1 Reproduction in Lower and Higher Plants

Can you recall?

1. How do plants reproduce without seeds ?
2. How does vegetative propagation occur in nature ?

Reproduction is the production of young ones like parents. Reproduction is an essential process as it leads to continuation of species as well as to maintain the continuity of life. Each organism has its own particular method of reproduction. All these methods generally fall into two categories :

i. Asexual reproduction

ii. Sexual reproduction.

1.1 Asexual Reproduction :

Asexual reproduction does not involve fusion of two compatible gametes or sex cells. It is the process resulting in the production of genetically identical progeny from a single organism and inherits the genes of the parent. Such morphologically and genetically identical individuals are called **clones**. Organisms choose to reproduce asexually by different modes or ways:

i. **Fragmentation :** Multicellular organisms can break into fragments due to one or the other reasons. e.g. *Spirogyra*. These fragments grow into new individuals.

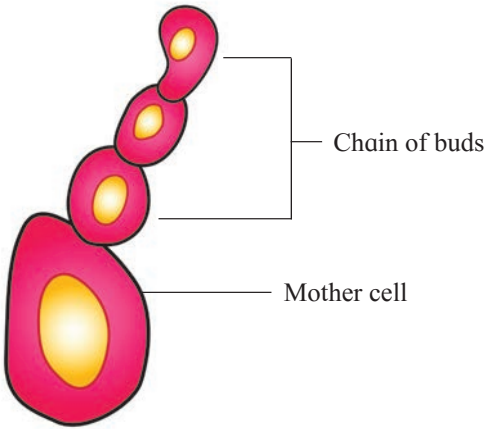


Fig. 1.1 : Budding in Yeast

ii. **Budding :** It is the most common method of asexual reproduction in unicellular Yeast. Usually it takes place during favourable conditions by producing one or more outgrowths (buds). These buds on seperation develop into new individual.

iii. **Spore formation :** In *Chlamydomonas* asexual reproduction occurs by flagellated, motile zoospores which can grow independently into new individuals.

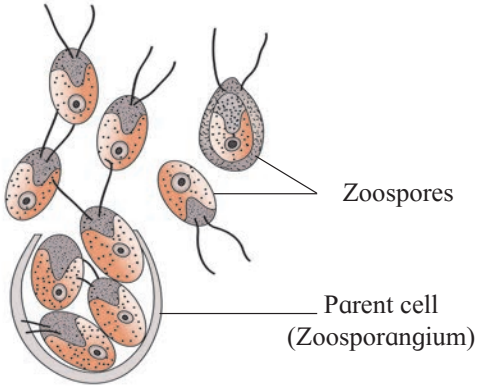


Fig. 1.2 : Zoospores in *Chlamydomonas*

Other methods of asexual reproduction include - **Binary fission** which occurs in *Amoeba*, *Paramoecium*; **Conidia formation** in *Penicillium* and **Gemmules formation** in Sponges.

Activity :

Sprinkle a small spoonful of yeast over a warm water and then add sugar. Cover it and wait for 10 minutes. Yeast becomes bubbly over the water proving that it is still active.

Can you recall?

The capacity to reproduce by vegetative propagation :

- Root - Sweet potato, *Asparagus*, *Dahlia*.
- Leaf - *Bryophyllum*, *Kalanchoe*, *Begonia*, etc.
- Stem - rhizome (turmeric), tubers (potato), bulbs (onion), etc.
- How does vegetative propagation occur in nature?

Vegetative Reproduction :

Plants reproduce asexually through their vegetative parts. Hence, the new plants formed are genetically identical to their parents.

There are also few methods which would not occur naturally in the plants. Agriculture and horticulture exploit vegetative reproduction in order to multiply fresh stocks of plants. Artificial methods are used to propagate desired varieties according to human requirements. The various methods are as follows :

a. Cutting :

The small piece of any vegetative part of a plant having one or more buds is used for propagation *viz*. Stem cutting - e.g. Rose, *Bougainvillea*; leaf cutting - e.g. *Sansvieria*; root cutting e.g. Blackberry.

b. Grafting :

Here parts of two plants are joined in such a way that they grow as one plant. In this method, part of the stem containing more than one bud (**Scion**) is joined onto a rooted plant called **stock**, is called grafting. Whereas budding is also called **bud grafting** in which only one bud is joined on the stock, e.g. Apple, Pear, Rose, etc.

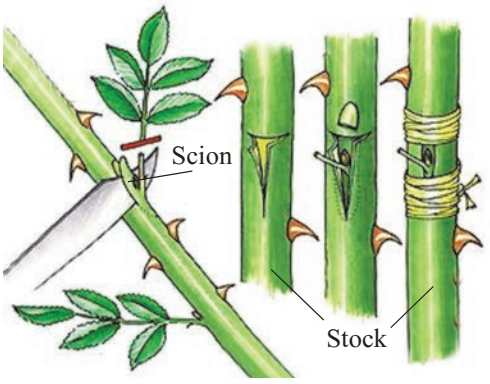


Fig. 1.3 : Grafting in Rose

c. Tissue culture : It is a method by which a small amount of plant tissue is carefully grown to give many plant lets. Micropropagation method is also used now a days.

Do you know ?

Why does gardner choose to propagate plants asexually?

1.2 Sexual Reproduction :

It involves fusion of two compatible gametes or sex cells. All organisms reach to the maturity in their life before they can reproduce sexually. In plants, the end of juvenile or vegetative phase marks the begining of the reproductive phase and can be seen easily in the higher plants at the time of flowering.

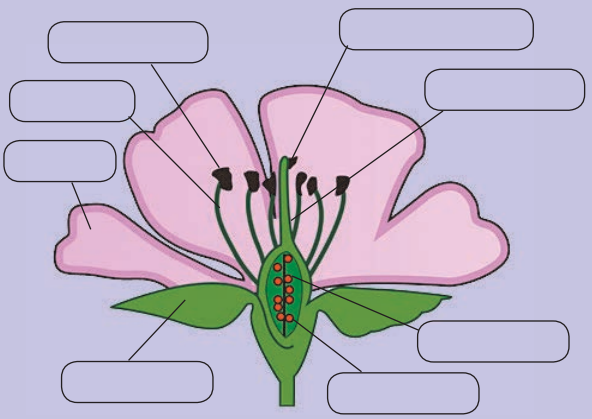
The flower is specialized reproductive structure of a plant in which sexual reproduction takes place. The function of flower is to produce haploid gametes and to ensure that fertilization will take place. Typical flower consists of four different whorls viz. calyx, corolla androecium and gynoecium.

Sexual reproduction involves two major events viz. meiosis and fusion of gametes to form diploid zygote and the production of genetically dissimilar offsprings. Variations are useful from the point of view of the survival and the evolution of species, over the time.

Sexual reproduction is characterised by fusion of the male and female gametes (fertilization), the formation of zygote and embryogenesis. Sequential events that occur in sexual reproduction are grouped into three distinct stages *viz*, Pre-fertilization, Fertilization and the Post-fertilization.

Activity :

Label the parts of flower in the given diagram :



Always Remember

Diploid sporophyte is the predominant plant body in all angiosperms, where meiosis takes place to produce haploid spores that form gametophyte. Gametophytes are considerably reduced and develop within the flower. They produce gametes.

The male reproductive whorl of flower is called **androecium**. Individual member of androecium, is called **stamen**. Stamen consists of filament, connective and anther.

Structure of Anther :

An immature stage of anther is represented by group of parenchymatous tissue surrounded by single layered epidermis. Anther is generally dithecous (having two lobes) and tetrasporongiate. Each monothecous anther contains two **pollen sacs**. In dithecous anther four pollen sacs are present. Therefore, it is **tetrasporongiate**. The heterogenesity (differenciation) arises when some hypodermal cells get transformed into **archesporial cells**.

T. S. of Anther :

The archesporial cell divides into an inner sporogenous cell and outer primary parietal cell. Sporogenous cell forms sporogenous tissue. Each cell of sporogenous tissue is capable of giving rise to a microspore tetrad. Parietal cell undergoes divisions to form anther wall layers. The wall of mature anther consists of four layers. **Epidermis** is the outermost protective layer made up of tabular (flattened) cells. **Endothecium** is sub-epidermal layer made up of radially elongated cells with fibrous thickenings. Inner to endothecium is **middle layer** made up of thin walled cells (1-2 layered), which may disintegrate in mature anther. **Tapetum** is the inner most nutritive layer of anther wall. It immediately encloses the sporogenous tissue (microspore mother cells).

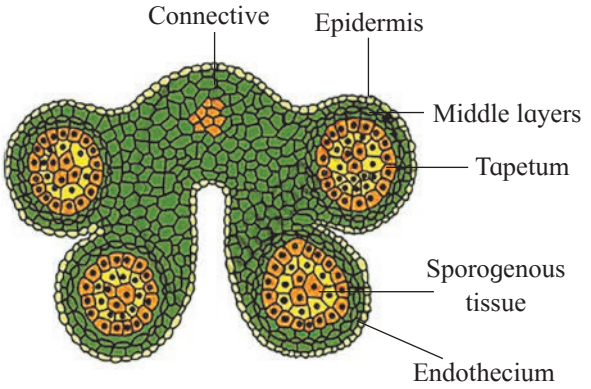


Fig. 1.4 : (a) T. S. of anther

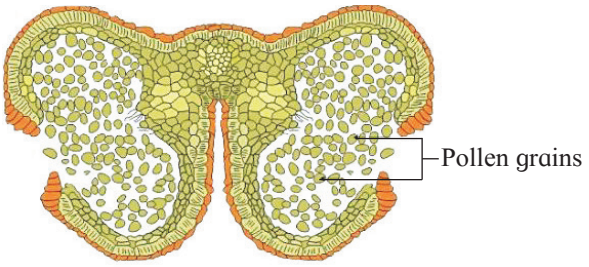


Fig. 1.4 : (b) Dehisced anther

1.3 Microsporogenesis :

Each microspore mother cell divides meiotically to form tetrad of haploid microspores (**pollen grains**).

Structure of microspore :

Typical pollen grain is a non-motile, haploid, unicellular body with single nucleus. It is surrounded by a two layered wall called **sporoderm**. The outer layer **exine** is thick and made up of complex, non-biodegradable, substance called **sporopollenin**. It may be smooth or with a sculptured pattern (characteristic of the species). It is resistant to chemicals. At some places exine is very thin showing thin areas known as **germ-pores**. These are meant for the growth of emerging pollen tube during germination of pollen grain. The inner wall layer, **intine** consists of cellulose and pectin.

Find out

Why pollen grains can remain well preserved as fossil?

Always Remember

- Pollen viability (viability is the functional ablity of pollen grain to germinate to develop male gametophyte) depends upon environmental conditions of temperature and humidity. It is 30 minutes in rice and wheat. But in some members of family Solanaceae, Rosaceae, Leguminosae, it lasts even for months.

Development of male gametophyte :

Pollen grain marks the begining of male gametophyte. It undergoes first mitotic division to produce bigger, naked **vegetative cell** and small, thin walled **generative cell**. The vegetative cell is rich in food and having irregular shaped nucleus. The generative cell floats in the cytoplasm of vegetative cell.

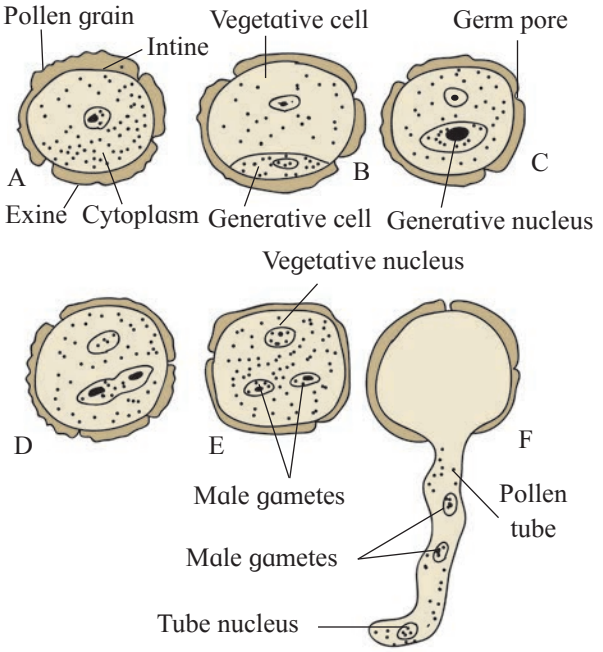


Fig. 1.5 : Development of male gametophyte

The second mitotic division is concerned with generative cell only and gives rise to two non-motile male gametes. The mitotic division of generative cell takes place either in pollen grain or in the pollen tube. The pollen grains are shed from the anther, at this two- celled stage in most of the angiosperms.

Female reproductive whorl of flower is **gynoecium** (Pistil). Individual member of gynoecium is called **carpel** (megasporophyll). A flower with many, free carpels is called **apocarpous** (e.g. *Michelia*). A **syncarpous** flower is one that has many carpels fused together (e.g. Brinjal). Typical carpel has three parts viz, ovary, style and stigma. The number of ovules in the ovary varies e.g. paddy, wheat and mango are **uniovulate** whereas tomato and lady's finger are **multiovulate**.

1.4 Structure of Anatropous ovule :

Each ovule develops inside the ovary and is attached to the **placenta** by a small stalk called **funiculus**. The place of attachment of funiculus with the main body of ovule, is called **hilum**. In angiosperms, the most common type of ovule is **anatropous** in which micropyle is directed downwards and is present adjacent to the funiculus (funicle). The ovule consists of central parenchymatous tissue, the **nucellus** which is surrounded usually by two protective coverings called **integuments** viz. Outer and an inner integument.

A narrow opening at the apex of the ovule is called **micropyle**. Chalaza is the base of ovule directly opposite to micropyle. **Embryo sac** (female gametophyte) is oval multicellular structure embedded in the nucellus.

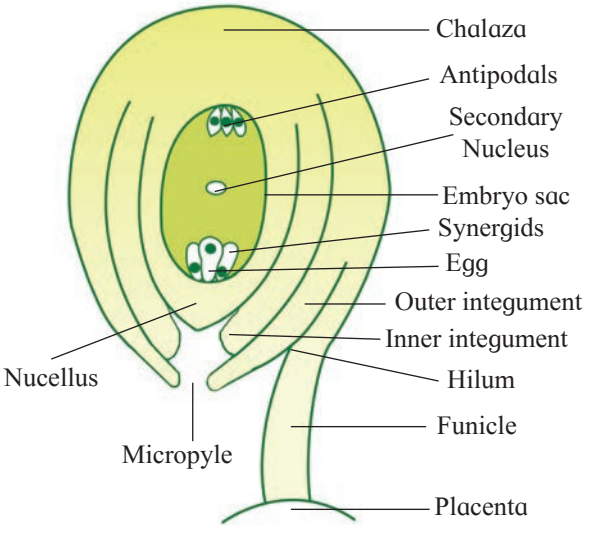


Fig. 1.6 : Anatropous Ovule

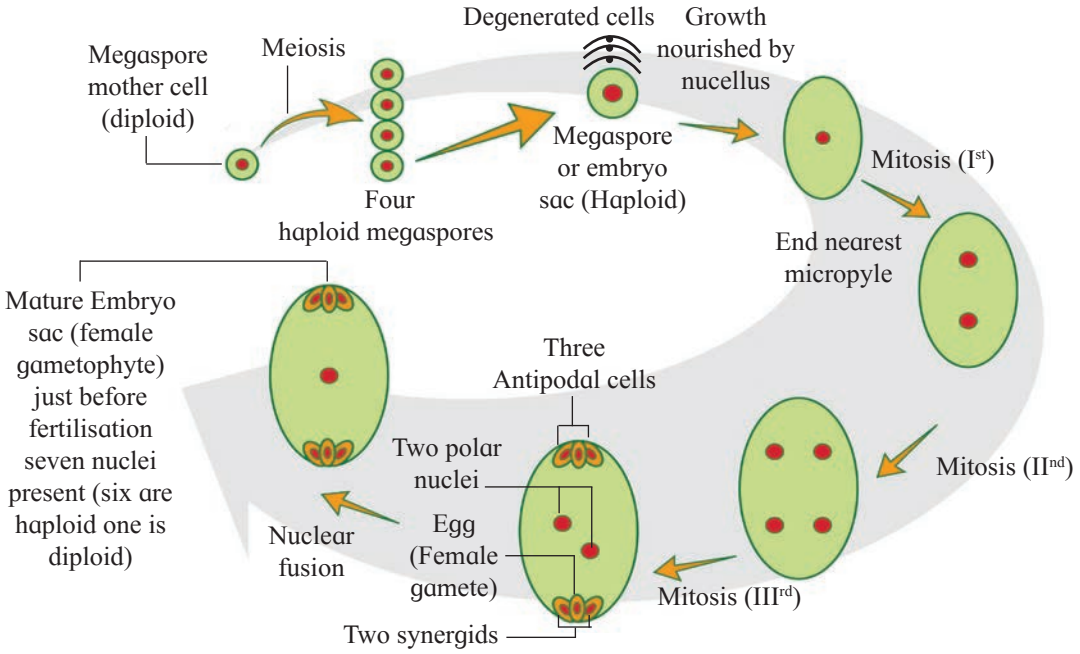


Fig. 1.7 : Development of female gametophyte

1.5 Megasporogenesis :

It is the process of formation of haploid megaspores from diploid **megaspore mother cell** (MMC). Megaspore mother cell becomes distinguished in the nucellus, more or less in the centre but towards micropylar end of ovule.

Development of female gametophyte :

Megaspore mother cell undergoes meiosis to form linear tetrad of haploid cells i.e. megaspore. Upper three megaspores abort and lowest one towards centre of nucellus remains functional. It acts as the first cell of female gametophyte. Generally one megaspore towards centre is functional megaspore. It is infact the first cell of female gametophyte. It undergoes three successive, free nuclear **mitotic** divisions. Thus total eight nuclei are formed, four of which are located at each pole. One nucleus from each pole migrates towards the centre and are called **polar nuclei**. Three nuclei towards micropylar end constitute **egg apparatus**. It consists of large central, haploid egg cell and two supporting haploid synergid cells. Synergid shows hair like projections called **filiform apparatus**, which guide the pollen tube towards the egg.

Antipodal cells are group of three cells present at the chalazal end. The two haploid polar nuclei of large central cell fuse to form diploid **secondary nucleus** or **definitive nucleus,** just prior to fertilization. This seven-celled and eight nucleated structure is called an **embryo sac**. This method of embryo sac development from a single megaspore is described as **monosporic development**. In angiosperms, the development of female gametophyte is endosporous i.e. within the megaspore. Female gametophyte is colourless, endosporic and is concealed in the ovule enclosed by ovary.

1.6 Pollination :

Pollen grains being non motile, angiosperms have evolved the strategy to use abiotic agents (wind, water) and biotic agents (birds, insects, snails) to their flowers, feeding the visitors and exploiting their mobility for pollination and also seed dispersal. Pollen grains are non-motile and they are usually carried from flower to flower by means of external agents. Pollination is the transfer of pollen grains from anther to the stigma of the flower. It is the pre-requisite for fertilization because both the male and female gametes are non-motile. Moreover gametes are produced at two different sites.

Self pollination is a type of pollination which occurs in a single flower or two flowers on a single plant. It results in inbreeding or selfing. In contrast cross pollination is the transfer of pollen grains from the anther of one flower to the stigma of another flower of different plants of same species. Pollination can be further divided into three types on the basis of source of pollination.

a. Autogamy (self pollination) :

It is a type of pollination in which bisexual flower is pollinated by its own pollen grains. Offsprings are genetically identical to their parents e.g. pea.

Always Remember

- Flowers which use autogamy consist of several adaptations in the structure of a flower to facilitate this process. It occurs without external pollinating agents.
- When flower opens to expose its sex organs, it is called **Chasmogamous**.
- The contrivances (a condition that leads to) favour self pollination are- Bisexuality, Homogamy and Cleistogamy.
- Homogamy : When anther and stigma of a flower become mature at the same time, called **homogamy**.
- Some flowers are self pollinated even before the opening of flower. Such condition is called **cleistogamy**. Underground flowers in some plants which exhibit cleistogamy are never opened e.g. *Commelina benghalensis*.
- Plants like *Viola*, *Commelina* can produce both chasmogamous and cleistogamous flowers on the same plant.

Think about it

Why do some plants have both chasmogamous and cleistogamous flowers ?

b. Geitonogamy :

It is the transfer of pollen grain to a stigma of a different flower produced on the same plant. It is functionally similar to cross pollination as it involves pollinating agents, but it cannot bring about genetic variations and is only of ecological significance e.g. *Cucurbita maxima*. It is similar to antogamy as pollen grains come from same plant.

c. Xenogamy (cross polination/ out breeding) :

It is a type of cross pollination when pollen grain of one flower is deposited on the stigma of a flower of different plant belonging to same species, with the help of pollinating agency. It generates genetically varied offsprings.

Majority of flowering plants depend on the transfer of pollen grains. Virtually all seed plants need to be pollinated. Most of the food and fibre crops grown throughout the world, depend upon pollinators for reproduction.

The agents responsible for pollination have been grouped into two main categories :

A. Abiotic agents

B. Biotic agents

A. Abiotic Agents : These are non-living agents which include wind and water.

1. Pollination by wind (Anemophily) :

Most of the important crop plants are wind pollinated. These includes wheat, rice, corn, rye, barley and oats. Palms are also wind pollinated.

Adaptations in anemophilous flowers :

- The flowers are small, inconspicuous, colourless, without nectar and fragrance (odour).
- The pollen grains are light in weight, dry and produced in large numbers to increase chances of pollination considering wastage of pollengrains.
- Stigma is feathery to trap pollens carried by wind currents.

- Stamens are exserted with long filaments and versatile anthers.
- Stamens and stigmas are exposed to air currents.

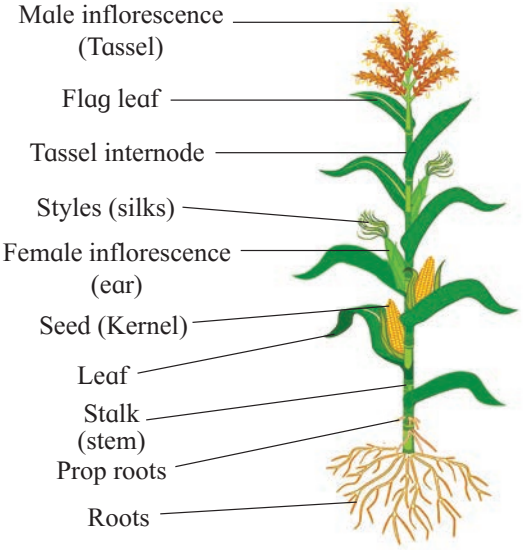


Fig. 1.8 : Pollination by wind (Maize)

Always Remember

The pollens of wind pollinated plants are most frequently associated with symptoms of hayfever among people those are sensitive to pollens. It is caused by hypersensitivity to pollen.

2. Pollination by water (Hydrophily) :

Found only in some 30 genera of aquatic monocots. E.g. *Vallisneria*, *Zostera*, *Ceratophyllum* etc.

Adaptations in hydrophilous flowers :

- Flowers are small and inconspicuous.
- Perianth and other floral parts are unwettable.
- Pollen grains are long and unwettable due to presence of mucilage.
- Nectar and fragrance are lacking in flowers.

Hydrophily is of two types -

Hypohydrophily : Pollination occurs below the surface of water. Here the pollen grains are heavier than water, sink down and caught by stigmas of female flowers, e.g. In *Zostera* (sea grass) the pollen grains are long, ribbon like and without exine.

Epihydrophily : The pollen grains float on the water surface and reach the stigma of female flower. e.g. *Vallisneria* is a submerged dioecious, fresh water aquatic plant in which female flowers reach the water surface temporarily to ensure pollination and male flowers float on the surface of water.

- Specific gravity of pollen grain is equal to that of water. That is why they float on surface of water.
- Some aquatic plants are anemophilous e.g. *Potamogeton*, *Halogaris*, etc.
- Some aquatic plants are entomophilous e.g. Lotus, water hyacinth, waterlily, etc.

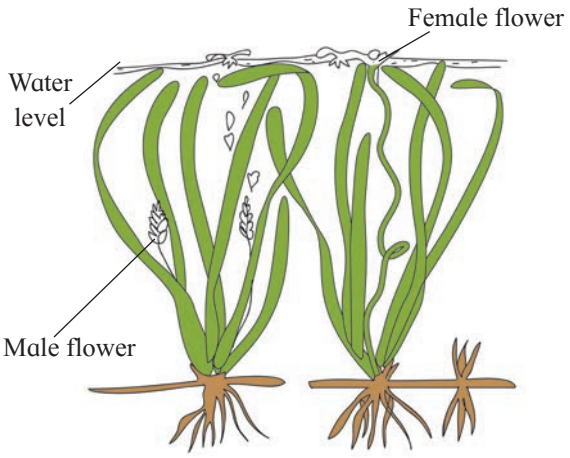


Fig. 1.9 : Male and female plant *Vallisneria*

B. Biotic Agents : It includes living agents. About 80% of plants require the help of other living, moving creatures such as insects, birds, bats, snails to transfer their pollens from one flower to another. These also sustain our ecosystems and produce natural resources by helping plants to reproduce.

1. Pollination by insects (Entomophily) :

It occurs in Rose, Jasmine, *Cestrum*, etc.

Adaptations in entomophilous flowers :

- They are large, showy and often brightly coloured.
- The flowers produce sweet odour (smell) and have nectar glands.

- The stigma is rough due to presence of hair or is sticky due to mucilaginous secretion.
- The pollen grains are spiny and surrounded by a yellow sticky substance called pollen-kit.
- Some plants have special adaptations for the insect visitor to help in cross pollination, e.g. lever mechanism or turn-pipe mechanism in *Salvia*.

Do you know ?

In biotic pollination, plants are adapted to encourage the specific pollinators they need. They are said to have developed pollination contrivance. Plants and pollinators have co-evolved physical characteristics that make them to interact successfully. Such characteristics are considered pollination syndromes.

Fig. 1.10 : Lever mechanism in *Salvia*

Think about it

You may see bumblebee early in the year as they try to find a suitable place to establish a nest and rear a colony. If you find a bumblebee nest please leave it alone. Their nest lasts only for a season. Educate the world about the need to help the bees.

2. Pollination by birds (Ornithophily) :

Only a few types of birds are specialised for pollination. They usually have small size and long beaks e.g. Sun birds and humming birds. Some ornithophilous plants are *Bombax*, *Callistemon* (Bottle Brush), *Butea*, etc.

Fig. 1.11 : Ornithophily

Adaptations in ornithophilous flowers :

- Flowers are usually brightly coloured, large and showy.
- They secrete profuse, dilute nectar.
- Pollen grains are sticky and spiny.
- Flowers are generally without fragrance, as birds have poor sense of smell.

3. Pollination by Bats (Chiropteryphily) :

Bats can transport pollens over long distance, some times several kilometers.

Adaptations in Chiropterphilous flowers :

- Flowers are dull coloured with strong fragrance.
- They secrete abundant nectar.
- Flowers produce large amount of edible pollen grains, e.g. *Anthocephalous* (kadamb tree), *Adansonia* (Baobab tree), *Kigelia* (Sausage tree).

1.7 Outbreeding devices (contrivances):

Many plants have mechanisms that discourage or prevent self pollination. To promote cross pollination and increase genetic diversity, plants have evolved a wide variety of sexual strategies. Genetic diversity is an essential factor for evolution by natural selection. Continued self pollination results in the inbreeding depression.

Thus plants have developed many devices to encourage cross pollination. The examples of outbreeding devices are as follows:

Unisexuality :

In this case, the plant bears either male or female flowers. It is also called as **dioecism**. As flowers are unisexual, self pollination is