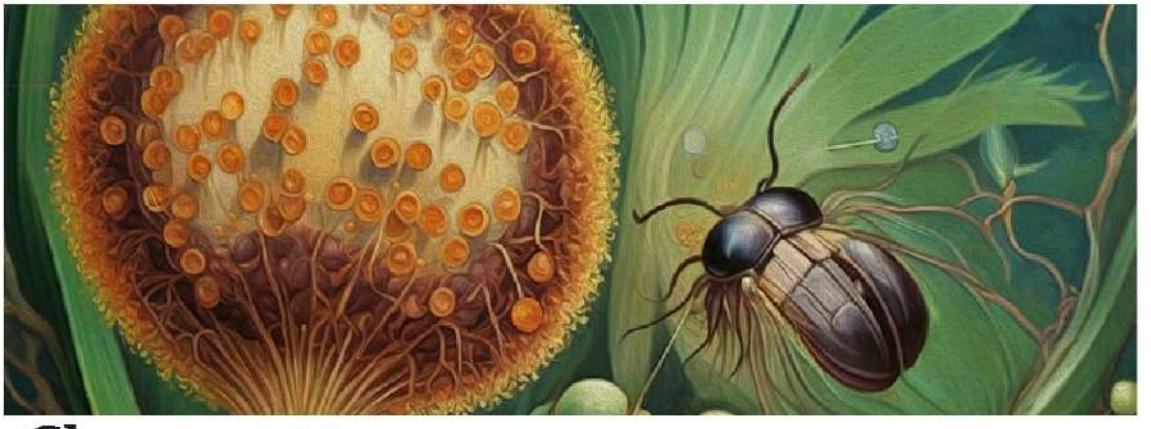


Chapter 10
REPRODUCTION IN PLANTS

After studying this chapter, students will be able to:

- Describe different types of asexual reproduction i.e. binary fission, budding, spore formation and vegetative propagation.
- Distinguish between vegetative propagation and artificial propagation.
- Explain vegetative propagation in plants (through stem, suckers and leaves).
- Describe the two methods of artificial vegetative propagation (stem cuttings and grafting).
- Explain sexual reproduction in Plants.

You know that reproduction is the process in which organism produce new organisms of their own kind. There are two main kinds of reproduction. The reproduction that does not involve the fusion of gametes is called **asexual reproduction**. The offspring produced by asexual reproduction are genetically identical to the parents. On the other hand, the reproduction that involves the fusion of male and female gametes is called **sexual reproduction**. In sexual reproduction, the offspring have variations among themselves and with the parents.

This chapter explores the methods of reproduction in plants, both asexual and sexual reproduction. We will study the vegetative and artificial propagation methods. Artificial propagation techniques like stem cuttings and grafting will also be discussed.

10.1 - Types of Asexual Reproduction

Some common methods of asexual reproduction in different organisms are given next.

1. Binary Fission

Binary fission means division in to two. It is the usual method of reproduction in **bacteria**. During binary fission, the bacterial DNA replicates and the daughter DNA molecules move to opposite sides. Then, the cell membrane pinches in. New cells wall is synthesized in the middle and so two identical daughter cells bacteria are produced.

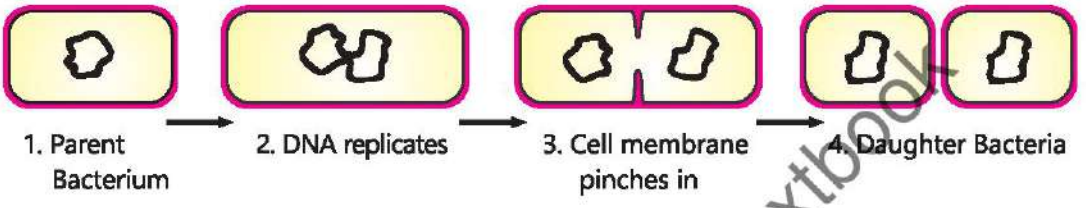


FIGURE 10.1: Binary fission in bacteria

Many **protists** (unicellular eukaryotes e.g. *Amoeba*, *Euglena* etc.) also reproduce by binary fission. In protists, the nucleus of parent organism divides into two. This is followed by the division of cytoplasm. So, two daughter protists are formed.

Some animals e.g. Planarians also reproduce asexually by binary fission.

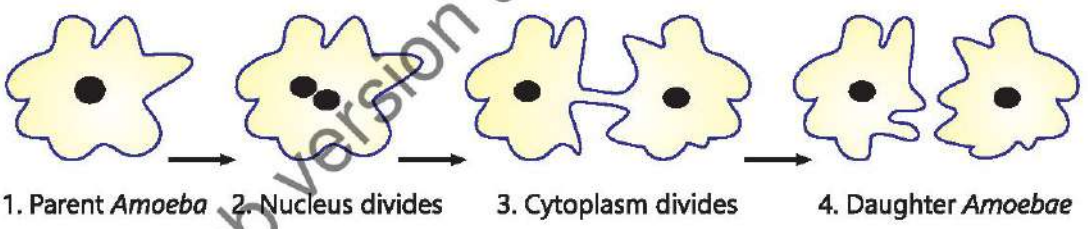


FIGURE 10.2: Binary fission in Amoeba

2. Budding

This method is very common in yeast (a unicellular fungus). During budding, a part of the parent organism grows out from its body. This part is called a **bud**. When the bud has grown big, it may separate from parent body or may remain attached.

Some animals e.g. hydra also reproduce asexually by budding.

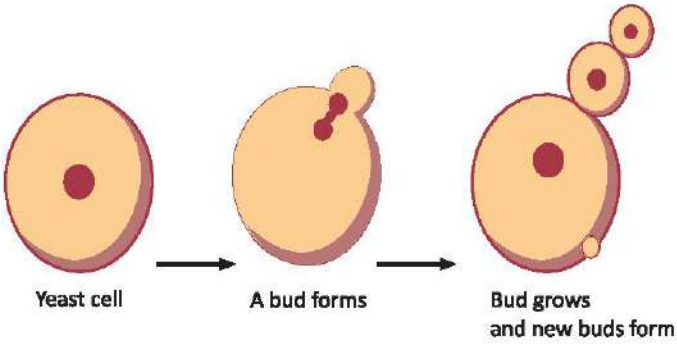


FIGURE 10.3: Budding in Yeast

3. Spore Formation

Spores are thick-walled asexual reproductive cells. Most fungi (e.g. *Rhizopus:* bread mold) produce spores in special sac-like structures called **sporangia** (*Singular:* sporangium). When spores are mature, the sporangium bursts and spores are released.

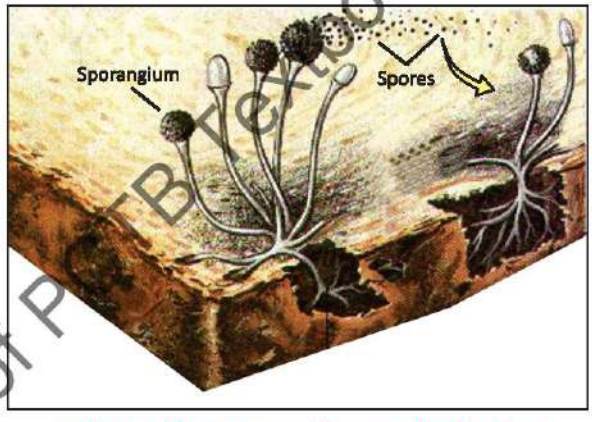


FIGURE 10.4: Asexual reproduction by spores (in Rhizopus)

Spores can tolerate unfavourable conditions due to their thick walls. When favourable conditions are available, the spores germinate to produce new fungus.

Some bacteria reproduce by forming **endospores** (spores produced inside the cell). They form endospores in unfavourable environmental conditions. Even if the original cell dies, the endospore survives. When conditions improve, the endospore grows into a new bacterium.

The improperly sterilized canned foods may contain endospores of bacteria. When endospores germinate, new bacteria make toxins.

4: Vegetative Propagation

It is a methods of asexual reproduction in plants. In this method, new plant is produced from the vegetative part (root, stem or leaf) of the parent plant.

Vegetative propagation takes much less time to produce new generation as compared to the sexual method. Secondly, the offspring are genetically identical to the parent plant. Vegetative propagation may be natural or artificial.

- Natural vegetative propagation is a process where plants reproduce on their own, using structures like stems, roots, or leaves.
- Artificial vegetative propagation means the processes in which humans use the vegetative parts of plants for their reproduction by methods like cuttings, grafting, or layering.

In the natural vegetative propagation, plants use the following vegetative parts for producing new plant.

(a)- Stem

The following types of stems take part in vegetative propagation in plants:

1. Stolon (runner): It is a horizontal stem that grows above the ground. A stolon has nodes where new leaves and roots grow. The leaves grow upwards and roots grow down. In this way, a new plant is formed at the node. Strawberry reproduces by using its stolon.

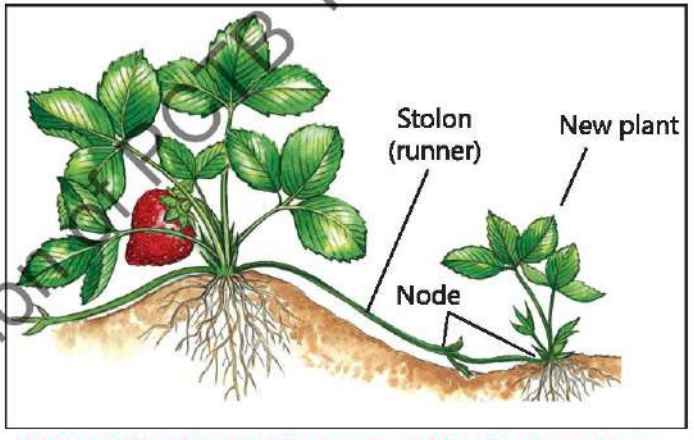


FIGURE 10.5: Vegetative propagation in strawberry (through runner)

2. Tuber: It is fleshy stem that grows underground. It has "eyes" which are actually its buds. Eyes can grow into new plants. Potatoes reproduce by tubers.

3. Rhizome: It is a horizontal stem that grows below the ground. It has nodes where new leaves and roots grow. In this way, a new plant grows from each node. Ferns, ginger, and sugar cane reproduce by using rhizome.

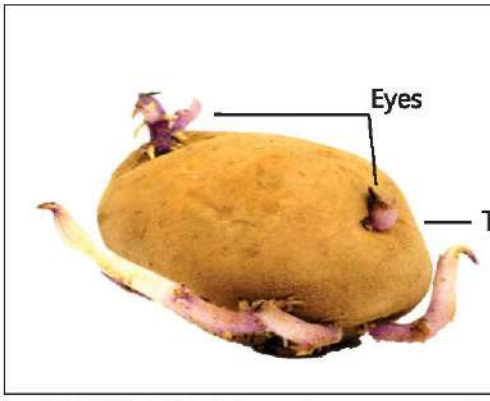


FIGURE 10.6: Vegetative propagation in potato (through tuber)

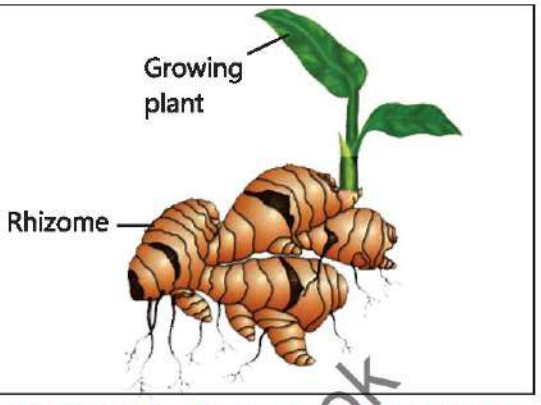


FIGURE 10.7: Vegetative propagation in ginger (through rhizome)

4. Bulb: It is a very short stem that grows underground. It has bud and fleshy leaves. Bulbs grows naturally to produce new plants. Tulips, onions and lilies reproduce by bulbs.

5. Corm: It resembles the bulb but does not have fleshy leaves. Almost all of a corm consists of stem, with a few brown non-functional leaves on the outside. Dasheen and garlic reproduce by corms.

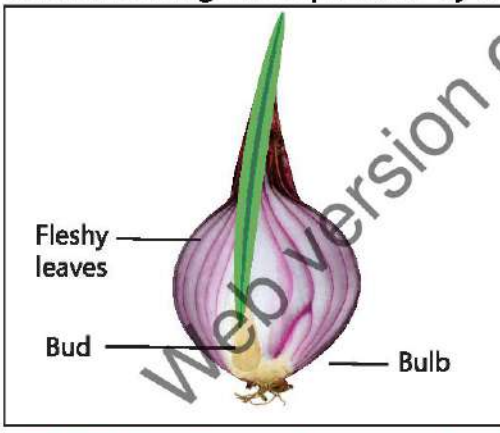


FIGURE 10.8: Vegetative propagation in onion (through bulb)

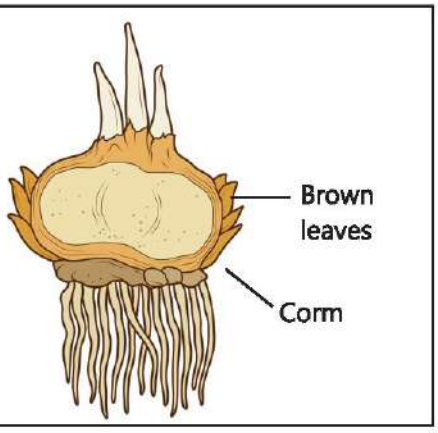


FIGURE 10.9: Vegetative propagation in garlic (through corm)

(b)- Suckers

Suckers are new shoots that emerge from the base of the parent plant or from its underground roots. These shoots grow into new plants while still attached to the parent. When suckers develop their own root system, they become independent. Examples are banana and raspberry plants.

(b)- Modified Leaves

The leaves of some plants (e.g. *Bryophyllum)* are modified for vegetative propagation. Such leaves have buds at their margins. When leaf falls on ground, the buds grow into new plants.

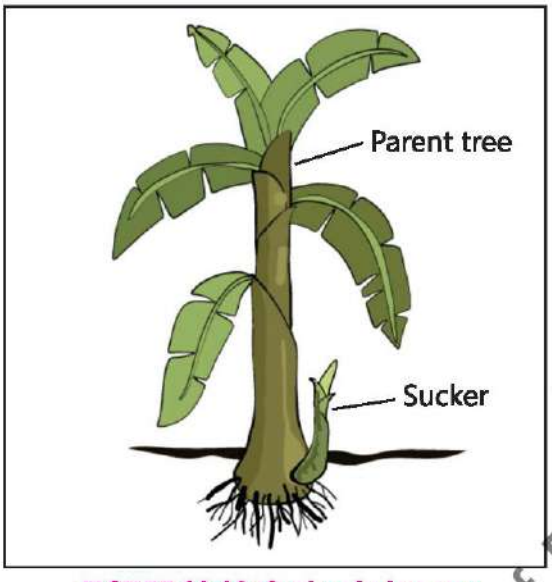


FIGURE 10.10: Sucker in banana

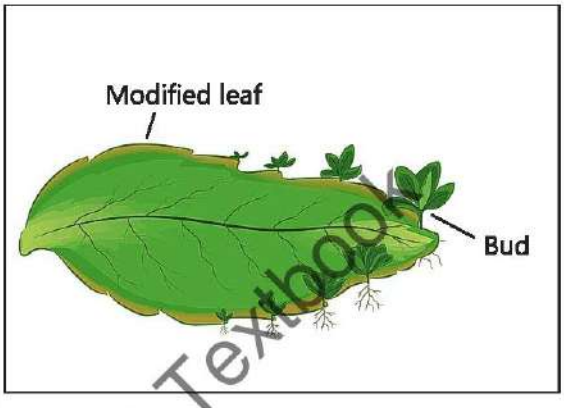


FIGURE 10.11: Modified leaf of bryophyllum

10.2- Artificial Propagation

Artificial propagation includes the methods in which humans produce new plants by using the vegetative parts of plants. It includes techniques such as cutting, grafting, or tissue culture. Artificial propagation is used to cultivate plants with desirable characteristics or to increase crop production. The following two are the most common methods of artificial propagation.

1. Cutting

In some plants, a piece of stem or a piece of root can form a new plant. Such a piece of stem or root that are cut from a plant and used to grow new plant is called **cutting.** Cuttings are widely used to propagate houseplants, ornamental trees and shrubs, and some fruit crops. Roses and grapevines are grown from stem cuttings. Sweet potato is grown from root cuttings.

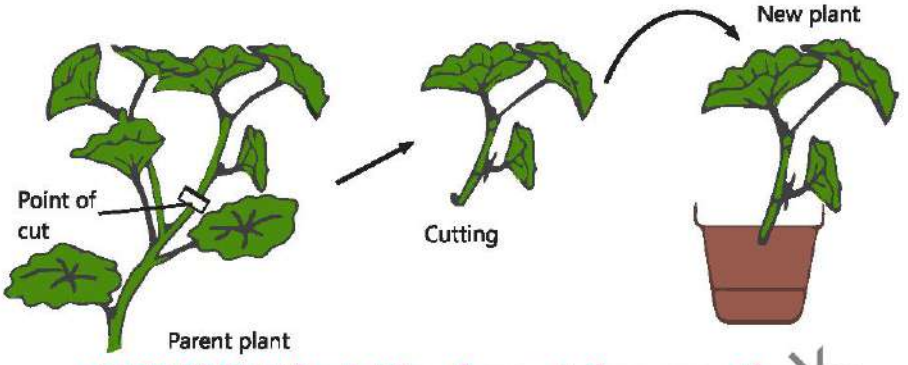


FIGURE 10.12: Using Cuttings for vegetative propagation

2. Grafting

Grafting is the joining of two or more plant parts of the same type to form a single plant. In grafting, a bud or small stem of one plant is attached to the roots or stems of a second plant. Grafting enables to combine the beneficial characteristics of two plants. This method is used to propagate almost all commercial fruit trees and (e.g. almond, plum, cherries etc.), many ornamental trees and shrubs.

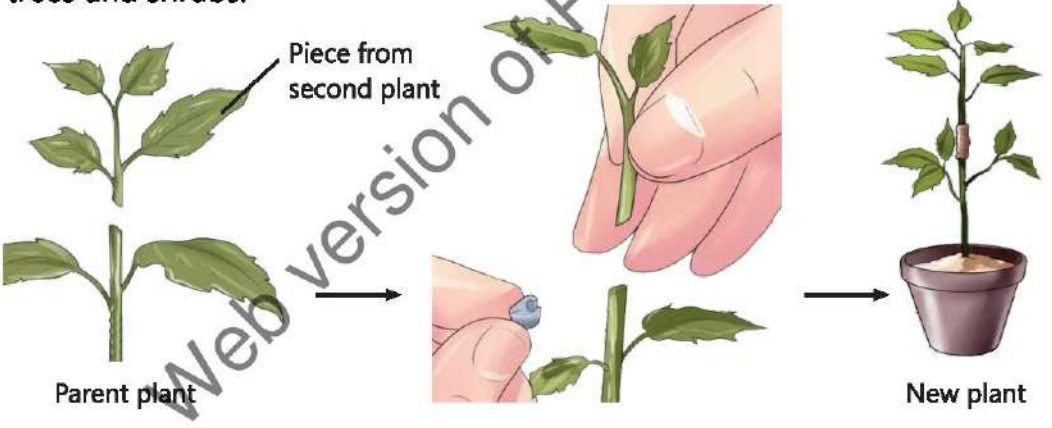


FIGURE 10.13: Grafting

Advantages and Disadvantages of Vegetative Propagation

Advantages: Vegetative propagation allows to produce many new plants in a short time. The new plants are exactly like the parent plant, so they all have the same good characteristics. This means useful qualities, like good fruit or strong growth, are passed on to the next generation.

Disadvantage: Plants produced through vegetative propagation do not have genetic differences. In other words, all the offspring are identical. Due to it, they are equally sensitive to environmental changes and prone to the same diseases or pests.

10.3- Sexual Reproduction in Plants

The major groups of plants have two type generations during sexual reproduction which come one after the other. These are sporophyte generation and gametophyte generation. The sporophyte generation produces spores which grow and make the new **gametophyte** generation. The gametophyte generation produces gametes which unite and make the new sporophyte generation. This phenomenon is called **alternation of generations**.

The sporophyte generation is diploid (2n) and produces haploid (1n) spores by meiosis. The spores develop into haploid gametophyte generation. The gametophyte produces haploid gametes by mitosis. The haploid gametes fuse to form diploid zygote, which develops into the next sporophyte stage.

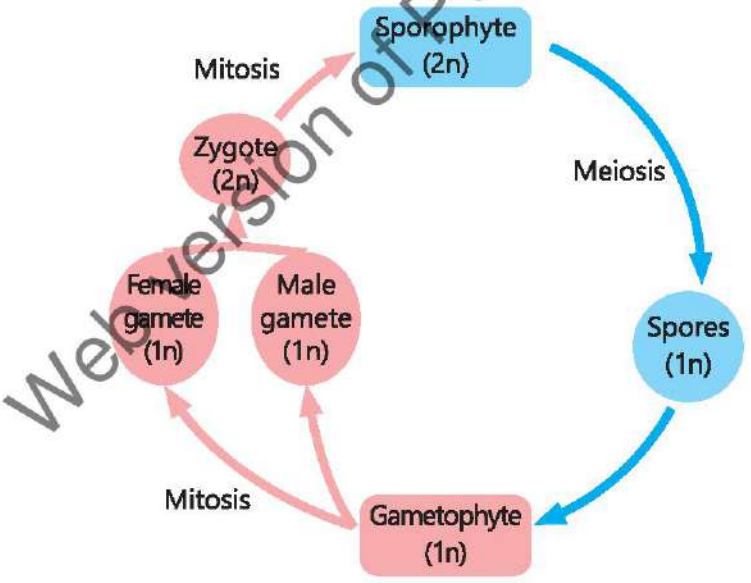


FIGURE 10.14: Alternation of generations in plants

Life Cycle of Angiosperms (Flowering Plants)

In angiosperms, flowers are the organs for sexual reproduction.

Parts of a Flower

The **receptacle** is the swollen tip of a flower stalk where all the floral parts (are attached. It serves as the base that supports the flower's structure.

Floral parts are in the form of the following four concentric whorls, or rings:

1. **Calyx:** It is the outermost whorl. It is made of green leaf-like **sepals.** Sepals protect the inner parts of a developing flower before it opens.
2. **Corolla:** It is the second whorl and made of **petals**. Most flowers have coloured petals.
3. **Androecium:** It is the third whorl and is made of male reproductive structures called **stamens**. Each stamen consists of an anther and a filament. Anther contains pollen sacs (microsporangia), which produce microspores. The stalk-like filament supports the anther.
4. **Gynoecium**: It is the innermost whorl made of the female reproductive structures called **carpels**. A carpel consists of three parts.
   i. The enlarged base of carpel is called ovary. It is the part where ovules are produced. Ovules produce megaspores during reproduction.
   ii. The stalk-like part attached to ovary is called style.
   iii. The tip of style is called stigma.

In some flowers, one or more carpels are fused to form a structure called **pistil.**

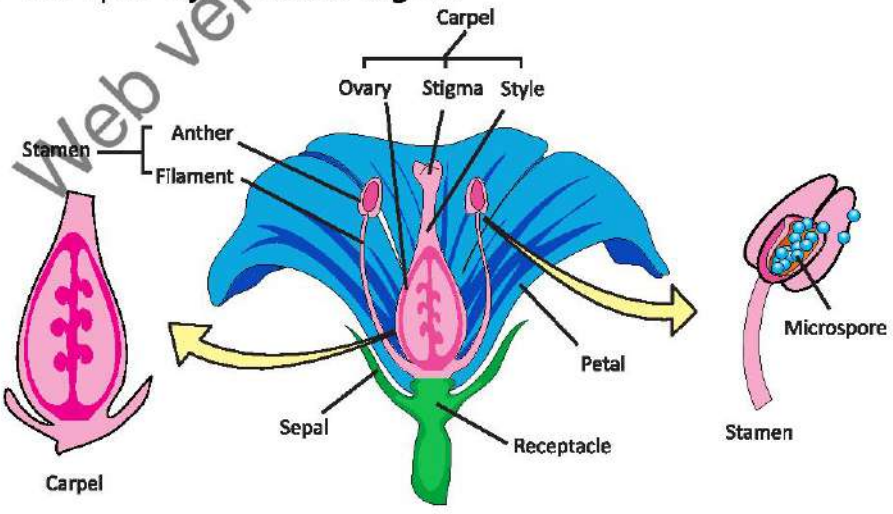


FIGURE 10.15: Parts of a flower

Stages of the Life Cycle

An angiosperm plant represents the sporophyte generation. When a flower matures, it produces spores. The spores germinate and make female and male gametophytes. The gametophytes are small structures consisting of few cells only. They make gametes which combine to form zygote that develops into new sporophyte.

Following are the main stages in the life cycle of an angiosperm.

1- Development of Female Gametophyte (Embryo Sac)

The ovule acts as megasporangium. It contains a diploid **megaspore mother cell** which undergoes meiosis and produces four haploid **megaspores**. Only one megaspore remains alive. Inside megaspore, eight haploid nuclei are formed by mitosis. Two nuclei migrate to the center and fuse to form a **fusion nucleus**. One nucleus out of the remaining six forms the female gamete i.e., egg cell.

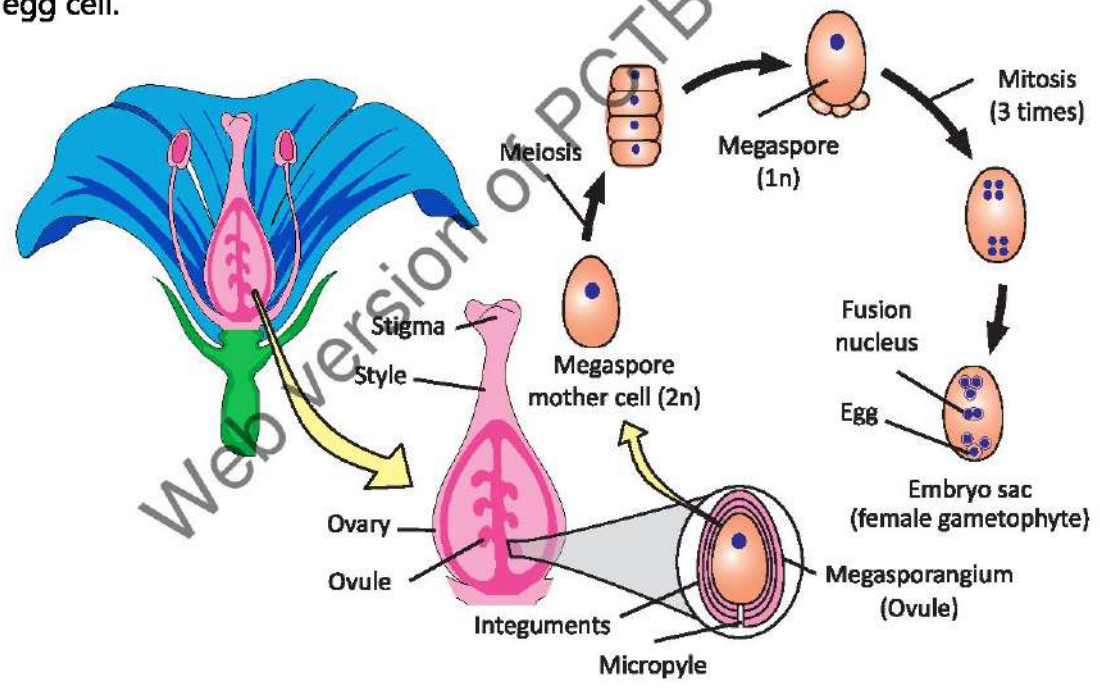


FIGURE 10.16: Development of female gametophyte (embryo sac)

The resulting structure, which contains seven cells (one egg cell, one fusion nucleus, and five non-functional cells), is the female gametophyte or embryo sac.

2- Development of Male Gametophyte (Pollen Grain)

The pollen sacs present in anther act as microsporangia. Each pollen sac contains many diploid **microspore mother cells**. Each microspore mother cell undergoes meiosis and produces four haploid **microspores** A microspore undergoes mitosis. The resulting two-celled structure is a pollen grain, which is the male gametophyte. One cell in pollen grain is the **tube cell**, which will form the pollen tube. The other cell is the **generative cell**, which will form two sperms.

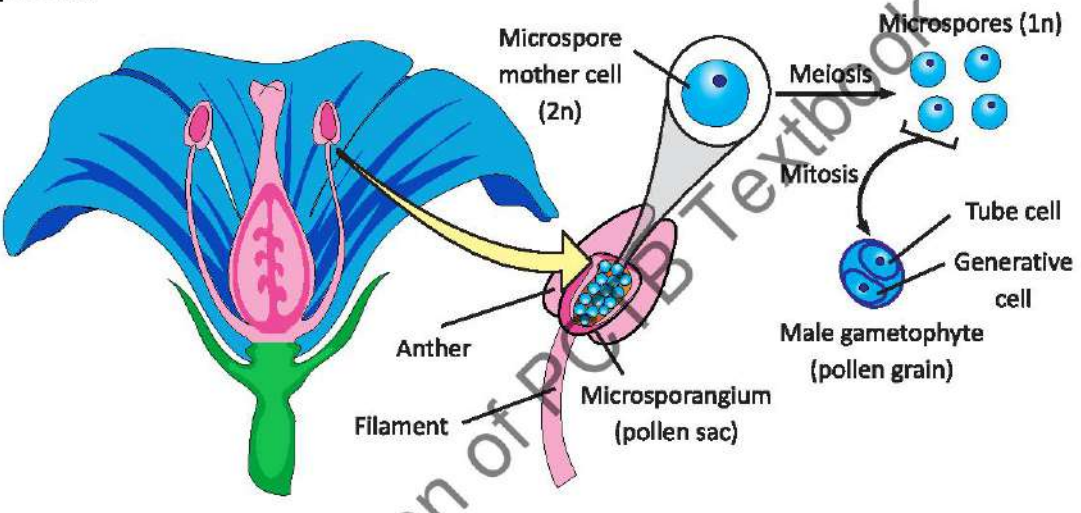


FIGURE 10.17: Development of male gametophyte (pollen grain)

3- Pollination

The male gametophyte (pollen grain) contains sperms while the female gametophyte (embryo sac) contains egg. The pollen grains are transferred from the anther to the stigma so that the sperms can fertilize the egg. It is called **pollination** i.e. the transfer of pollen grains from an anther to a stigma.

The transfer of pollens from the anther to the stigma of the same flower or another flower on the same plant is called **self-pollination.**

The transfer of pollens from the anther of one plant to the stigma of a flower on a different plant of the same species. is called **cross-pollination.**

4- Fertilization

When pollen grain reaches stigma, its tube cell forms a pollen tube. This tube grows through the stigma and style towards the ovary. The pollen tube reaches

the ovule and enters in it through the micropyle. The generative cell of pollen grain forms two sperms, which enter the embryo sac to reach the egg.

One sperm fuses with the egg, forming a diploid **zygote**. The zygote eventually develops into an embryo. The second sperm fuses with the fusion nucleus, producing a **triploid (3n) nucleus**. This nucleus then develops into tissue called **endosperm**. The endosperm provides nourishment for the embryo. This process of the fusion of two sperms (one with the egg and the other with the fusion nucleus) is called **double fertilization**. It is a unique characteristic of angiosperms.

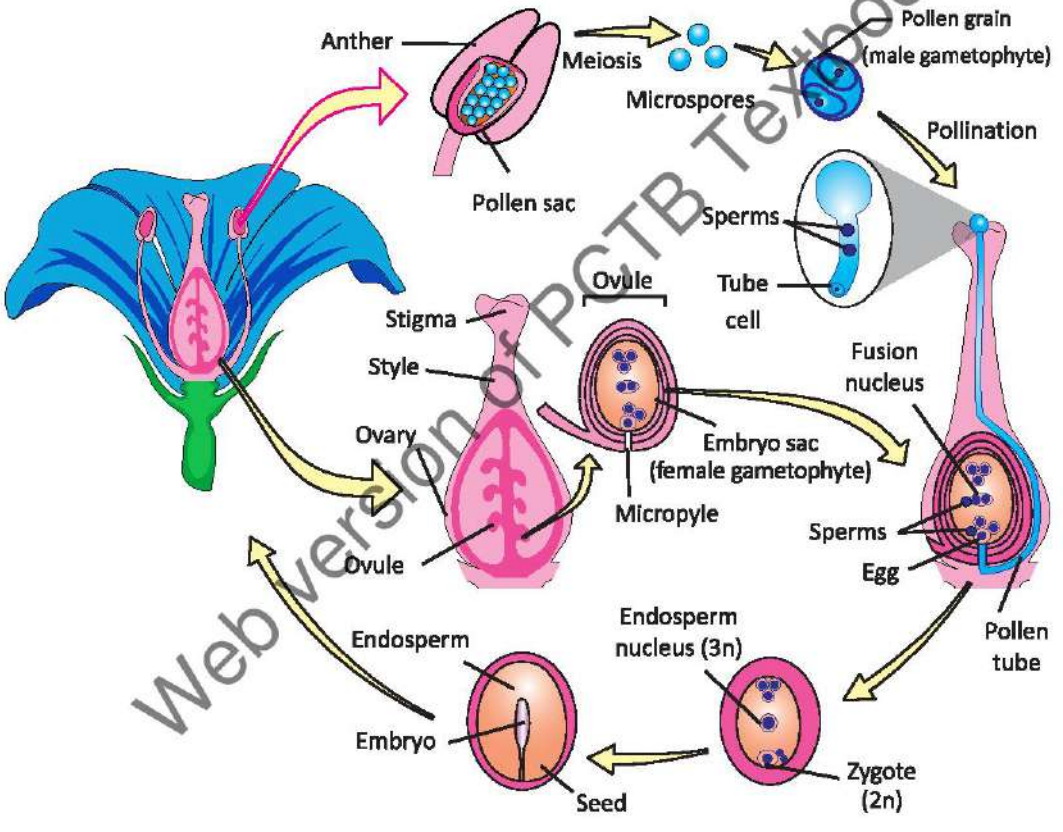


FIGURE 10.18: Life cycle of a flowering plant

5-Seed and Fruit Formation

After fertilization, the zygote develops into embryo and the triploid nucleus develops into endosperm tissue. After these developments, the ovule is said to be matured and is now called **seed**. The ovary changes into **fruit**.

6- Development of Sporophytes

When seeds mature, they are dispersed. If seeds get suitable conditions, their embryos develop into new plants (the sporophytes of the next generation).

In some plants, ovaries develop into fruits without fertilization of egg in ovule. So, there is no seed in fruit. This process is known as **parthenocarpy**. It results in seedless fruits e.g. bananas and seedless varieties of grapes.

KEY POINTS

- Binary fission is the division in which the parent cell simply divides into two daughter cells, each genetically identical to the parent.
- In budding, the offspring develops from a small outgrowth or "bud" on the parent organism.
- Vegetative propagation is a method of plant reproduction where new plants are produced from vegetative structures like stems, roots or leaves.
- Cloning is the technique of producing identical offsprings from small pieces of tissue taken from shoot tips or other suitable parts of the plant.
- Plants have two different generations. The diploid generation produces spores and is called sporophyte generation, while haploid generation produces gametes and is called gametophyte generation.
- The microspore undergoes mitosis and produces two haploid cells i.e., a tube cell which form pollen tube and a generative cell which divides to produce two sperms.
- A germinated microspore has a tube nucleus and two sperms is male gametophyte generation of plant.
- Ovule contains one megaspore mother cell which undergoes meiosis and produces four haploid megaspores. In one ovule, only one megaspore remains functional. Here it germinates into haploid female gametophyte, called embryo sac.
- Embryo sac consists of seven cells. There is one egg and two other cells at one end. There are three cells at the other end. There is a large cell in the centre which contains two polar nuclei (fusion nucleus 1n + 1n).

EXERCISE

A. Select the correct answers for the following questions.

1. Which of the following organisms commonly reproduce by binary fission?
   a) Yeast
   b) Bacteria
   c) Rhizopus
   d) Plants
2. What is the primary method of reproduction in yeast?
   a) Binary fission
   b) Spore formation
   c) Budding
   d) Fragmentation
3. Which of the following statements is true about spore formation in fungi?
   a) They produce spores during sexual reproduction
   b) They produce two kinds of spores
   c) Spores can only grow into new fungi in dry environments
   d) Spores are produced to withstand harsh conditions
4. What happens in some bacteria during harsh conditions?
   a) Creation of a bud that detaches from the cell
   b) Formation of thick-walled endospores
   c) Splitting the cell into two identical daughter cells
   d) Fusion of two bacterial cells
5. Which of the following is an example of vegetative propagation through runners?
   a) Potato
   b) Strawberry
   c) Onion
   d) Ginger
6. Which plant propagates through tubers?
   a) Onion
   b) Potato
   c) Ginger
   d) Garlic
7. The horizontal aboveground stem, which produces leaves and roots at its nodes;
   a) Stolon
   b) Bulb
   c) Rhizome
   d) Corm
8. Which of these does NOT help a plant for vegetative propagation?
   a) Rhizome
   b) Corm
   c) Runner
   d) Flower
9. Which part of the flower is responsible for producing pollen?
   a) Stigma
   b) Anther
   c) Ovary
   d) Petal

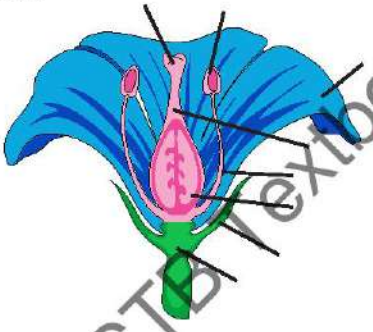
10. Which of the following is NOT a part of carpel?
    a) Filament b) Style
    c) Stigma d) Ovary
11. Which structure forms the female gametophyte in flowering plants?
    a) Pollen grain b) Ovule
    c) Anther d) Sepal
12. The male gametophyte in flowering plants is known as:
    a) Pollen grain b) Embryo sac
    c) Ovary d) Carpel
13. In the life cycle of flowering plants, which structure is triploid (3n)?
    a) Egg b) Fusion nucleus
    c) Endosperm nucleus d) Sperm
14. Embryo sac is formed inside;
    a) Filament b) Anther
    c) Style d) Ovule
15. Double fertilization involves;
    a) Fertilization of the egg by two male gametes
    b) Fertilization of two eggs in the same embryo sac by two sperms
    c) Fertilization of the egg and the fusion nucleus by two sperms
    d) Fertilization of the egg and the tube cell by two sperms

B. Write short answers.

1. Write a short note on budding in yeast.
2. Write a short note on spore formation in fungi.
3. What are the advantages of spore formation in fungi and bacteria?
4. Describe how vegetative propagation occurs through runners.
5. State how potatoes reproduce through tubers.
6. Describe the advantages and disadvantages of vegetative propagation.
7. Name the four whorls present in a flower and also tell the components of each whorl.
8. Briefly describe the formation of egg cell and polar nuclei within embryo sac of a flower.
9. Differentiate between:
    i. Asexual and sexual reproduction
    ii. Binary fission in bacteria and amoeba

iii. Stolon and rhizome
iv. Bulb and corm
v. Cutting and grafting
vi. Vegetative propagation and artificial propagation
vii. Male and female gametophytes
viii. Calyx and corolla
ix. Stamen and carpel

10. Label the given diagram of flower.



C. Write answers in detail.

1. Explain the process of binary fission in bacteria and describe how it leads to the formation of two daughter bacteria.
2. What do you mean by vegetative propagation? Differentiate among different plant structures modified for vegetative propagation.
3. Describe the ways by which humans can grow new plants by using the vegetative parts of the parent plants?
4. Define sporophyte and gametophyte. State their roles in the life cycle of plants.
5. Explain the lifecycle of flowering plants, focusing on the alternation between the gametophyte and sporophyte generations.
6. Describe how the female gametophyte (embryo sac) develops within the ovule of a flower.

D. Inquisitive questions.

1. Why are spores considered an adaptation for survival n harsh environmental conditions?
2. How do asexual and sexual reproduction contribute differently to genetic diversity of plant populations?
3. How does the pollen tube facilitate the process of fertilization in flowering plants?