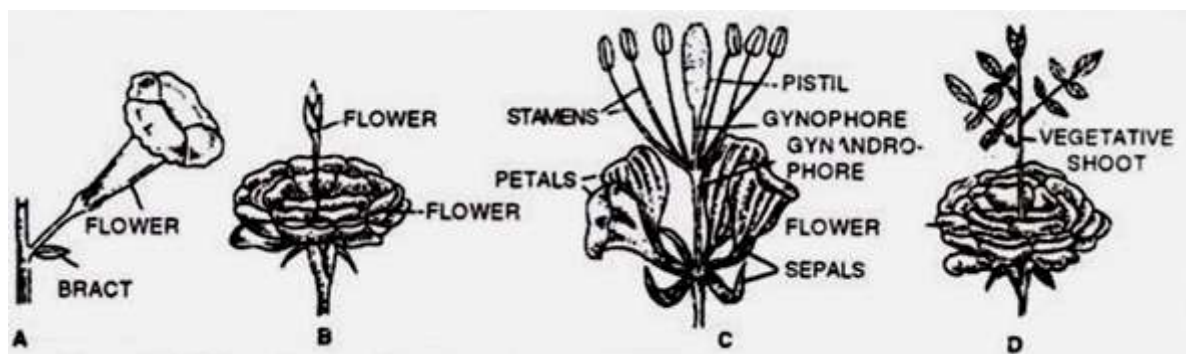
Introduction

- ❖ The flower is generally defined as a highly specialized reproductive shoot, comparable to leaves-bearing shoot.
- ❖ The sepals and petals may be regarded as modified leaves.
- ❖ Stamens and carpels also show some resemblance to leaves in position, arrangement, internal structure and development.
- ❖ Based on these similarities, they are comparable with leaves which bear reproductive organs.
- ❖ The terms microsporophylls and megasporophylls are often applied to stamen and carpel respectively.
- ❖ The flower, then, can be defined as a group of sporophylls usually surrounded by perianth.

Flower is a Modified Shoot: Citing the Following Facts

Stem Nature of Thalamus

- ❖ The thalamus is in fact a stem producing flower can be proved by the following evidences.
- ❖ The first evidence is in majority of cases, the internodes in floral stem remain highly reduced, yet in a number of plants such as *Capparis*, *Gynandropsis*, *Passiflora* etc. the thalamus shows prominent nodes and internodes.
- ❖ Second evidence comes from monstrous development of foliage leaves in some flowers (e.g., Rose, Larkspur, Pear etc.). In the flowerpot' these plants, the receptacle of the flower continues its growth even after producing all the four types of floral appendages and then produces normal foliage leaves.

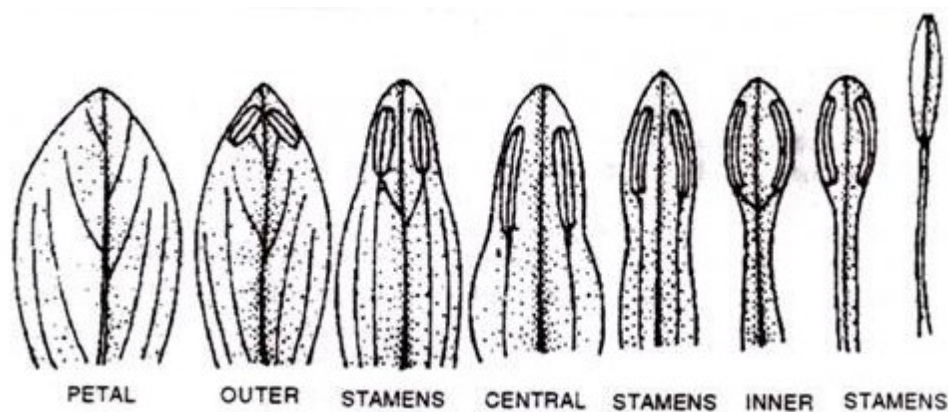


- ❖ Third evidence comes from *Michelia champaca* where the thalamus elongates like an ordinary stem beyond carpels and bears aggregate fruit.

Leaf Nature of Floral Parts:

- ❖ The floral parts, calyx, corolla, androecium and gynoecium are modified leaf can be proved by the following facts.
- ❖ **Phyllotaxy:** Foliage leaves and floral parts have identical arrangement on the stem.

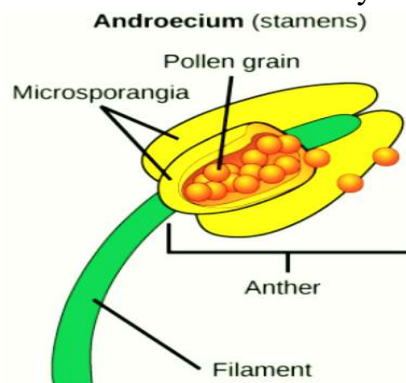
- ❖ **Aestivation:** Pre-foliation of foliage leaves and aestivation of floral leaves (calyx and corolla) is virtually identical.
- ❖ **Foliar nature of sepal:** That sepal is a modified leaf can be clearly seen in *Mussaenda*. Here one of the sepals enlarges abnormally and becomes green like any foliage leaf.
- ❖ **Transition of floral leaves:** In nature, in many cases, such as *Nymphaea* (water lily) all degrees of transition from sepals to petals and from petals to stamens can be seen. In *Canna*, the stamens and the style become petaloid. In *Zinnia*, some of the stamens and carpels become petaloid or sepaloid. In *Hibiscus rosa-sinensis* (China rose) it is believed that stamens have modified into petals. This point has been proved by identical vasculature of the two.



Structure of Typical Stamen, Structure of Tetrasporangiate Anther and Pollen Grain

Structure of Typical Stamen

- ❖ Androecium is the third set of floral organs and is the first essential whorl.
- ❖ It is the male reproductive whorl of a flower consisting stamens or microsporophylls (as they are supposed to be modified floral leaves bearing microspores or pollens).
- ❖ The stamen is the individual unit of androecium.
- ❖ A typical stamen shows three distinct parts, lower sterile part called filament, and an upper fertile part called anther and middle part connecting filament to anther is called connective.
- ❖ The filament is slender stalk of the stamen and its apex an anther is fixed.
- ❖ Each anther is main fertile part of stamen which possesses two lobes called anther lobes. Both these lobes are connected by a connective.

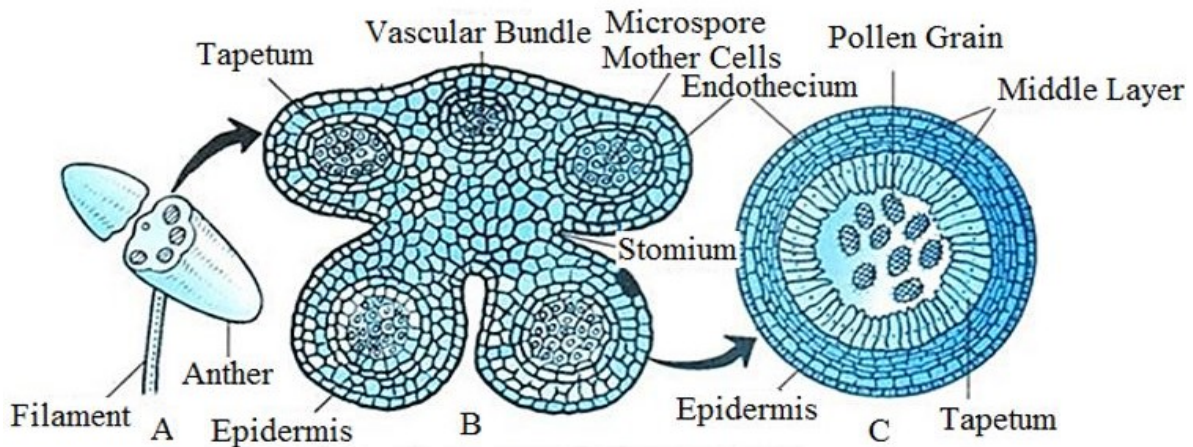


- ❖ The anther lobe is composed of a pair of sacs called pollen sacs or pollen chambers.
- ❖ As each pollen sac/chamber bears pollens or microspores, so these sacs are also called microsporangia (singular microsporangium).
- ❖ Usually in angiosperms, each anther is four chambered (but in some plants there are two and in some only one chamber is present).
- ❖ Each pollen chamber is called microsporangium bearing pollen grains or microspores.

Structure of Tetrasporangiate Anther

- ❖ The young anther shows four elongated sporogenous tissues where pollens develop.
- ❖ At each corner the tissue is distinguished to form archesporium of the anther, which undergo repeated divisions to form anther wall, while primary sporogenous tissue give rise to microspore mother cells and later develop into microspores.
- ❖ The mature anther wall shows four layers *i.e.*, Epidermis, Endothecium, Middle Layer and Tapetum

- ❖ **Epidermis:** It is the outermost wall layer of the anther with stretched and flattened cells. Sometimes the cells are highly lignified or cutinized.



- ❖ **Endothecium:** It is the subepidermal layer of an anther wall. Usually it is single layered parenchymatous tissue but it is sometimes two layered (e.g. *Coccinia indica*). The cells are radially arranged and are elongated and attain maximum elongation during maturity of pollen grains. The wall of endothecium cells are provided with characteristic fibrous thickening bands with 'U' shape, stored with starch. These cells are hygroscopic and have role in dehiscence of anthers. The endothecium is not developed all around the microsporangium (pollen sac) as continuous layer but it is thin walled forming strip along the line of dehiscence which is called stomium in each anther lobe.
- ❖ **Middle layer:** Next to endothecium, there may be one to three layers of cells form middle layer. These cells degenerate completely during pollen mother cell meiosis. Sometimes the middle layer may store starch (e.g. *Coccinia*) which is utilized as food by pollen mother cells during development.
- ❖ **Tapetum:** It is the innermost layer of the anther. Usually it is single layered around the sporogenous tissue. Physiologically tapetum cells play important role as food material to sporogenous tissue. The tapetal cells are relatively large and centripetally extended with cytoplasm and nuclei. Sometimes cytoplasm of tapetal cells is pigmented. e.g. Apple with red-brown pigments.
 - ✚ Tapetum is homogeneous layered which surrounds the sporogenous tissue. Exceptionally (e.g. *Alectra*, *Nigella*) the tapetum is dimorphic called p-tapetum and c-tapetum.
 - ✚ The tapetal cells divide either by endomitosis, normal mitosis or by restitution nuclei.
 - ✚ There may be different types of tapetum.
 - ✚ Two types of tapetum were identified as - Amoebiod or plasmodial (e.g. *Typha*, *Tradescantia*) and found in lower monocots.

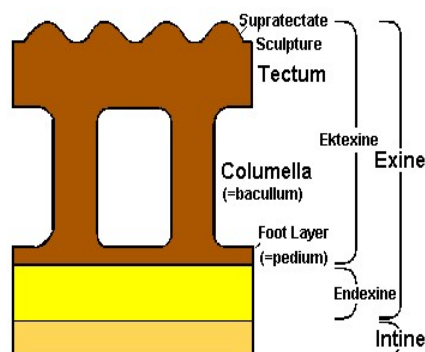
- ✦ This type of tapetum is supposed to be primitive type, secretory or glandular tapetum which is attached to middle layer till the pollen grain development which may help in formation of exine of a pollen grain.
- ❖ Tapetum functions in transport of food material stored inside the anther.
- ❖ This food is used during development of pollen grain and making of exine of pollen.

Structure of Pollen Grain

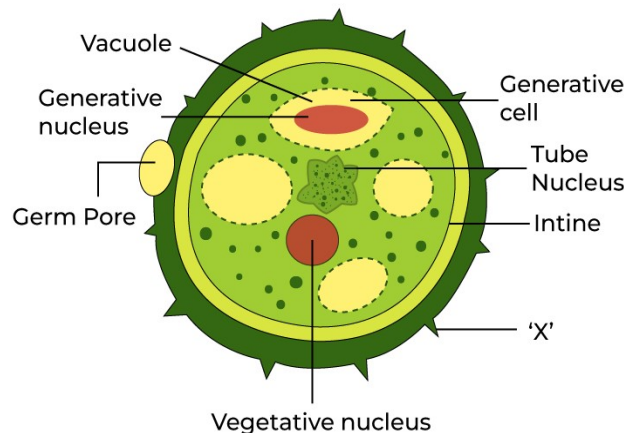
- ❖ The microspores or pollen grains in a seed bearing plants like angiosperms are the mother cells of male gametophyte.
- ❖ These are formed in a microsporangium by reduction division of microspore mother cell (MMC) through meiosis I and II and resulted into spore tetrad.
- ❖ Four microspores or pollen grains are separated from microspore tetrad and lie in a pollen sac/microsporangium.
- ❖ This pollen grain is a male reproductive structure when the pollen grains are in tetrad it is called tetrahedral tetrad, while in isobilateral tetrad, they are arranged in one plane.
- ❖ Sometimes microspores are arranged in different manner. In *Magnolia* these are arranged in decussate manner, in *Aristolochia* they are arranged in 'T' shape while in *Halophila* they are in a linear tetrad, but sometimes microspores/pollen grains are not separated even after its maturity and they remain in groups, in such condition it is called compound pollen grains.
- ❖ In *Calotropis* Single compact mass of pollens are formed in pollen sac is called pollinium. However, in Ericaceae members pollens are permanently united in tetrahedrons.

Structure of Pollen Grain/Microspores

- ❖ Usually pollen grains are spherical in shape.
- ❖ The wall of pollen grain is stratified differentiated into two layers viz. outer exine and the inner intine.
- ❖ The exine is considerably thick and made up of sporopollenin, which is resistant to physical and biological decomposition so that pollens are preserved for longer periods as in fossil deposits.
- ❖ Exine is further divided into sublayer, ectexine (sexine) and endexine (nexine).



- ❖ The Ektexine is again divided into three layers, upper- tectum, middle- baculum and basal- foot layer.
- ❖ The exine is completely absent or it may be represented by endexine only below the pore or aperture region.
- ❖ The intine is pecto-cellulosic in nature.
- ❖ The cellulose component is with microfibrils in a plane parallel to surface.
- ❖ It also includes beads, ribbons or plates of enzymatic proteins near the region of germ pore.
- ❖ A mature pollen grain is composed of proteins (7-26%), carbohydrates (24-48%), fats (0.9-14.5%), ash (0.9-5.4%), water (7-16%).

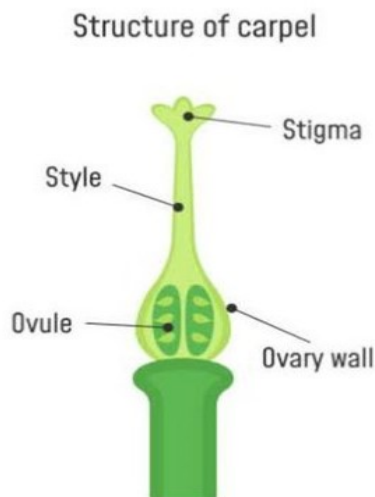


- ❖ The pollen grain/microspore when get separated from pollen (microspore) tetrad these is uninucleate.
- ❖ The nucleus gets enlarged in size and cytoplasm becomes very thicker and increases in amount. Ultimately vacuoles are formed in fully grown pollen.
- ❖ During the development of male gametophyte, the first division is unequal to form two unequal cells: a larger vegetative cell and a smaller generative cell. Usually generative cell is attached initially to intine of pollen wall.
- ❖ Each cell possesses single nucleus.
- ❖ Further division leads to develop male gametes before pollen shades from the anther.

Structure of Typical Carpel

Structure

- ❖ The carpel is the fourth whorl of the flower. It is an essential and female reproductive whorl.
- ❖ The gynoecium is composed of one or more functional units called carpel (in Greek - fruit) and is commonly regarded as megasporophyll.
- ❖ The term pistil is also used for carpel.
- ❖ Some authors use the term pistil for ovary but it is not correct because ovary denotes only the lower part of the gynoecium and not the other parts viz. style and stigma.
- ❖ A typical carpel shows three parts viz. basal ovary, middle style and apical stigma.

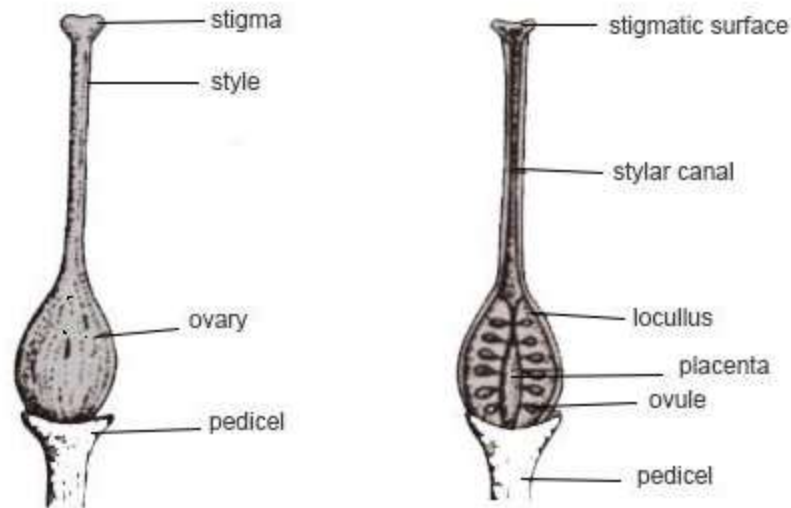


- ❖ The ovary is the lowermost part of a carpel.
- ❖ It is attached to the thalamus and has one to many chambers. In each chamber, one or many ovules are present.
- ❖ In each ovule a megaspore is present.
- ❖ Therefore, the ovule is a megasporangium.
- ❖ In the region above the ovary, carpel shows long or short stalk called style.
- ❖ The style is the passage for the male gametes from stigma to ovule.
- ❖ The terminal expanded end of the style is the stigma.
- ❖ The surface of which is sticky due to sugary substance.
- ❖ This surface helps in the deposition of pollens during pollination.
- ❖ When carpel bears sterile ovules or shows incomplete development or it is in reduced form, it is called pistillode.

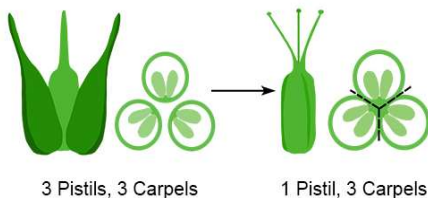
Nature of Carpel

- ❖ Gynoecium is made up of one or more carpels.
- ❖ When it is made up of only one carpel, it is called simple or monocarpellary.

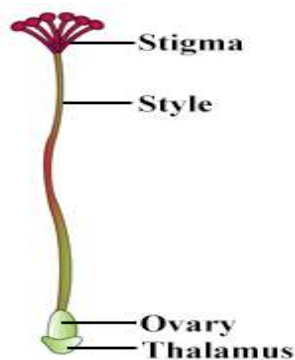
- ❖ Such carpel is the characteristic of families Fabaceae, Mimosaceae and Caesalpiniaceae.
- ❖ When carpel consists of more than one carpel it is called compound gynoecium.
- ❖ In compound gynoecium *i.e.*, when carpels are more than one, the gynoecium or pistil is made up of either free carpels or the carpels show fusion amongst themselves.



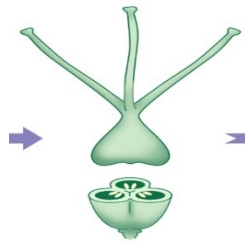
- ❖ When carpels are free the gynoecium is called apocarpous and when carpels are fused, the gynoecium is called syncarpous.



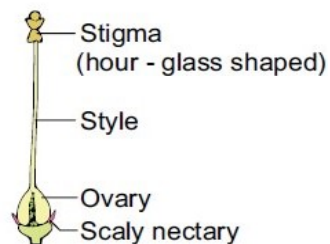
- ❖ In syncarpous gynoecium the carpels exhibit variation in the degree of fusion.
- ❖ Complete fusion in all the three parts ovary, style and stigma *e.g.* *Datura*
- ❖ Fusion in ovary and style but stigma remains free. *e.g.* China rose



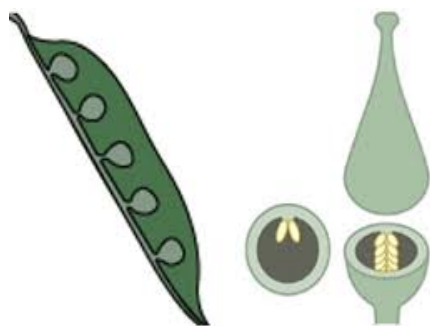
- ❖ Fusion in ovaries only, styles and stigma free. e.g. *Dianthus*, *Linum*



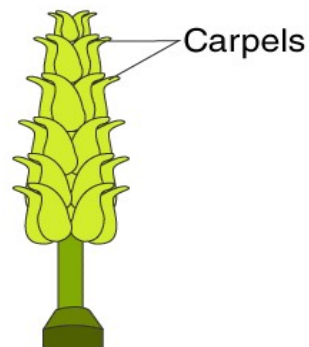
- ❖ Fusion in styles and stigma but ovaries remains free e.g. *Vinca*, *Calotropis*.



- ❖ In all these conditions since some degree of fusion is present in the carpels, gynoecium is to be considered as syncarpous.
- ❖ Therefore, though in *Vinca*, *Calotropis* and other members of natural orders (Families) Apocynaceae and Asclepiadaceae, ovaries are free, the gynoecium is syncarpous and not apocarpous.
- ❖ In both the types a gynoecium (apo/syncarpous) it is described as bicarpellary, tricarpe llary, tetracarpe llary, pentacarpe llary and polycarpe llary when number of carpels is two, three, four, five and many respectively.
- ❖ A monocarpe llary ovary e.g. Pea is always unilocular or one chambered.
- ❖ In case of apocarpous ovary consists carpels free from one another e.g. *Michelia*



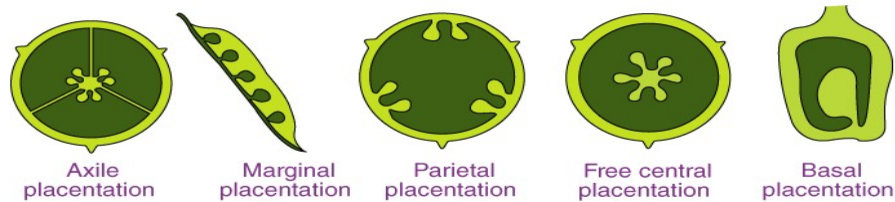
Pea



Michelia

- ❖ The megasporophyll or carpel is differentiated into a proximal fertile ovule bearing part of the ovary, distal capitate, lobed, bifid or branched pollen receptive part called stigma and middle sterile short or long big stalk called style.
- ❖ After fertilization in ovarian region, ovules are formed. These ovules are borne on the placenta.
- ❖ The arrangement of placentae is called placentation and it may be marginal, parietal, axile, free central and basal.

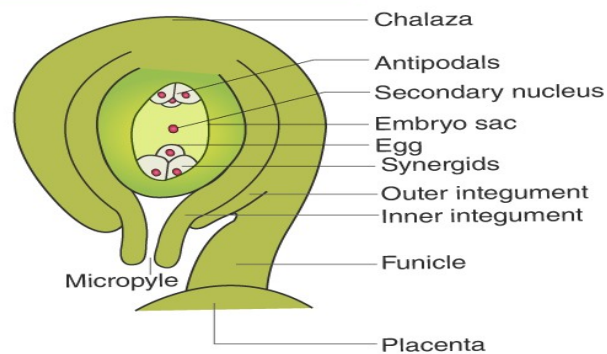
TYPES OF PLACENTATION



Structure of a Typical Ovule

- ❖ The megasporangium or ovule is located within the carpel.
- ❖ It is developed from the placental tissue.
- ❖ These ovules further give rise to seeds after fertilization.
- ❖ Their number in a carpel varies from species to species.
- ❖ A typical ovule in angiosperm show following parts.

STRUCTURE OF THE MATURE OVULE OF ANGIOSPERMS

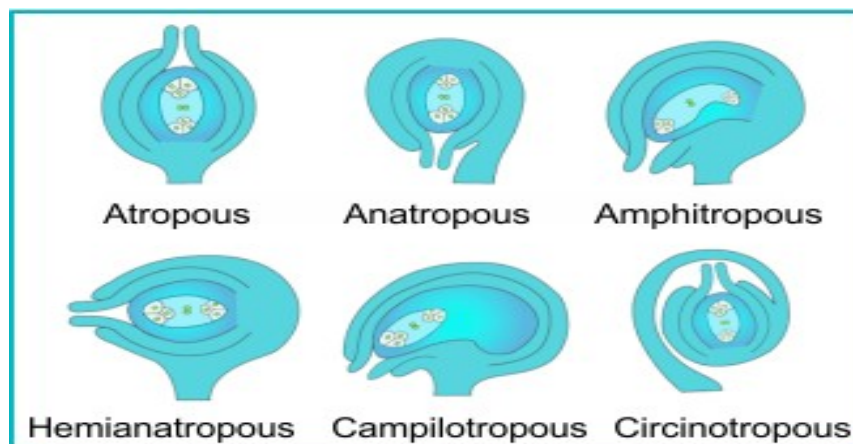


- ❖ **Funicle:** The slender stalk by which ovule is attached to the placenta is called funicle or funiculus. The ovule without funicle is called sessile ovule.
- ❖ **Hilum:** The point of attachment of the ovule to the funicle of stalk is termed as hilum.
- ❖ **Raphe:** The part of the funicle which extends beyond the hilum, along the body of the ovule forming a ridge like structure is known as raphe. Through raphe, the food is supplied to the nucellus.

- ❖ **Chalaza:** It is the distal end of the raphe or base of the ovule from where integuments arise.
- ❖ **Nucellus:** The main body of the ovule consisting thin walled parenchymatous cells called nucellus. In which the embryo sac is present at the upper end.
- ❖ **Integuments:** The nucellus is surrounded by two envelopes called integuments (inner and outer). The inner integument is formed first and then the outer integument is developed. In some flowers of natural order (Family) Asteraceae (Compositae) ovule show only one integument while ovules of some plants like *Santalum* (Sandlewood), *Loranthus*, *Viscum* etc. are without integuments.
- ❖ **Micropyle:** The integuments leave an opening at the apex of the ovule and this opening is known as micropyle. It may be narrow or broad depending on the extent of nucellus enclosed. In majority of the angiospermic plants, ovule is found to be inverted *i.e.*, the micropyle and funicle lie parallel and close to each other while chalaza lies away from the funicle.
- ❖ **Embryo sac:** It is a large oval cell lying embeded in the nucellus towards the micropyle end. The embryo sac is the proper female gametophyte. This embryo sac after fertilization shows development of embryo which is the most important part of the fertilized ovule or young seed.
- ❖ The mature embryo sac or the female gametophyte in majority of angiospermic plants is eight nucleate organised structures. Of these eight nuclei three form antipodals and remain opposite the micropylar end in the sac. In the middle of embryo sac two polar nuclei fuse and form a secondary nucleus. The remaining three nuclei form the egg apparatus towards micropylar end in the embryo sac. The egg apparatus consist a central large ovum or egg and lateral two synergids.

Types of Ovules

- ❖ Different types of ovules are found in angiosperms.
- ❖ On the basis of position of the axis of ovule in relation to funicle and chalaza, the ovules are classified into four types viz. Orthotropous/Atropous, Anatropous, Amphitropous, Hemianatropous, Campylotropous and Circinotropous.



Orthoropous ovule (Orthos - stright, trophos - a turn)

- ❖ When the ovule is vertically straight, the micropyle, chalaza and funiculus also lie in one straight vertical line. Such ovule is termed as orthotropous.
- ❖ It is comparatively rare in angiosperms. It is found in plants of natural orders (Families) Piperaceae and Polygonaceae.

Anatropous ovule (Anatroph - turn backward/inverted)

- ❖ In this type the body of the ovule bends through 180° due to which the funicle and the micropyle lie close to each other.
- ❖ The micropyle and chalaza lie in straight vertical line and the funicle lies parallel to it.
- ❖ Hence, the ovule becomes completely inverted. It is very common in angiosperms, e.g. Sunflower, Safflower, Bean, Pea, Gram etc.

Amphitropous ovule (Amphi - both sides)

- ❖ The ovule is placed in transverse plane *i.e.*, at right angle to the stalk or funicle.
- ❖ In this type, the chalaza and micropyle lie in straight horizontal plane at right angle to funicle.
- ❖ This is also not very common in angiosperms, e.g. *Ranunculus*, *Lemna* etc.

Hemianatropous (or Hemitropous) Ovule

- ❖ A hemianatropous (or hemitropous) ovule is characterized by the ovule body bending at a 90-degree angle to the funiculus, resulting in the micropyle and chalaza lying in the same plane but the micropyle being positioned away from the hilum.
- ❖ A common example of a plant with hemianatropous ovules is *Ranunculus*.

Campylotropous ovule (Kampylos-curved)

- ❖ This type also shows transverse ovule but it is bent round like a horse shoe.
- ❖ Due to bending, the micropyle and chalaza do not lie on the same horizontal straight line but micropyle, funicle and chalaza come close to each other.
- ❖ Such condition of ovule is described as campylotropous.
- ❖ It is present in four O' clock plant, Mustard, Radish, *Chenopodium*, *Dianthus*.

Circinotropous Ovule

- ❖ A circinotropous ovule is a type of ovule where the funicle (stalk) is long and wraps around the ovule, causing it to twist 360 degrees.
- ❖ This results in the micropyle (opening for pollen) and chalaza (base of the ovule) ending up on the same side, away from the hilum (point of attachment to the ovary wall).
- ❖ The best example of a plant with circinotropous ovules is *Opuntia*, commonly known as prickly pear or cactus

Significance

- ❖ This can be used as a criterion for finding out the phylogenetic relationship and evolution in the natural orders (Families) of angiosperms

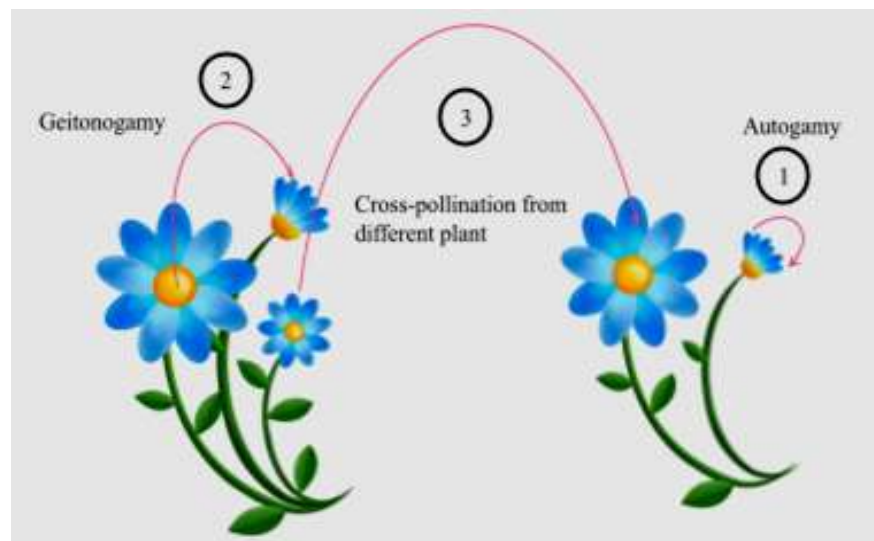
Definition and Types of Pollination

Introduction

- ❖ The majority of flowering plants reproduce sexually i.e., through seed formation.
- ❖ We know sexual reproduction is incomplete without fertilization.
- ❖ The male and female gametes have to meet for fertilization and further development.
- ❖ Reproduction is the life process, which helps an organism procreate its own offspring. There are a lot of events involved in this.
- ❖ In plants, pollination is one among them.
- ❖ Definition: ***"Pollination is defined as the pre-fertilization event or process, where pollen grains from anther are transferred to the stigma of a flower."***
- ❖ Plants are immobile. They can't copulate with each other by themselves.
- ❖ They need a vector for this. Pollination is the process that helps to unite the male and female gametes and thus helps in fertilization.
- ❖ It can be broadly classified into two, cross-pollination and self-pollination and this is achieved with the help of a variety of vectors/agents.

Types of Pollination

- ❖ Pollinations can occur either within a flower or between flowers of the same plant or flowers of different plants.
- ❖ Depending on this, pollinations are of three types, namely autogamy, geitonogamy and xenogamy.



Autogamy

- ❖ It is a type of self-pollination where the transfer of pollen grains from the anther to the stigma takes place within the same flower.
- ❖ Coordinated opening, maturation and exposure of the anther and stigma are necessary for autogamy.
- ❖ There are two conditions for autogamy to take place:

- Anther-stigma synchronization; when the pollen is released, stigma should be ready to receive it.
- The position of or distance between anther and stigma. Both should be close enough for pollination.
- ❖ In chasmogamous flowers, anther and stigma are exposed.
- ❖ The exposed reproductive parts give a chance of cross-pollination in chasmogamous flowers.
- ❖ While in cleistogamous flowers anther and stigma are not exposed but lie close enough for transfer.
- ❖ Thus, the chances of cross-pollination in cleistogamous flowers are almost none.
- ❖ In addition, they barely require a pollinating agent.

Geitonogamy

- ❖ Geitonogamy is the type of self-pollination where the transfer of pollen grains from the anther to the stigma takes place between different flowers in the same plant.
- ❖ Though it seems like cross-pollination and takes place with the help of pollinators, both the gametes have the same plant as their origin.

Xenogamy

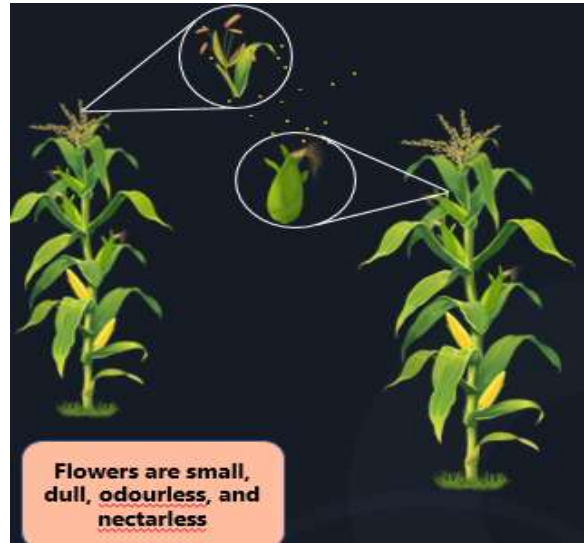
- ❖ Xenogamy refers to the process of cross-pollination between flowers of different plants, specifically involving the transfer of pollen from the flower of one plant to the flower of a genetically different plant of the same species.
- ❖ This form of pollination promotes genetic diversity in plant populations, as it mixes genetic material from different individuals, which can result in stronger offspring with a wider range of traits that may be beneficial for survival.
- ❖ Xenogamy is common in plants that rely on external agents such as wind, insects, birds, or animals to transfer pollen.

Types of Pollination Based on Pollinating Agents

Anemophily (*Zea mays*)

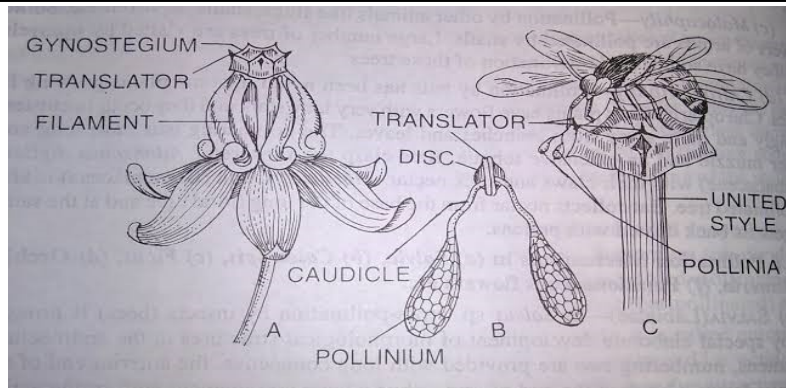
- ❖ Anemophily, or wind pollination, is a process where pollen is transferred from one plant to another through the wind.
- ❖ In *Zea mays* (corn or maize), anemophily plays a crucial role in its reproduction.
- ❖ Maize is a monoecious plant, meaning it has both male and female flowers on the same plant.
- ❖ The male flowers (tassels) are located at the top of the plant, and the female flowers (silks) are found lower down, where the ears of corn develop.
- ❖ Pollen Production: The tassels produce and release large amounts of light, dry pollen grains.
- ❖ Pollen Dispersal: The wind carries the pollen away from the tassels, sometimes over long distances.
- ❖ Pollination: Some of the dispersed pollen grains land on the silk (the female reproductive part). Each silk is connected to an individual kernel.

- ❖ Fertilization: If a pollen grain successfully lands on the silk, it travels down the silk to fertilize the ovule, resulting in kernel formation.
- ❖ Because wind pollination is random, maize produces a large volume of pollen to increase the likelihood of successful fertilization.
- ❖ This is an adaptation to ensure effective reproduction in a wind-pollinated system.



Entomophily (*Calotropis*)

- ❖ Entomophilous pollination refers to pollination facilitated by insects.
- ❖ In *Calotropis* (commonly known as milkweed), this type of pollination is crucial, as the plant relies on insects such as bees, butterflies, and moths to transfer pollen between flowers.
- ❖ Flower Structure: *Calotropis* flowers have a complex structure with a corolla and a crown-like corona. The pollen is not in loose grains but grouped into specialized structures called pollinia (waxy pollen masses).
- ❖ Insect Attraction: *Calotropis* flowers produce nectar and emit a strong fragrance, attracting insect pollinators. The flowers are brightly colored (often white or purple), which also aids in attracting insects.
- ❖ Pollination Mechanism: When an insect visits the flower to collect nectar, it inadvertently brushes against the pollinia.
- ❖ The pollinia get attached to the insect's body through special structures called translator arms.
- ❖ As the insect moves to another flower, the pollinia are transferred, allowing for cross-pollination.
- ❖ Fertilization: Once the pollinia are transferred to another flower, they come into contact with the stigma, leading to fertilization.
- ❖ The reliance on insects ensures that *Calotropis* achieves effective cross-pollination, which is essential for the genetic diversity and reproduction of the species.



Ornithophily (*Bombax*)

- ❖ Ornithophily refers to pollination by birds.
- ❖ In *Bombax* (commonly known as the silk cotton tree), ornithophily plays a significant role, as birds, particularly nectar-feeding species like sunbirds and hummingbirds, help with the pollination process.
- ❖ Flower Structure: *Bombax* flowers are large, brightly coloured (often red or orange), and tubular, which is ideal for bird pollination.
- ❖ The flowers are typically positioned at the ends of branches, making them easily accessible to birds.
- ❖ Nectar Production: The flowers produce copious amounts of nectar, which attracts birds.
- ❖ Since *Bombax* blooms during seasons when bird pollinators are abundant, the tree takes full advantage of their presence.
- ❖ Bird Interaction: When birds come to feed on the nectar, they brush against the numerous stamens, picking up pollen on their feathers and beaks.
- ❖ As they move from flower to flower, the pollen is transferred to the stigma of another flower, facilitating cross-pollination.
- ❖ Adaptation to Birds: The flowers of *Bombax* are sturdy and have no strong fragrance (as birds rely on sight more than smell).
- ❖ The structure is designed to endure the weight of birds, and the bright colours are easily visible to them.
- ❖ *Bombax* is well-adapted to ornithophily, and this relationship with birds ensures successful pollination, contributing to the reproduction and spread of the species.



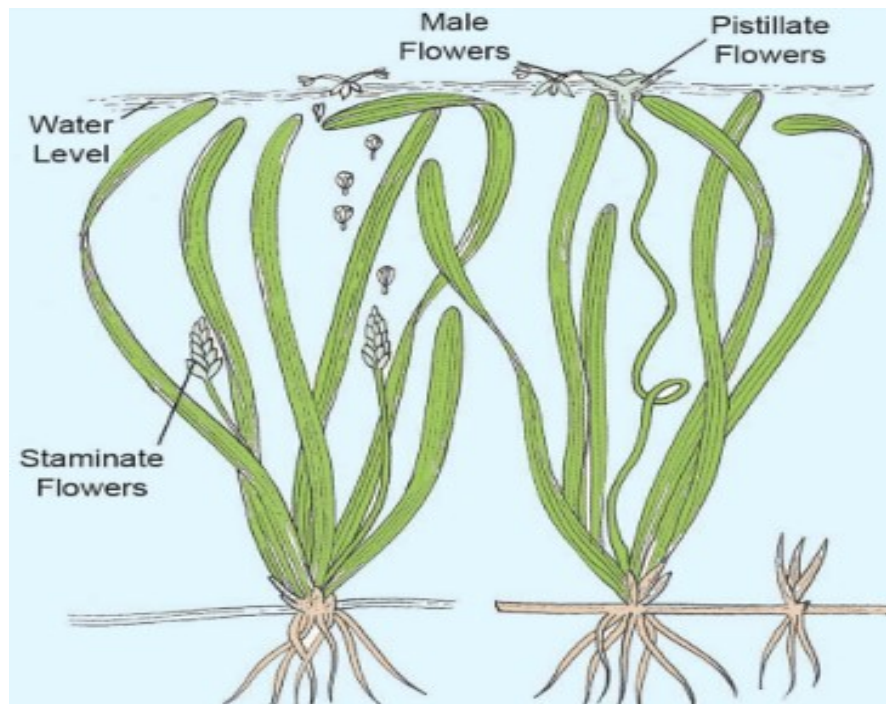
Chiropterophily (*Kigelia*)

- ❖ Chiropterophily refers to pollination by bats.
- ❖ In the case of *Kigelia africana* (commonly known as the sausage tree), this form of pollination plays a key role in its reproductive process.
- ❖ *Kigelia*'s flowers are adapted to attract nocturnal bats, which act as the primary pollinators.
- ❖ Flower Structure: The flowers of *Kigelia* are large, bell-shaped, and typically reddish or purplish in colour.
- ❖ They hang in clusters on long, pendulous stalks, making them accessible to bats, which can hover or cling while feeding on the flowers.
- ❖ Scent and Nectar: *Kigelia* flowers open at night and release a strong, musky odour that attracts fruit bats, which are nocturnal and rely on their sense of smell to locate food.
- ❖ The flowers produce copious amounts of nectar, a key reward for bats.
- ❖ Bat Interaction: As bats approach to feed on the nectar, their faces and bodies come into contact with the flowers' reproductive parts (the stamens and stigma).
- ❖ Pollen sticks to the bats' fur, and when they visit other flowers, they transfer the pollen, facilitating cross-pollination.
- ❖ Adaptation to Bats: The flowers are sturdy enough to withstand the bats' feeding behaviour.
- ❖ They are typically positioned at night when bats are active, and their strong odour is an adaptation to attract these nocturnal pollinators.
- ❖ This mutualistic relationship between *Kigelia africana* and bats ensures effective pollination and reproductive success for the tree, while providing bats with an important food source.



Hydrophily (*Vallisneria*)

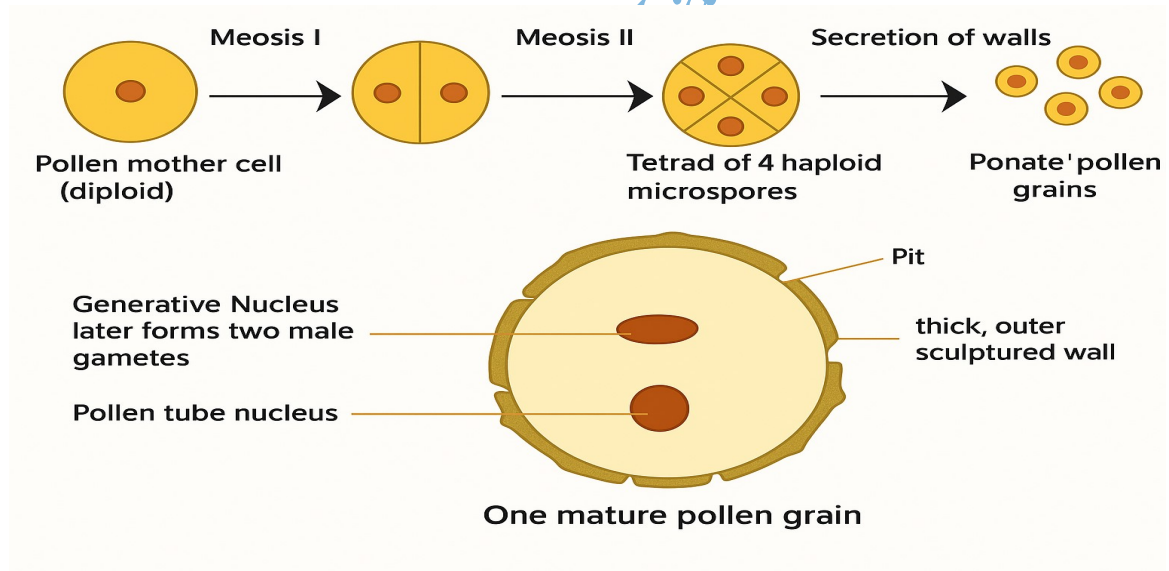
- ❖ Hydrophily refers to pollination that occurs through water.
- ❖ In *Vallisneria*, an aquatic plant, hydrophilous pollination is the primary mode of reproduction.
- ❖ *Vallisneria*, also known as eelgrass, has a specialized mechanism for water pollination that allows it to reproduce effectively in aquatic environments.
- ❖ Dioecious Nature: *Vallisneria* is a dioecious plant, meaning that male and female flowers are found on separate plants.
- ❖ Female Flower Structure: The female flowers grow on long, flexible stalks that extend to the surface of the water.
- ❖ Once they reach the water's surface, they float, exposing their stigma to potential pollen.
- ❖ Male Flower Structure: The male flowers are produced underwater but are not attached by long stalks.
- ❖ Instead, they detach from the male plant and float to the surface of the water.
- ❖ Pollination Mechanism: Once the male flowers reach the surface, they drift with the current, and as they move, they come into contact with the floating female flowers.
- ❖ The male flowers or their pollen are transferred to the stigma of the female flowers, resulting in pollination.
- ❖ Fertilization: After successful pollination, the female flower is pulled back underwater by its coiling stalk, and the fertilized ovules develop into seeds underwater.
- ❖ This adaptation allows *Vallisneria* to use water as a medium for pollen transfer, ensuring successful reproduction in its aquatic habitat.



Microsporogenesis, Pollen Germination and Development of Male Gametophyte

Microsporogenesis

- ❖ Microsporogenesis is a highly coordinated developmental process in angiosperms that leads to the formation of haploid microspores from diploid pollen mother cells (PMCs) within the anthers.
- ❖ It begins with the differentiation of hypodermal archesporial cells in the anther primordium, which divide periclinally to give rise to primary parietal cells and primary sporogenous cells.
- ❖ The parietal cells undergo further divisions to form the concentric anther wall layers: the epidermis, endothecium, one to three middle layers, and the innermost nutritive tissue called the tapetum.
- ❖ The tapetum plays a crucial role in supplying enzymes, proteins, lipid precursors, and sporopollenin materials necessary for the development of pollen walls.
- ❖ The sporogenous cells develop into pollen mother cells, which are large, round, diploid cells characterized by dense cytoplasm and a prominent nucleus.

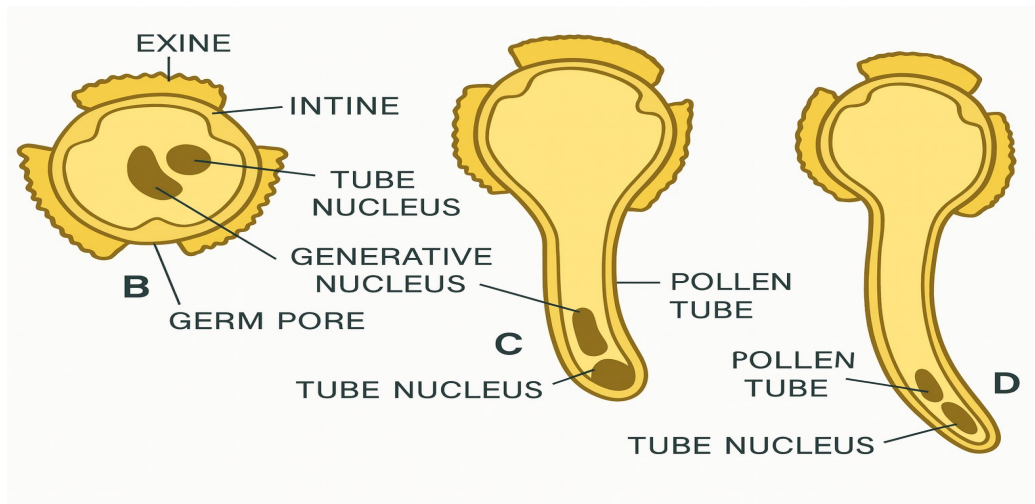


- ❖ Each PMC undergoes meiotic division, where meiosis I results in the reduction of chromosome number (from diploid to haploid) and meiosis II separates the chromatids, producing a tetrad of four haploid microspores.
- ❖ The cytokinesis following meiosis may occur either simultaneously (all four nuclei divide before wall formation) or successively (walls form after each meiotic division), resulting in different tetrad arrangements such as tetrahedral, isobilateral, decussate, T-shaped, or linear, depending on the species.
- ❖ The newly formed microspores are initially enclosed by a callose wall, secreted by the PMC.

- ❖ Callase enzymes produced by the tapetum later degrade this callose, releasing the free haploid microspores into the locule.
- ❖ Each microspore undergoes polarity establishment, vacuolation, and wall differentiation; the exine (outer wall) is formed from sporopollenin, secreted with the help of the tapetum, while the intine (inner wall) is composed of cellulose and pectin.
- ❖ The functional outcome of microsporogenesis is the production of viable, morphologically distinct pollen grains that serve as the male gametophyte.
- ❖ This process is tightly regulated by hormonal control (auxins, gibberellins, jasmonic acid), gene expression (such as MS1, TDF1 in Arabidopsis), and timely programmed cell death of the tapetum, ensuring proper pollen wall formation and male fertility.
- ❖ Disruptions in tapetal function, meiotic progression, or callose degradation often lead to male sterility, which has significant implications for plant breeding and hybrid seed production.

Pollen Germination

- ❖ Pollen germination is a highly regulated and essential process in the sexual reproduction of angiosperms, ensuring the delivery of male gametes to the female gametophyte.
- ❖ In the mature pollen grain, the cytoplasm remains in a metabolically quiescent state due to desiccation, which allows long distance dispersal.
- ❖ In contact with a compatible stigma, the pollen grain rehydrates through water uptake and nutrient transfer from the stigmatic papillae, reactivating its metabolism.
- ❖ This initial step is accompanied by species-specific recognition systems, such as gametophytic and sporophytic self-incompatibility mechanisms, which prevent self-fertilization and promote genetic diversity.
- ❖ Once pollen hydrated, germination initiates at specialized germinal apertures, where the intine expands outward, giving rise to the pollen tube.
- ❖ At this stage, calcium ion gradients and localized accumulation of reactive oxygen species play a crucial role in establishing polarity and regulating exocytosis.
- ❖ The cytoskeleton, especially actin filaments, reorganizes to direct vesicle trafficking toward the tip of the emerging pollen tube, enabling polarized or tip growth.
- ❖ Hydrolytic enzymes such as pectinases, cutinases, and cellulases are secreted to digest the stigmatic cell wall and facilitate tube penetration.
- ❖ As the pollen tube elongates, its cell wall remains dynamically regulated, with deposition of callose, pectin, and cellulose ensuring both flexibility at the apex and rigidity along the shank.
- ❖ Ion fluxes, particularly the calcium gradient at the tip and proton pumps that establish intracellular pH domains, coordinate growth, while osmotic gradients generate the turgor pressure necessary for tube extension.

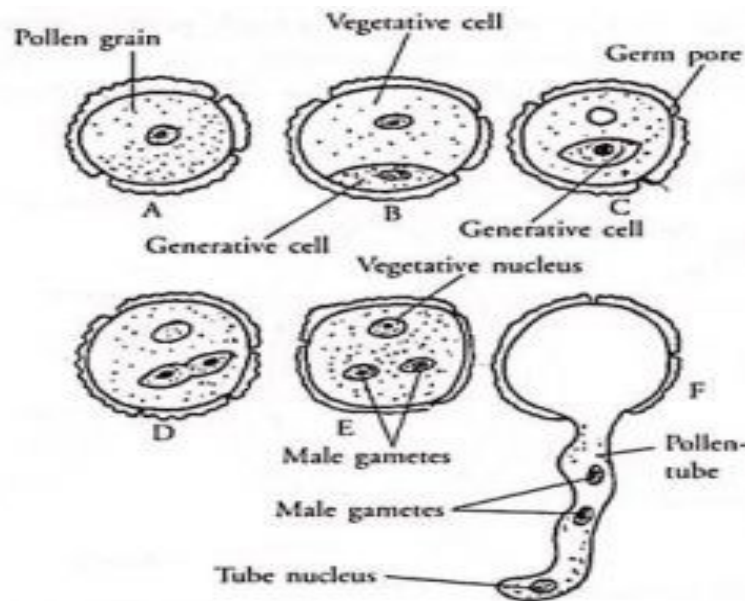


- ❖ Pollen tube guidance is achieved through signaling molecules, including cysteine rich LURE peptides secreted by synergid cells, which provide chemotropic cues directing the tube toward the ovule.
- ❖ Once the pollen tube reaches the ovule, it enters the embryo sac through the micropyle, guided by synergid cell degeneration, and undergoes tube rupture to release the two sperm cells.
- ❖ Thus, pollen germination represents a finely coordinated interplay of cellular, molecular, and biochemical events, not only central to reproductive success but also of great importance in applied research such as hybrid breeding, haploid production through pollen culture, and the development of strategies to overcome cross-incompatibility in crop improvement.

Development of Male Gametophyte

- ❖ The development of the male gametophyte in angiosperms begins with microsporogenesis, where diploid microspore mother cells (microsporocytes) located within the anthers undergo meiosis to produce a tetrad of haploid microspores.
- ❖ Each microspore then separates and functions as the initial cell of the male gametophyte.
- ❖ During microgametogenesis, each haploid microspore undergoes asymmetric mitotic division to form a large vegetative cell and a smaller generative cell.
- ❖ The vegetative cell, also called the tube cell, contains a prominent vacuole and a nucleus which plays a vital role in directing pollen tube growth during fertilization.
- ❖ The generative cell is initially enclosed within the cytoplasm of the vegetative cell and eventually divides mitotically to give rise to two non-motile sperm cells, which are the actual male gametes.

- ❖ At this stage, the pollen grain becomes a two-celled or three-celled structure depending on the plant species.

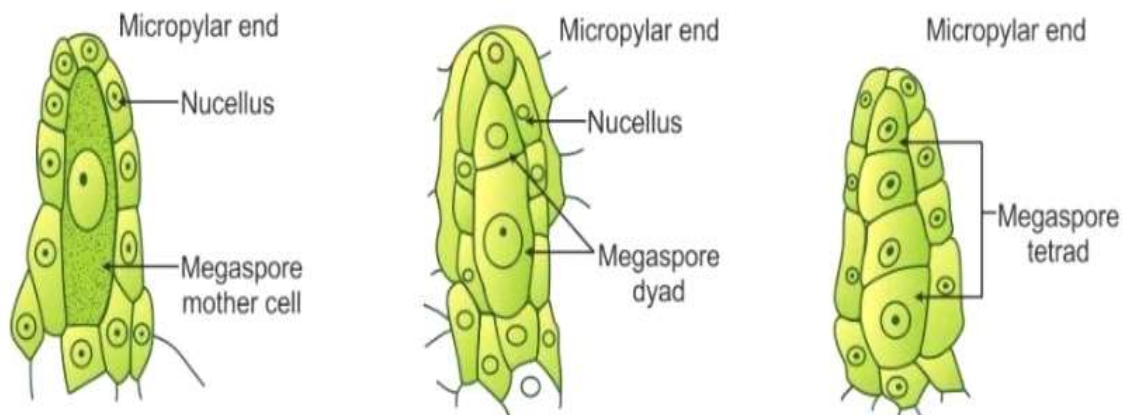


- ❖ The mature pollen grain, representing the reduced male gametophyte, is surrounded by a tough outer wall called the exine, which provides protection, and an inner wall called the intine, which facilitates germination.
- ❖ Landing on a compatible stigma, the pollen grain germinates by producing a pollen tube through the germ pore.
- ❖ The vegetative cell directs the tube's growth through the style toward the ovule, while the generative cell or sperm cells travel within the tube.
- ❖ Ultimately, the two sperm cells are released into the embryo sac, where one fuses with the egg cell to form the diploid zygote and the other fuses with the central cell to form the triploid endosperm.
- ❖ Thus, the male gametophyte, though highly reduced and dependent on the sporophytic tissues for nutrition, plays an indispensable role in double fertilization, a unique characteristic of angiosperms.

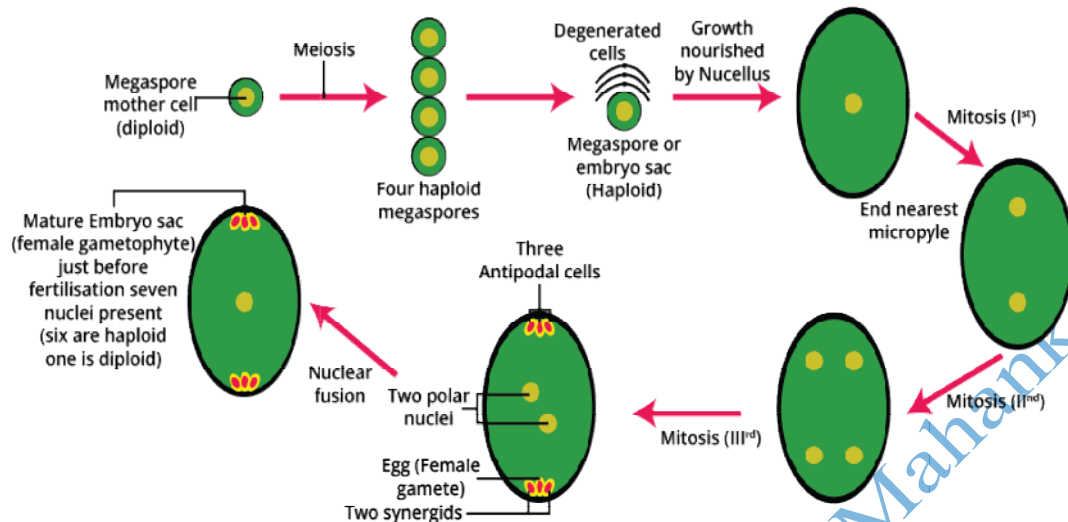
Megasporogenesis, Development and Structure of Embryo Sac

Megasporogenesis

- ❖ Megasporogenesis is the process by which the female spore, or megaspore, is formed inside the ovule of seed plants through meiotic division of the diploid megaspore mother cell (MMC).
- ❖ It represents the crucial link between the sporophytic and gametophytic generations.
- ❖ The process begins in the nucellus tissue of the ovule, where a single hypodermal cell differentiates into the archesporial cell.
- ❖ This cell enlarges, develops a conspicuous nucleus, and functions directly as the MMC or may divide periclinally to give rise to a primary parietal cell and the inner megaspore mother cell.
- ❖ The MMC is diploid, large, with dense cytoplasm and destined to undergo meiosis.
- ❖ The MMC undergoes meiosis, comprising Meiosis I and II, to yield a linear tetrad of four haploid megaspores.



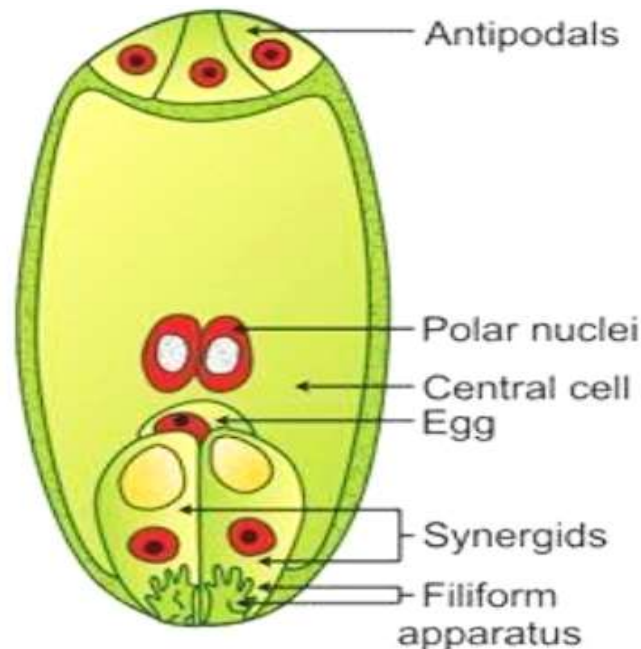
- ❖ The tetrad arrangement may be linear, T-shaped, inverted T-shaped, or isobilateral, depending on the orientation of the meiotic spindle.
- ❖ Out of these four megaspores, typically three degenerate, leaving behind a single functional megaspore that usually occupies the chalazal position.
- ❖ This functional megaspore represents the first cell of the female gametophytic generation and undergoes successive mitotic divisions to give rise to the mature embryo sac (megagametophyte).
- ❖ Based on the number of megaspore nuclei participating in embryo sac formation, three developmental patterns are recognized: (1) Monosporic development – where only one megaspore contributes (e.g., *Polygonum* type, the most common in angiosperms), (2) Bisporic development – where two haploid nuclei derived from the MMC take part (e.g., *Allium* type), and (3) Tetrasporic development – where all four haploid nuclei contribute without wall formation (e.g., *Peperomia* type).



- ❖ These variations result in differences in the ploidy and organization of the resulting embryo sac.
- ❖ Megasporogenesis is thus not merely a reductional division but a highly regulated developmental event influenced by genetic and hormonal factors, ensuring the establishment of the female gametophyte for double fertilization.
- ❖ The degeneration of the non-functional megaspores is considered a selective process that allows the survival of a single megaspore with optimal position and nutrition.
- ❖ The process highlights the evolutionary refinement in angiosperms, maximizing reproductive efficiency by producing a single functional embryo sac per ovule, which is critical for successful seed formation.

Structure of Embryo Sac

- ❖ The embryo sac, also known as the female gametophyte of angiosperms, develops inside the ovule within the ovary and plays a crucial role in sexual reproduction by housing the female gametes.
- ❖ It usually develops from a single functional megaspore after megasporogenesis.
- ❖ Out of the four haploid megaspores produced from the meiotic division of the megaspore mother cell, only one remains functional, while the others degenerate.
- ❖ The functional megaspore undergoes three successive mitotic divisions, resulting in eight haploid nuclei. These nuclei are then organized into a characteristic structure known as the *Polygonum* type embryo sac, which is the most common type in angiosperms and is described as an eight nucleate but seven celled structure.
- ❖ The mature embryo sac shows a distinct polarity, with the micropylar and chalazal ends having specialized groups of cells.
- ❖ At the micropylar end lies the egg apparatus, which consists of one centrally placed egg cell and two synergids on either side.



- ❖ The synergids are provided with a special structure called the filiform apparatus, which helps in attracting and guiding the pollen tube for the release of male gametes.
- ❖ In the center of the sac is a large central cell that contains two polar nuclei.
- ❖ These nuclei may remain free or fuse to form a secondary nucleus, which later participates in double fertilization by fusing with one of the male gametes to form the triploid primary endosperm nucleus, giving rise to the nutritive endosperm.
- ❖ At the chalazal end of the embryo sac are three antipodal cells, which are generally short lived and degenerate after fertilization, though in some plants they may persist and play a nutritive role.
- ❖ Thus, the structure of the mature embryo sac can be summarized as a seven celled, eight nucleate body consisting of an egg apparatus (one egg cell and two synergids) at the micropylar end, three antipodal cells at the chalazal end, and a large central cell containing two polar nuclei.
- ❖ Each component of the embryo sac has a specific function that ensures the success of fertilization and seed development: the egg cell fuses with one male gamete to form the zygote, the synergids guide the pollen tube, the central cell forms the endosperm after fertilization, and the antipodals may contribute to nutrition.
- ❖ This highly specialized organization of the embryo sac ensures double fertilization, a unique and defining feature of angiosperms.

Monosporic Embryo Development

- ❖ The monosporic embryo sac development is the most common mode of female gametophyte formation in angiosperms and is typically represented by the *Polygonum* type.

- ❖ In this type, out of the four haploid megaspores formed after meiosis of the megaspore mother cell (MMC), only one survives, while the other three degenerate.
- ❖ The functional megaspore, which is haploid, alone gives rise to the entire embryo sac; hence the development is called monosporic.
- ❖ This megaspore undergoes three successive free nuclear mitotic divisions without cytokinesis.
- ❖ After the first division, two nuclei are formed and migrate to opposite poles of the enlarging megaspore.
- ❖ The second division produces four nuclei, two at each pole, and the third division produces a total of eight nuclei, four at each pole.
- ❖ These eight nuclei are arranged in a characteristic pattern and later get organized into cells with a definite polarity.
- ❖ At the micropylar end, three nuclei organize to form the egg apparatus, which consists of one central egg cell flanked by two synergids.
- ❖ The synergids are provided with a specialized structure known as the filiform apparatus, which guides the pollen tube during fertilization.
- ❖ At the chalazal end, three nuclei form the antipodal cells, which are usually ephemeral but may have a nutritive role in some plants.
- ❖ The remaining two nuclei, one from each pole, migrate toward the center of the embryo sac and form the polar nuclei, which either remain free or fuse to form the secondary nucleus.
- ❖ These two polar nuclei constitute the central cell, which participates in double fertilization by fusing with one of the male gametes to produce the triploid primary endosperm nucleus.
- ❖ Thus, the mature monosporic embryo sac is typically seven-celled and eight-nucleate, with one egg cell, two synergids, three antipodals, and the large central cell containing two polar nuclei.
- ❖ The *Polygonum* type, a monosporic embryo sac, is considered the most prevalent type of embryo sac in angiosperms, being present in over 70% of families. It serves as the classical model for understanding the structure and function of the female gametophyte.
- ❖ The monosporic type ensures genetic uniformity of the nuclei within the embryo sac, since all are derived from a single megaspore, and it plays a key role in the angiosperm reproductive process by facilitating double fertilization and subsequent endosperm development.

Bisporic Embryo Development

- ❖ The bisporic embryo sac development is a type of female gametophyte formation in angiosperms in which two of the four megaspore nuclei formed after meiosis of the megaspore mother cell (MMC) take part in embryo sac development.
- ❖ In this case, the MMC undergoes meiosis, producing a dyad and then a tetrad of four haploid megaspores.

- ❖ However, due to the suppression of cytokinesis after the second meiotic division, the cell wall fails to form between the two nuclei at the chalazal end, resulting in a binucleate functional megaspore.
- ❖ This functional unit containing two haploid nuclei gives rise to the embryo sac and hence it is called bisporic.
- ❖ The two nuclei in the functional megaspore undergo two successive mitotic divisions, which lead to the formation of eight nuclei in total, similar to the *Polygonum* type.
- ❖ However, the key difference is that in the bisporic type, these eight nuclei are derived from only two meiotic products instead of one, meaning they are genetically only two spored.
- ❖ The organization of the mature bisporic embryo sac usually resembles the *Polygonum* type, with three cells forming the egg apparatus (one egg cell and two synergids) at the micropylar end, three antipodal cells at the chalazal end, and a large central cell containing two polar nuclei.
- ❖ Thus, the mature embryo sac is seven celled and eight nucleate.
- ❖ A common example of the bisporic type is the *Allium* type embryo sac, where the two nuclei derived from one dyad of the tetrad function together.
- ❖ In this case, after the first mitotic division, four nuclei are formed and arranged in two groups of two at each pole.
- ❖ The second division produces eight nuclei, which then organize into the typical seven-celled, eight-nucleate structure.
- ❖ Functionally, the embryo sac components remain the same as in the *Polygonum* type, but the genetic origin of the nuclei is different, as they are derived from two meiotic products.

Tetrasporic Embryo Development

- ❖ The tetrasporic embryo sac development is a type of female gametophyte formation in angiosperms where all four haploid megaspore nuclei, produced from the meiotic division of the megaspore mother cell (MMC), participate in embryo sac formation.
- ❖ In this case, meiosis occurs normally, but cytokinesis (cell wall formation) is completely suppressed after both meiotic divisions, resulting in a multinucleate cell with four haploid nuclei instead of a linear tetrad of megaspores.
- ❖ Since no cell walls are laid down, all four nuclei remain together in a common cytoplasm and function collectively as the starting unit for embryo sac development.
- ❖ This makes the development tetrasporic, in contrast to monosporic (one nucleus functions) and bisporic (two nuclei function) types.
- ❖ The subsequent behavior of the four nuclei varies among species, giving rise to different subtypes of tetrasporic embryo sacs such as *Fritillaria* type, *Penaea* type, *Adoxa* type, *Plumbago* type and *Drusa* type, each differing in nuclear arrangement and contribution to the final structure.

- ❖ In general, the four nuclei undergo two or more rounds of mitotic division, leading to an embryo sac that may contain eight, twelve, or even sixteen nuclei depending on the subtype.
- ❖ For example, in the *Fritillaria* type, two nuclei move to the micropylar end and two to the chalazal end, but before further division, the two chalazal nuclei fuse, resulting in three nuclei at the chalazal pole and two at the micropylar pole.
- ❖ Further divisions give rise to an embryo sac with unequal genetic contributions from the four meiotic products. In other types like *Penaea*, all four nuclei contribute equally, leading to a more symmetrical arrangement.
- ❖ This is a significant evolutionary feature of tetrasporic development because it increases endosperm ploidy, enhancing its nutritive capacity for the developing embryo.
- ❖ Thus, in tetrasporic embryo sac development, all four meiotic products participate, leading to genetically more diverse nuclei within the sac compared to monosporic or bisporic types.
- ❖ It results in variations in nuclear arrangement and endosperm ploidy, with the mature sac generally being seven-celled but with greater nuclear complexity in the central cell.
- ❖ This type, though less common than the *Polygonum* type, is important in certain plant families and is considered to represent an advanced evolutionary trend in angiosperm reproduction.

A	Monosporic 8-nucleate <i>Polygonum</i> -type							
B	Bisporic 8-nucleate <i>Allium</i> -type							
C	Tetrasporic 8-nucleate <i>Adoxa</i> -type							
D	Tetrasporic 16-nucleate <i>Peperomia</i> -type							
E	Tetrasporic 16-nucleate <i>Penaea</i> -type							
F	Tetrasporic 16-nucleate <i>Drusa</i> -type							
G	Tetrasporic 8-nucleate <i>Fritillaria</i> -type							

Fertilization: Entry of Pollen Tube, Double Fertilization and Triple Fusion, Significance of Double Fertilization

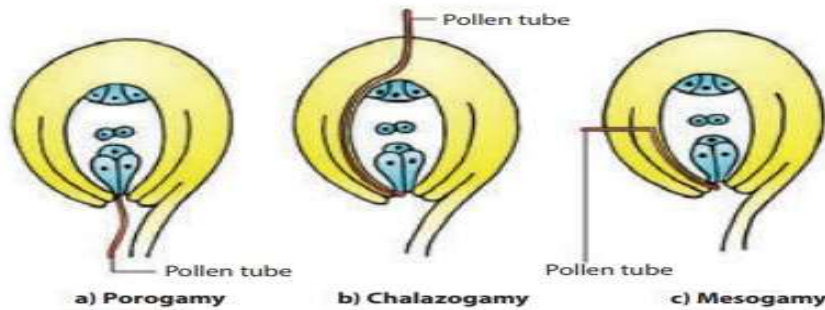
Introduction

- ❖ In angiosperms, the development of female gametophyte is endosporous i.e. develops inside the megaspore.
- ❖ In typical female gametophyte in angiosperm, the nucleus of the functional megaspore acts as a nucleus of the embryo sac.
- ❖ During development, this nucleus undergoes mitotic divisions and forms two, then four and finally eight nuclei. Out of these eight nuclei, four remain at micropylar end and four at chalazal end in the developing embryo sac.
- ❖ In the final stages of embryo sac development, one nucleus from each end of the embryo sac moves to the centre of the embryo sac and two nuclei fuse to form a diploid fusion nucleus or secondary nucleus.
- ❖ During organization of embryo sac, the three nuclei at chalazal end form the antipodals, while the three at the micropylar end develop into egg apparatus.
- ❖ So the typical mature female gametophyte in angiosperm is an organised embryo sac with 3 haploid nuclei in the form of 3 antipodals at chalazal end, 3 haploid nuclei in the form of egg apparatus at micropylar end and the diploid secondary or fusion nucleus in the centre.
- ❖ Such organized embryo sac is ready for fertilization.

Entry of Pollen Tube

- ❖ The fusion of nucleus in the male gamete with the nucleus in the female gamete is called fertilization.
- ❖ After successful pollination, when pollen grain is lodged on the receptive surface of the mature stigma, it germinates and the pollen tube grows with two male gametes.
- ❖ After landing of pollen grain on the receptive stigma, it starts germination and at a time many pollen grains germinate on stigmatic surface.
- ❖ Stigmatic exudate includes stigmatic sticky fluid and pollen grains adhere to it. Stigmatic surface shows papillose growth on their walls.
- ❖ Through these papillae pollen tube enter into the intercellular spaces of stigmatic tissue and passes through style towards embryo sac.
- ❖ In certain taxa of angiosperms, styler region is filled with secretion which provides food to growing pollen tube.
- ❖ This secretion contains proteins, carbohydrates, lipids, enzymes (esterases, acid phosphatases).
- ❖ Thus, the path of pollen tube is guided by secretion.
- ❖ The path of the pollen tube through styler region to embryo sac depends on nature of styles.
- ❖ In case of solid styles, the secretions consists tissue dissolving enzymes (pectinase) making passage for pollen tube through styler region.

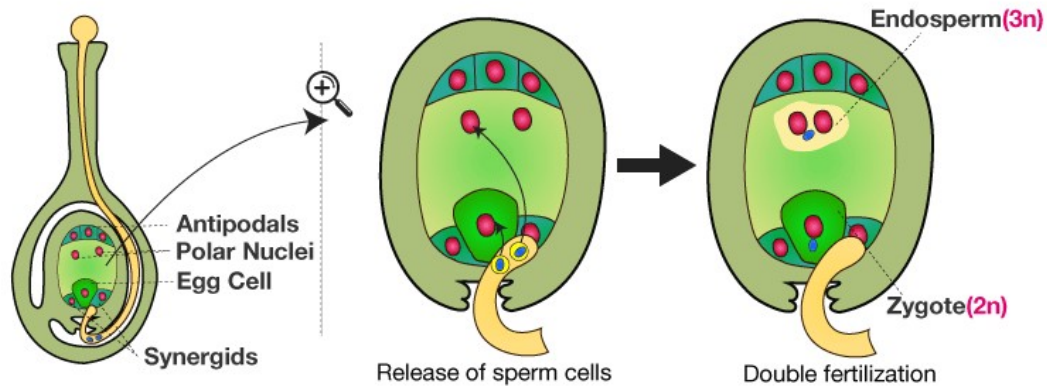
- ❖ While in some Legume taxa and some monocots style is hollow, where style, there is stylar canal runs from stigma to the base of style, provided with glandular cells that contain secretion fluids which help pollen tube reach ovule.
- ❖ Thus the growth of pollen tube is always directed towards the ovary which is unidirectional probably due to hydrotropic chemotropic and some mechanical factors.
- ❖ The course of the growing pollen tube is to find out the ovule and to reach the mature embryo sac.



- ❖ The growing pollen tube usually enters the ovule through the micropyle, but in some cases it enters through chalaza region and in some pollen tube enters by piercing the integuments.
- ❖ The entry of pollen tube through micropyle is described as porogamy, through chalaza is called chalazogamy and while through integuments is described as mesogamy.
- ❖ In all the three processes, finally the pollen tube, after its entry in the ovule, reaches the embryo sac, in the nucellus region of the ovule.

Double Fertilization and Triple Fusion

- ❖ On penetrating the nucellus, the pollen tube finally penetrates the embryo sac and reaches the region with egg apparatus.
- ❖ When pollen tube along with its gametes reaches to embryo sac at the micropylar end, the tube enters and reaches in cytoplasm of synergid.
- ❖ Once the tube penetrates one of the synergids, the synergid starts degeneration.
- ❖ The degeneration of synergid may be possibly due to the GA-3 concentration in the ovule as a consequence of pollen tube-pistil interaction (e.g. Cotton).
- ❖ This time, the pollen tube discharges its contents with a great force and then tube does not grow further in embryo sac.
- ❖ Then it penetrates the egg wall and discharge male gametes (sperms) along with tube nucleus between central cell and egg cell.
- ❖ Thus, pollen tube discharge consist two sperms, vegetative nucleus and fair amount of cytoplasm, later on this cytoplasm amount degenerates.
- ❖ The cytoplasm amount of synergid remain confined to micropylar end while the cytoplasm amount of pollen tube is restricted to the chalazal end which later on also get degenerated.
- ❖ Near the egg apparatus the tip of the pollen tube bursts and releases two male gametes in the embryo sac.
- ❖ One of the male gametes fuses with the egg in the egg apparatus.



- ❖ The other male gamete fuses with the diploid secondary nucleus or fusion nucleus, in the centre of the embryo sac.
- ❖ This process exhibiting the behaviour of two male gametes is called **double fertilization**.
- ❖ The process shows in angiosperms, both the male gametes in a male gametophyte are utilized and they fuse with two different nuclei in female gametophyte, exhibiting two reactions of fertilization.
- ❖ As result of first reaction of fertilization, in which first male gamete fuses with egg cell, the oospore is formed.
- ❖ The oospore is a diploid cell and it is the mother cell of the embryo.
- ❖ The second reaction of fertilization shows fusion between the second male gamete and the diploid secondary (fusion) nucleus.
- ❖ Since this second reaction involves three haploid nuclei (two during formation of secondary or fusion nucleus and one in the form of male gamete), the process is called **triple fusion**.
- ❖ This triple fusion is responsible for production of triploid nucleus. This triploid nucleus is the first nucleus of the endosperm.
- ❖ As the entire process shows two fertilization reactions and development of triploid endosperm nucleus, in addition to oospore, it is described as double fertilization and triple fusion.
- ❖ The process is the characteristic of angiosperms.
- ❖ During post fertilization changes within the ovule, the embryo and endosperm develop simultaneously.
- ❖ The oospore develops into embryo, while the endosperm nucleus (product of triple fusion) develops into endosperm.
- ❖ The other nuclei (synergids, antipodals) degenerate during embryo development.

Significance of Double Fertilization

- ❖ In angiosperms, the male gametophyte is with two male gametes and both are utilized during fertilization.
- ❖ In all other plant groups, during fertilization one male nucleus fuses with one female nucleus. In angiosperms, two male nuclei fuse with two different nuclei in female gametophyte (i. e. two female nuclei) so it is double fertilization.

- ❖ It is unique feature of angiosperms and considered as important character of the group.
- ❖ The process of double fertilization has great evolutionary significance.
- ❖ The process makes the provision of nutrition for the development of embryo from oospores.
- ❖ The triploid nucleus produced as a result of triple fusion is the first endosperm nucleus and it develops into endosperm.
- ❖ The endosperm is a specialized nutritive tissue and therefore, its main function is to supply nutrition to growing embryo. So the endosperm is the post fertilization product in angiosperm and its formation ensures the proper growth and development of the embryo.
- ❖ As this provision is made only by double fertilization, the process is very important in angiosperms. In no other plant group, such provision is made by fertilization, so it is the significance of double fertilization.