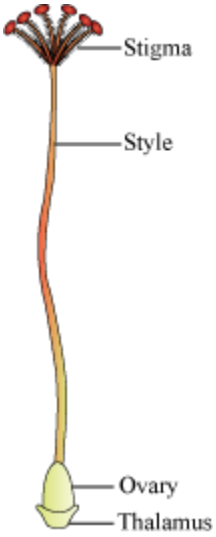
Pollination and Fertilisation

Gynoecium and Formation of Female Gametophyte

- The gynoecium represents the female reproductive part of a flower.
- It may be mono-carpellary (one pistil) or multi-carpellary (many pistils). In multi-carpellary, the pistils may be fused in one (syncarpous) or free (apocarpous).
- Each pistil consists of:
- **Stigma** − Receives the pollen grains
- **Style** − Elongated, slender part below the stigma
- **Ovary** − Bulged basal part containing the placenta, which is located inside the ovarian locule (cavity)
- The placenta contains the megasporangia or ovules.

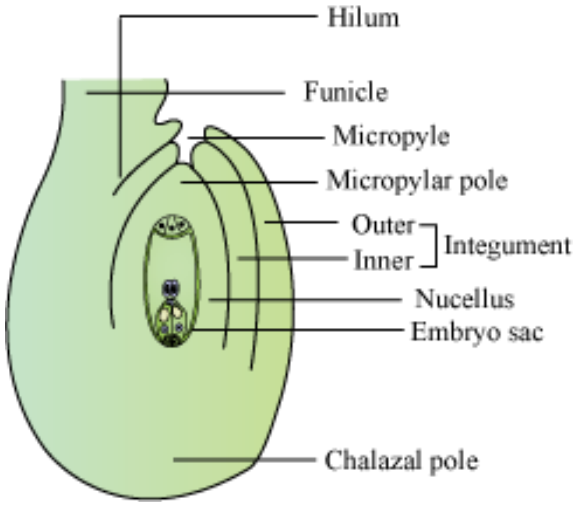


Megasporangium

- The ovule is attached to the placenta by the **funicle**. The junction of the ovule and the funicle is called **hilum**.
- Each ovule has one or two protective layers, called **integuments**, which cover the rest of the ovule, except for a small opening called **micropyle**.

- The **chalaza** lying on the opposite side of the micropyle end represents the basal part of the ovule.

- **Nucellus** is present within the integuments and contains reserved food. The **embryo sac** or female gametophyte is located within the nucellus.



Megasporogenesis

- The **megaspore mother cell** (MMC) gets converted into megaspores by the process of megasporogenesis.

- The MMC is large and contains a dense cytoplasm and a prominent nucleus. It undergoes meiosis to produce four megaspores.

Female Gametophyte

- In most flowering plants, only one megaspore is functional while the other three degenerate.

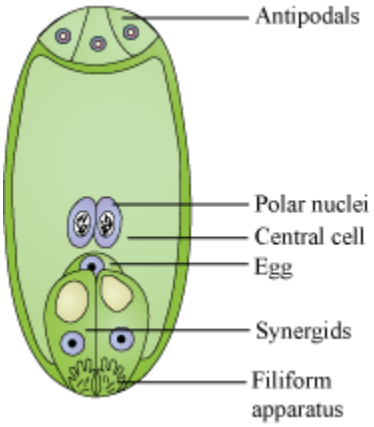
- The single functional megaspore develops into the female gametophyte. This kind of development is called monosporic development.

- The nucleus of the functional megaspore divides mitotically to form 2 nuclei, which move towards the opposite ends, forming a 2-nucleate embryo sac. Two more mitotic divisions ensue, leading to the formation of 4-nucleate and 8-nucleate embryo sacs.

- After the 8-nucleate stage, the cell walls are laid down and the typical female gametophyte (embryo sac) gets organised.

- Six of the 8-nuclei get surrounded by the cell wall and the remaining two, called **polar nuclei**, are situated below the egg apparatus in the large **central cell**.

- Three of the six cells are placed at the micropylar end and constitute the **egg apparatus** (2 **synergids** + 1 **egg cell**).
- The synergids have special thickenings at the micropylar end. These are together called the **filiform apparatus**. It helps in leading the pollen tubes into the synergids.
- Three cells are at the chalazal end, and are called **antipodal cells**.
- A typical angiosperm female gametophyte is 7-celled and 8-nucleated at maturity.



Self Pollination

Pollination

- It is the process of transfer of pollen grains from the anther to the stigma.
- Depending on the source of pollen, pollination can be divided as follows:
- **Autogamy** − It is the transfer of pollen grains from the anther to the stigma of the same flower. Autogamy requires the anther and the stigma to lie close. It also requires synchrony in the pollen release and stigma receptivity.

  Plants like *Viola*, *Oxalis*, etc., produce two kinds of flowers—**chasmogamous flowers** (with exposed anther and stigma) and **cleistogamous flowers** (which do not open at all and only autogamy occurs).
- **Geitonogamy** − It is the transfer of pollens from the anther of one flower to the stigma of another flower in the same plant. Genetically, it is similar to autogamy, but it requires pollinating agents.
- **Xenogamy** − It is the transfer of pollen grains from the anther to the stigma of a different plant. Pollination causes genetically different types of pollens to be brought to a plant.

Contrivances for Self-Pollination

Contrivances are the characteristics shown by a flower or adaptations in a flower to ensure the process of self pollination.

Flowers show following contrivances for self pollination.

- **Homogamy** − The anther and stigma of the flower mature at same time. It occurs in wheat, rice and *Mirabilis*.
- **Cleistogamy** − In this the bisexual flowers do not open and remained closed, so that pollen grains pollinate the stigma of same flower. It occurs in *Commelina*.

Advantages of Self-Pollination

- Self-pollination ensures a plant, genetically identical to the parent plant. Hence, it ensures continuity of the race.
- Preservance of the parental characteristics is ensured.
- This is useful for the plants that do not produce pollens in large amounts.

Disadvantages of Self-Pollination

- New varieties cannot be obtained by this process.
- Since, the variety so formed is exactly identical to the parent. So genetic defects of the plant are not removed.
- Inbreeding depression results, i.e., the plant remains devoid of novel hybrid characters (hybrid vigour) seeds produced are smaller and weaker.

Out Breeding Devices

- Repeated self pollination leads to inbreeding depression.
- Plants have developed methods to prevent self pollination. Autogamy is prevented by following ways:
- Pollen release and stigma receptivity not coordinated
- Different positioning of the anther and the stigma
- Production of unisexual flowers

- Ways to prevent both autogamy and geitonogamy:
- Presence of male and female flowers on different plants, such that each plant is either male or female (dioecy).
- This mechanism is present in several species of papaya.

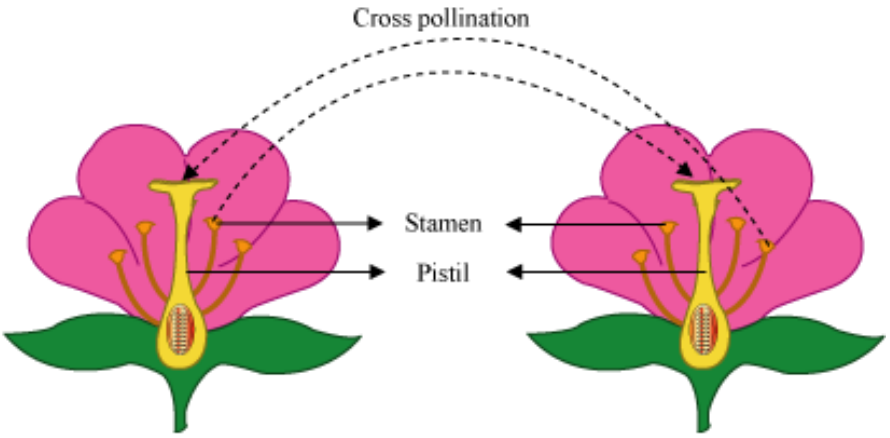
Pollen−Pistil Interactions

- Pollination does not always ensure the transfer of compatible pollens.
- Hence, the pistil has the ability to recognise the right type of pollen to promote post- pollination events.
- If the pollen is of the wrong type, the pistil prevents pollen germination.
- This interaction is mediated by chemical components of the pollen and the pistil.
- Pollen−pistil interaction is a dynamic process involving pollen recognition, followed by promotion or inhibition of the pollen.
- The pollen tube reaches the ovary and enters the ovule through the micropyle. Then, through the filiform apparatus, it reaches synergids. In this way, the pollen tube grows.

Cross Pollination

The transfer of pollen grains from anther of flower of a plant to the stigma of flower of another plant (of the same species) is called cross-pollination.

This may occur in unisexual and bisexual flowers both. Since two different flowers are involved, the new plant so formed is genetically different from parent plants.



Contrivances for Cross Pollination

- **Unisexuality** − When the flowers are unisexual, they will obviously undergo cross-pollination. This is a way how nature favours cross pollination.

- **Self-Sterility** − In this the pollen grains fallen on the stigma of same flower do not germinate, they germinate only on the stigma of other flowers; hence favour cross pollination.

  Apple, grape and rye are the examples of self-sterile flowers.

- **Dichogamy** − This condition is opposite to homogamy. Here stamens and carpels of bisexual flowers mature at different times. Thus, leaving no option than cross-pollination.

  Dichogamy is of two types

- Protogyny − When gynoecium develops earlier than anthers as in peepal.

- Protoandry − When androecium develops earlier than carpels as in pea, sunflower etc.

- **Herkogamy** − *Herkos* means barrier. When some sort of barrier develops between stamens and pistil of same flowers, and prevents self pollination. e.g., in pansy, a hood, covers the stigma and acts as a barrier for self pollination.

- **Heterostyly** − In this the plant bears flowers of different forms. One form has long stamens and short styles and other form has long style and short stamens. This ensures cross pollination. For e.g., primrose and oxalis.

Advantages of Cross Pollination

- Since the offsprings are genetically different, the desirable characteristics of parent plants are combined. The offsprings shows hybrid vigour.

- The seeds produced by cross pollination have much better germinating capacity.

- Sometimes, the diseased traits are suppressed.

Disadvantages of Cross Pollination

- The pollination is dependent on external agents, which may or may not be available.

- A lot of pollen is wasted, in course of transfer from one flower to another

Agents of Cross Pollination

Pollination by animals (Zoophily)

- Majority of flowering plants use butterflies, bees, wasps etc., for pollination.
- Most of the insect-pollinated flowers are large, colourful, fragrant, and contain nectar to attract the animal pollinators. These are called floral rewards. The pollination carried out by insects is called entomophily.
- Floral reward can be in the form of providing safe places to lay eggs (example: the tallest flower, *Amorphophallus*)
- The pollen grains are sticky and get stuck to the body of the pollinator.

Entomophily in Salvia

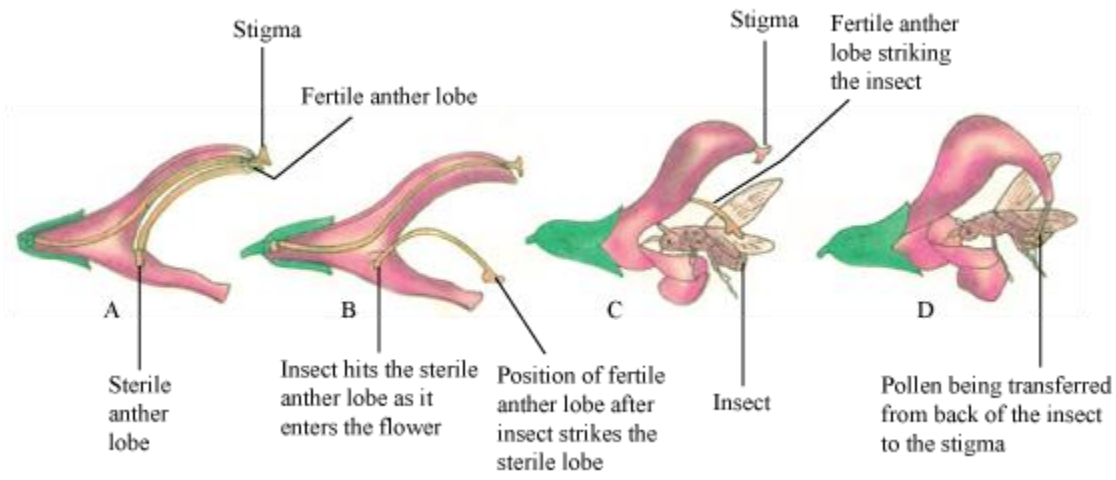
In *Salvia* pollination occurs by bees. *Salvia* has *blipped* corolla with two epipetalous stamens. The flowers are protoandrous i.e., with stamens maturing earlier than the carpel.

The stamen and style are hidden in upper lip and the lower lip serves as landing place for bees. The anther lobes are widely separated. The upper lobe is fertile while the lower one is sterile.

As the bee enters the flower it pushes the sterile lobe, the stamen bends down with a jerk to sprinkle pollen grain on the back of the bee.

When this bee visit another flower with stigma ripe and protruding out of the hood of the upper lip, the pollen laid back of insect brushes against the stigma and pollens stick to the stigma.

This mechanisms is called **‘lever mechanism**



Pollination by wind

- Pollination by wind is known as anemophily.
- It is the most common form of abiotic pollination.
- Plants possess well-exposed stamens and large, feathery stigma.
- Pollens should be light and non-sticky so that they can be carried easily by winds.
- Wind-pollinated flowers often have single ovule in the ovary and numerous flowers packed in an inflorescence.
- It is common in grasses, maize, rice, sugarcane, etc.

Anemophily in Maize

In maize, the male flowers are borne at the apex of the plant and female flowers at the base in the axil of leaf.

As the anther burst, pollen grains are blown by the wind and fall on the feathery stigma of neighbouring plant.

Pollination by water

- Pollination by water is called hydrophily.
- It is rare in flowering plants, except for some aquatic plants like *Vallisneria* and *Hydrilla*.
- In most water-pollinated plants, the pollen grains are long and ribbon-like, and are protected from wetting by mucilaginous covering.

- In a majority of water plants like water hyacinth and water lily, flowers emerge above the water level and are pollinated by insects.

Hydrophily in *Vallisneria*

Vallisneria is a submerged plant. Female flowers of *Vallisneria* have long coiling stalks which bring the flowers on the surface of water.

On ripening, the male flowers detach from the plant and float on the surface of water.

These free floating male flowers cluster around female flowers. At this stage, their anther burst and pollen grains are released and get attached to the stigma of female flowers.

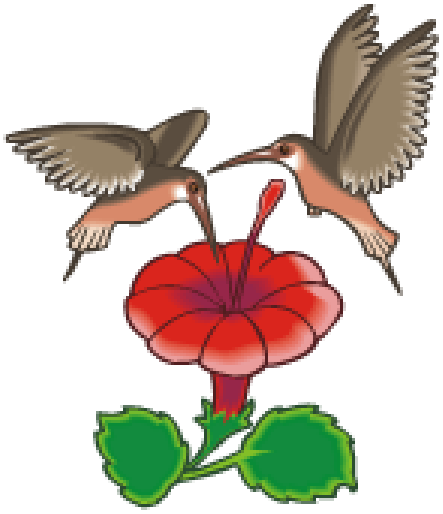
After pollination stalk of female flowers coils, thereby pulling the female flowers under water once again.

Pollination by bird

Birds also help in transfer of pollens from anther to stigma. The flowers of the plant that are pollinated by birds are brightly coloured and are very huge in size.

The huge size of the plant is to balance the weight of the bird with flower.

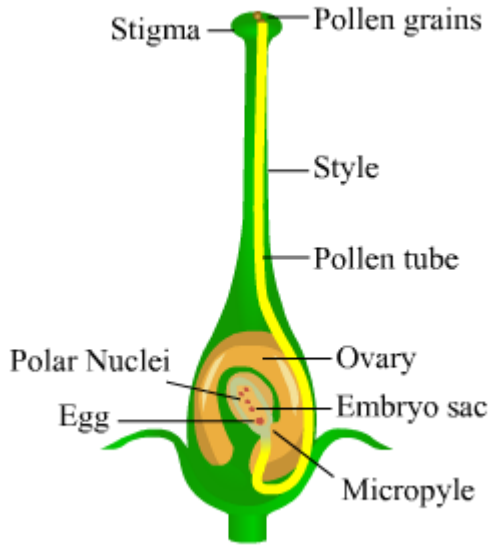
Also the flowers contain plenty of nectar to attract the birds. Pollination of flowering plants by birds is called **ornithophily.**



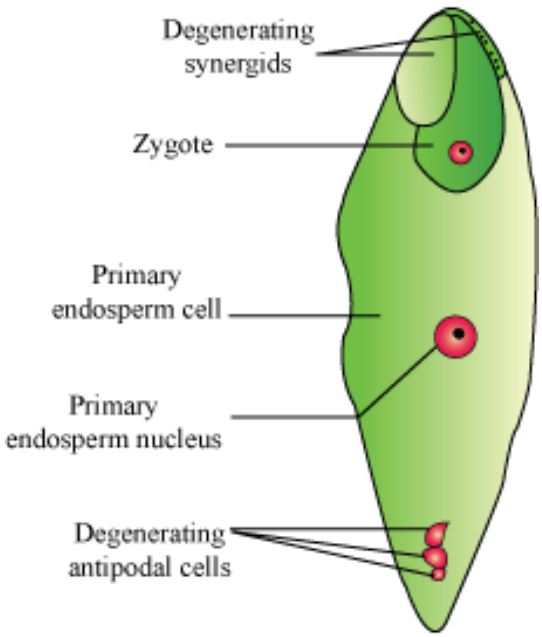
Pollination by bat is called **chiropterophily.**

Double Fertilisation

- When the pollen grains fall on the stigma, the pollen tube enters one of the synergids and releases two male gametes.
- One of the male gametes moves towards the egg cell and fuses with it to complete the **syngamy** to form the **zygote**.
- The other male gamete fuses with the two polar nuclei and forms triploid **primary endosperm nucleus (PEN)**. This is termed as **triple fusion**.
- Since two kinds of fusion—syngamy and triple fusion—take place, the process is known as double fertilisation, and is characteristic of flowering plants.
- After triple fusion, the central cell becomes the primary endosperm cell (PEC).
- The primary endosperm nucleus gives rise to the endosperm, while the zygote develops into the embryo.



Pollen Germination and Fertilisation



Embryo Sac After Fertilisation

Formation of Fruits and Seeds

We know that plants produce fruits.

When and why do plants produce fruits? Let us explore.

Seeds are present inside fruits. **Have you wondered why? Why do plants produce seeds inside the fruits?**

After fertilization i.e. after the fusion of male (pollen) and female (ovule) gametes:

- The **ovary gives rise to the fruit,** while the other structures of the flower fall down. **Thus, the fruit is a ripened ovary.**

- The **ovules present inside the ovary develop into a seed**. Seeds contain an embryo, which is protected by the seed coat.

Therefore, seeds when sown in the ground can give rise to new plants because they contain an embryo.

Seeds are present inside the fruit for protection. When fruits fall on the ground, seeds are protected and can grow into new plants. The fruit provides nourishment to the seeds.

A fruitful observation!

Visit a nearby market and observe different types of fruits available there. Observe the difference in the shape and size of fruits. Cut some fruits and observe the structures of the seed.

Do all seeds have a similar structure?

Do you know that seed of double coconut is the largest seed in the world?

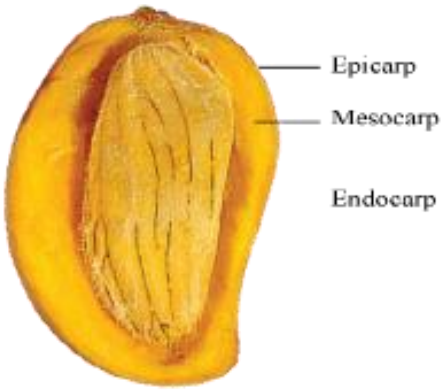
Fruit

A fruit consists of two portions − pericarp and seed.

Pericarp − Pericarp is the part that develops from the wall of the ovary. Pericarp may be thick or thin. It consists of three portions:

- Epicarp − The outer and leathery part of the fruit is called epicarp. It is usually not eaten.
- Mesocarp − It constitutes the sweet, fleshy part that is usually eaten by us.
- Endocarp − It is the innermost hard layer that contains the seed. You all must have noticed a white seed present inside the thin endocarp of an unripe mango.

The nature and presence of the three parts may vary for different fruits. In fact, in some plants, pericarp is not at all differentiated into three parts.



Functions of a fruit

- It protects the seeds from animals and harsh weather conditions.
- It helps in seed dispersal. We will learn more about seed dispersal later in this chapter.
- It stores food material.

Seed

Seeds are the mature ovules. Seeds vary greatly in their appearance and form.

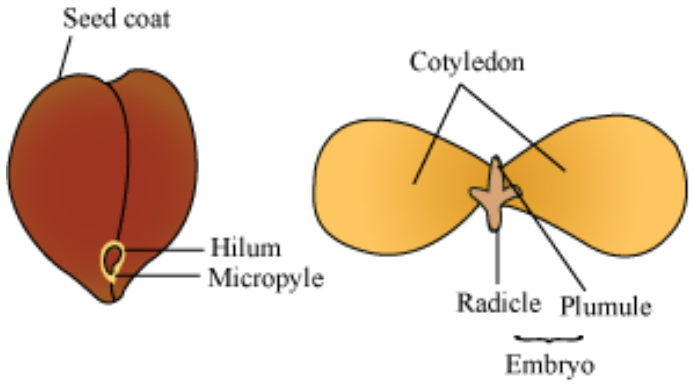
The outer part of the seed is called the **seed coat**. It is a hard outer covering consisting of two layers: outer exposed, hard layer, called **testa**, and inner thin, membranous layer, called **tegmen**. The purpose of seed coat is to protect the seed from insects or bacteria and from any physical damage.

On the lower end of the concave side of seed is a scar, called **hilum**. It actually represents the place where seed was attached to the ovary wall. Just above the hilum is a small pore, called **micropyle**. It helps in absorption of water during seed germination and in exchanging gases through diffusion.

On removing the seed coat, we will observe the following parts:

- **Cotyledons** − Cotyledons may be one or two depending upon whether the seed is monocot or dicot.

- **Axis** − Axis is a short, curved structure to which cotyledons are attached. Axis consists of two parts, one of which develops into **plumule (future shoot)** and the other one develops into **radicle (future root)**.



Under proper conditions, seed germinates to form new plants.

The seeds that we use as a part of staple food diet can be distinguished into pulses, millets, cereals and grains

- **Pulses-** They are primarily seeds occurring in variable sizes and colours inside a type of fruit called pod. All pulses, like black gram, pea, lentil belong to the pea family- Leguminosae. They are rich source of proteins.

India is the largest producer and consumer of pulses.

- **Grains**- They are small, hard dry seeds with or without the fruit wall attached. Variety of grasses belonging to the family Poaeceae produce grains. Most of the grains are generally cereals like maize, rice, wheat, etc.

  Maize, rice, wheat, barley, oats and sorghum are the common grains that account for more than 85% of the total grain production in the world.

- **Millets**- They are coarse grains with high protein content but smaller seeds. For example jowar, bajra and ragi etc.