

Chapter

8

Diversity Among Plants

At the end of this chapter the students will be able to:

- Outline the evolutionary origin of plants.
- List the diagnostic features shared by all plants, with emphasis on alternation of generation.
- Describe the general characteristics of bryophytes.
- Outline the life cycle of moss.
- Explain the land adaptations of bryophytes.
- List the advantages/uses of bryophytes.
- Describe the general characteristics of vascular plants.
- List the characters of seedless vascular plants with examples of whisk ferns, club mosses, horsetails and ferns.
- Explain the evolution of leaf in vascular plants.
- Outline the life cycle of ferns.
- Describe vascular plants as successful land plants.
- Summarize the importance of seedless vascular plants.
- Describe the evolution of seed.
- Describe the general characteristics and uses of gymnosperms.
- Define angiosperms and explain the difference between monocots and dicots.
- Explain the life cycle of a flowering plant.
- Explain how this life cycle demonstrates an adaptation of angiosperms on land.
- Define inflorescence and describe its major types.
- Describe the significance/benefits of angiosperms for humans.

Introduction

Virtually all other living creatures depend on plants to survive. Plants are found on land, in oceans, and in fresh water. They have been on Earth for millions of years. In order to study the billions of different organisms living on earth, biologists have sorted and classified them based on their similarities and differences. All plants are included in one kingdom (Kingdom *Plantae*), which is then further divided into smaller divisions based on several characteristics. The majority of the plant species are flowering herbs. Some are non vascular and other are vascular based on the presence and absence of conducting tissues. Still there is a group of plants that reproduces from spores rather than seeds, and the other that reproduces from seeds. Indeed this diversity of plants is of great importance and invites careful study.

8.1. Evolutionary Origin of Plants

Since the origin of life on earth, various organisms have evolved and dominated the earth at different times. The fossil records of different organisms show the time period on the geological time scale when they were present abundantly on earth. The discovery of the three billion years old bacteria by Barghoon and Schopf confirmed that life even existed before that and is not younger than the origin of the earth itself.

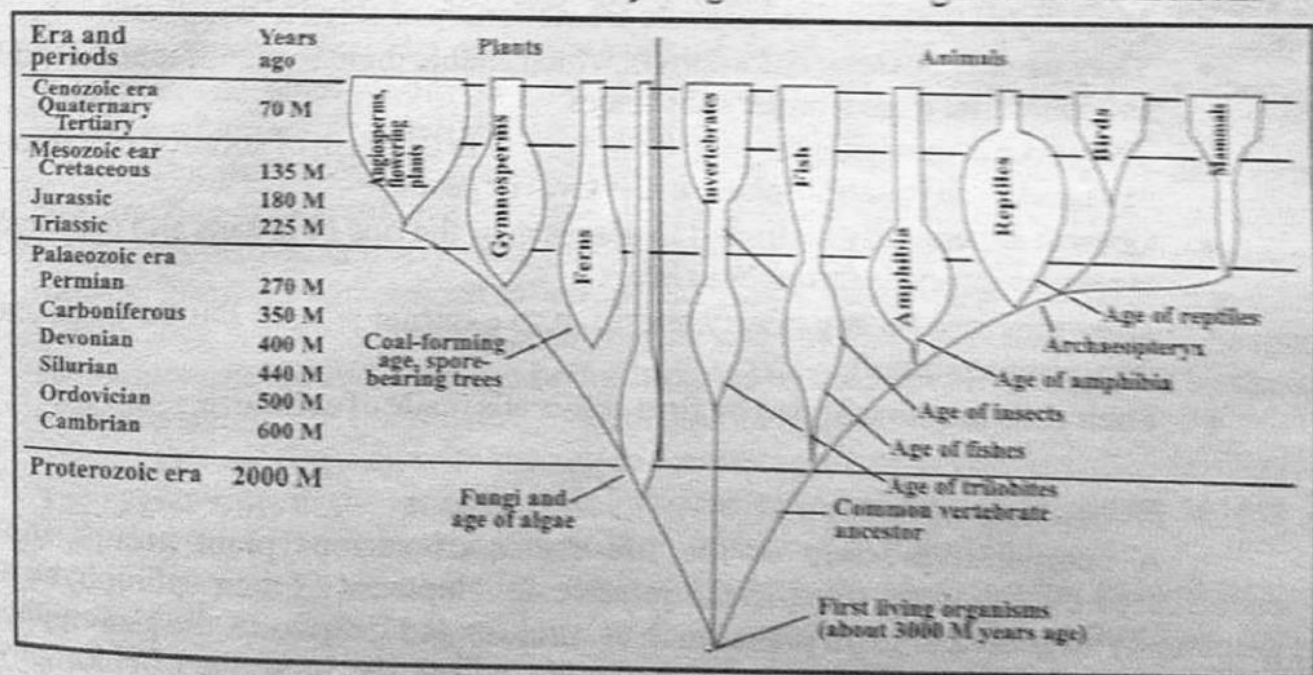


Fig: 8.1 Geological time chart

Fossils discovered by biologists provided the evidence of the dominated organisms in a particular era also, e.g. ferns flourished well and dominated the earth during the **Permian** and **Triassic** periods and ammonoid mollusks during **Triassic** and **Jurassic** period of the geological time chart.

8.1.1 Phyletic lineage

It is the sequence of arrangement of species from ancestors to the descendent through their evolution. The descendant populations have a resemblance with their ancestors in many respects as well as their immediate descendants in a certain sequence.

Phyletic lineage provides a link between the present day organisms with their remote past ancestors. The link has been established on the basis of the fossil records of both plants and animals as well as bacteria. Today almost two million species of living organisms in animals and about 0.5 million plant species have been identified by the biologists while still a large number is left unidentified.

8.1.2 Diagnostic Features of Plants

Some of the distinctive characteristics of plants are as follows:

- Higher plants possess, independent sporophytes, which may be trees, shrubs or herbs (primitive members are trees, while shrubs and herbs are considered to be derivatives or more advanced).
- They are differentiated into roots, stem and leaves traversed by vascular strands.
- Majority of the plants are as a rule are stationary or fixed to one place.
- They usually possess chlorophyll, which enable them to manufacture complex food material from simpler substances.
- They take in materials for food from the soil in the form of solution of inorganic salts and from the atmosphere in the form of gases.
- Growth is generally restricted to places near the tips of organs and continuous at regular intervals throughout life.
- They may not be apparently sensitive to external stimuli but they can show responses to stimuli.
- Their cells are surrounded by firm cell-walls made of cellulose.

8.1.3 Evolution of Alternation of Generations

A comparative study of the life-cycles of various plant groups shows pronounced evolutionary trend in the relative development of their sporophytic and gametophytic generations. In plants such as mosses and liverworts, the gametophytic generation is larger, dominant and autotrophic due to the presence of chlorophyll, while the sporophytic generation is smaller, less complex and heterotrophic, being partially or totally dependent upon the gametophyte. In certain algae like *Ulva* and *Ectocarpus*, both the generations are independent and morphologically and structurally identical (isomorphic).

In higher cryptogams, e.g., *Lycopodium*, *Selaginella*, ferns and phanerogams, gymnosperms and angiosperms, the relative development of the two generations is reverse of that as described above. The sporophyte is more prominent, structurally complex and autotrophic, contains chlorophyll and is differentiated into root, stem and leaves, traversed by vascular bundles, while the gametophyte is smaller and very simple in structure. The climax of this expansion of the sporophyte and reduction of the gametophyte is evident in angiosperms, where the sporophyte is a complex independent plant while the gametophytes are tiny, microscopic structures, devoid of chlorophyll and totally dependent nutritionally upon the sporophyte. Another conspicuous feature is the presence of vascular tissues only in the sporophyte; the gametophytic generation in no case being provided with a vascular tissue.

8.2 Non-Vascular Plants

8.2.1 General Characteristics of Bryophytes

The phylum **Bryophyta** include Musci - Mosses, Hepaticae - liverworts, Anthocerotae - hornworts as classes. Bryophytes are the first plants which migrated to land. Bryophytes comprise the small and simplest non flowering land plants which usually occur in moist shady places, rocks, walls and bank of rivers etc. They are non vascular plants. Thus the transportation of food, water and minerals occurs by diffusion. The plant - body is green branched thallus, lacking true roots, stems or leaves, but possessing hair like rhizoids instead of roots.

The plant body is gametophyte, which bear multicellular male and female reproductive organs called antheridia (singular antheridium) and archegonia (singular archegonium) respectively. The sex organs produce male and female gametes by mitosis. The male gametes are called sperms which are motile while the female gamete is called egg or oosphere which is non motile and one in each archegonium. The sperms swims towards the archegonium being attracted by the sweet fluid secreted by the neck of archegonium, and fuses with it to form diploid zygote.

Fusion of sperm with the egg to form oospore or zygote is called fertilization. The zygote rests in the archegonium for some time and then develops by mitosis into diploid embryo. Bryophytes are therefore, called embryophytes.

The embryo develops into diploid sporophyte which produces haploid spores by meiosis. The spores then develop into gametophyte. The sporophyte remains attached to the gametophyte for nourishment and protection. The bryophytes thus show alteration of generations, which is a useful process for successful survival of the plant. Examples of bryophytes are liverworts (*Marchantia*), hornworts (*Anthoceros*) and mosses (*Funaria* and *Polytrichum*) (Fig.8.2).

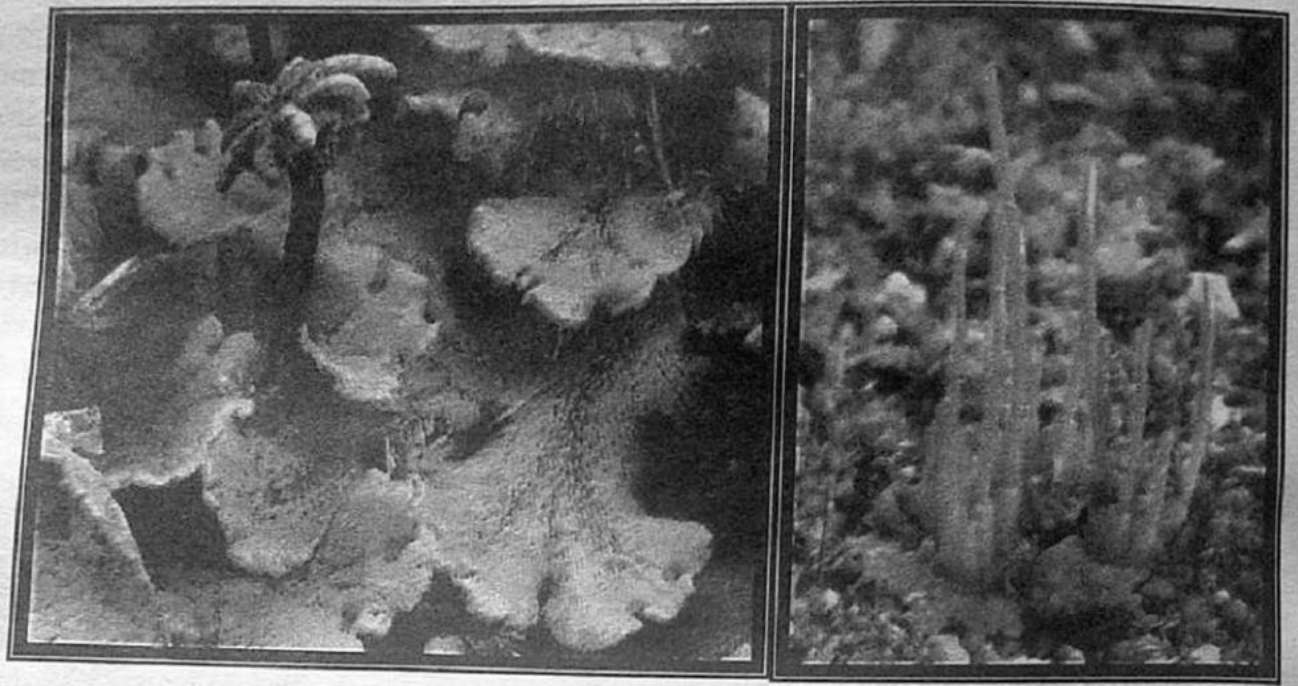


Fig: 8.2 a. *Marchantia*

b. *Anthoceros*

8.2.2 The Life Cycle of Moss

Life-history may be studied by referring to *Funaria* or *Polytrichum*. Moss occurs most commonly on old damp walls, trunks of trees, and on damp ground during the rainy season, while in winter, it is seen to dry up. It is gregarious in habit; wherever it grows it forms a green patch or a soft velvet-like, green carpet.

Moss plant is small, about 2.7 cm or so in height, and consists of a short axis with spirally arranged, minute, green leaves which are crowded towards the apex; true roots are absent. It bears a number of slender, multicellular, branching **rhizoids** which perform the functions of roots. The axis may be branched or unbranched.

Reproduction, The moss plant is the **gametophyte**, i.e. it bears gametes and reproduces by the sexual method. For this purpose highly differentiated male and female organs are developed at the apex of the shoot. The male organ is known as the **antheridium** and the female organ as the **archegonium**. These organs are sometimes intermixed with some multicellular hair-like structures, known as the **paraphyses** (para, beside; physo, to grow or an off shoot). Antheridia and archegonia may occur together on the same branch or shoot or on two branches of the same plant (monoecious) or on two separate plants (dioecious).

The **antheridium** is a multicellular, short-stalked, club-shaped body which is filled up with numerous small cells (Fig.8.4) known as antherozoid cells. The antheridium bursts at the apex and the antherozoid cells are liberated through it in a mass of mucilage.

The mucilaginous walls surrounding antherozoid cells dissolved in water and the **antherozoids** are set free. They are very minute in size, spirally coiled and biciliated; after liberation they swim in water that collects at the apex of the moss plant after rains.

The **archegonium** is also a multicellular body, but it is flask-shaped in appearance. It is provided with a short, multicellular stalk and consists of two portions; the lower swollen portion is known as the venter (belly), and the upper tube-like portion as the neck. The neck is long, narrow and straight. Within the venter there lies a large cell which is the **ovum** (egg-cell or oosphere) or female gamete; above this lies a small ventral canal-cell and higher up in the neck there are a few neck canal-cells. Except the ovum other cells mentioned above are functionless and soon get disorganized. The neck at first remains closed at the apex by a sort of lid, but as the archegonium matures, the lid opens and allows the antherozoids to enter and pass through it.

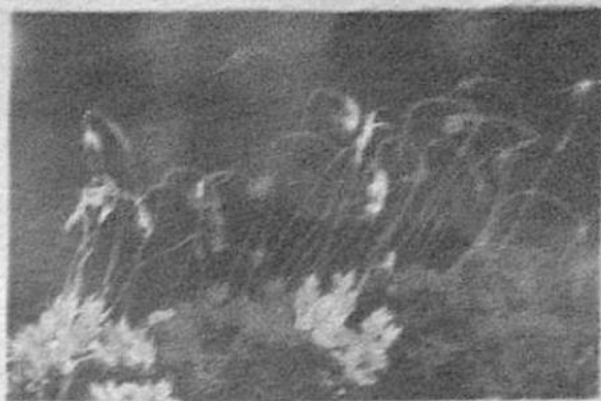


Fig:8.3 *Funaria*

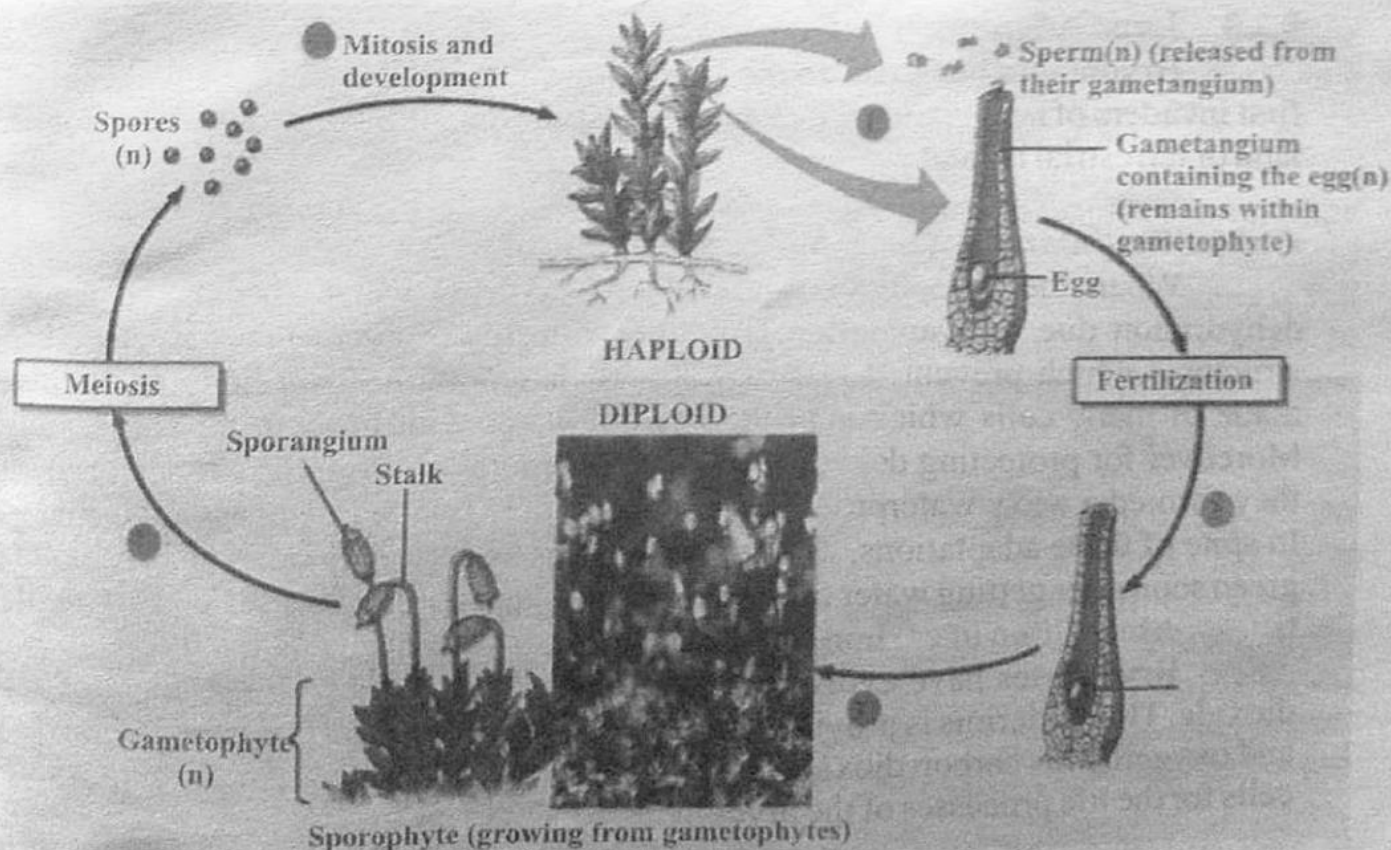


Fig: 8.4 Alternation of generation in a moss plant.

Egg and sperm fuse to form zygote which develop into sporophyte. The sporophyte plant produce haploid spores by meiosis. The spores give rise to new gametophyte plant. Examples of mosses are *Funaria* and *Polytrichum*.

For Your Information

Peat bogs and their Importance

Peat bogs are areas of great natural beauty, as well as being rich in wild plants, insects and animals. Peat bogs are fed by rainwater and the soil builds up its own water table and acidity. Sphagnum mosses grow and decay eventually forming layers of peat, then peat mounds many metres deep. This process takes thousands of years, which is why sustainable large-scale peat extraction is impossible; the extraction is always faster than the growth. Habitats like these simply take too long to grow back. Peat bogs are rich in diversity of plants and wildlife, some of which are unique to these environments.

8.2.3 Land Adaptation by Bryophytes

Bryophytes had invaded the land from water and therefore, they are called the first invaders of land among the plants. They show the following adaptations for life on land or terrestrial habitat.

a. Multicellular plant body and conservation of water

When the bryophytes migrated to land from water, they faced danger of dehydration due to evaporation. To cope with this problem they developed many structures which prevented loss of water or dehydration. Plant body or thallus was made of many cells which kept the needful water with in them for successful life. Moreover for protecting dehydration due to evaporation from the surface of the cells, they formed a waxy waterproof layer called cuticle (made of cutin) on the epidermis. In spite of these adaptations, if some bryophytes are dry, they become brittle and turn green soon after getting water from rain or any other source of water.

b. Absorption of carbon dioxide

Bryophytes have evolved elaborate structures to absorb sufficient of carbon dioxide. The epidermis is provided with many pores for the diffusion of carbon dioxide and oxygen. This carbon dioxide is absorbed by the wet surfaces of the photosynthetic cells for the life processes of the bryophytes.

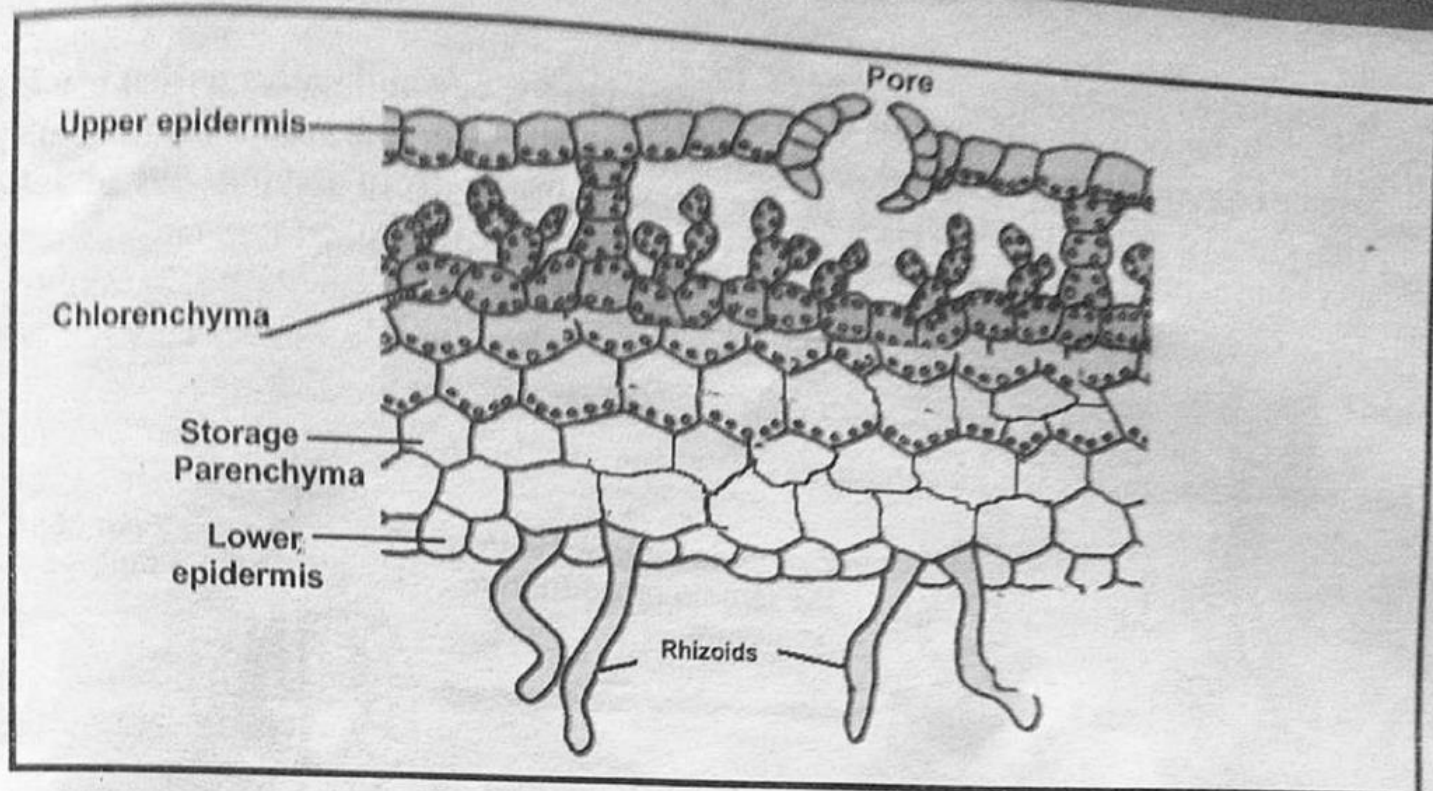


Fig: 8.5 Structure of thallus of bryophyte showing multicellular plant body and conservation of water .

c. Absorption of water

Bryophytes have no roots or root-hairs for absorbing water from the soil. They have developed long hair like structures called rhizoids from lower surface of the thallus to absorb water from the soil which enables the bryophytes to live on land

d. Heterogamy

The universal occurrence of sexual reproduction of heterogamous type involving the union of sperm and egg in green plants like bryophytes is the most successful type of reproduction. The large, non motile egg formed in heterogamy is full of stored food. After fertilization this stored food is used to nourish the early stages in the development of new offsprings. The heterogamous sexual reproduction is best suited for life on land.

e. Protection of reproductive cells

Reproductive cells should be safe and protected from any kind of injury for the plants to live on land. Fortunately the bryophytes possess this important character which enable them to survive land habitat. The reproductive cells are sperms and egg or oosphere. The sperms remain protected in male sex organ or antheridium and the egg in the female sex organ or archegonium. The sex-organs are prevented from drying by the leaf like structures and sterile hairs produced at the shoots which bear the sex organ. Moreover the spores of these land plants are also well protected from drying. Spores are produced in multicellular sporangia.

f. Embryo formation

In bryophytes the sperms are transported to the egg and unites with it inside the female reproductive structure. A zygote is formed here which develops into an embryo. The embryo remains protected in the female organ from drying out and from mechanical injury. In this way the chances of survival are increased.

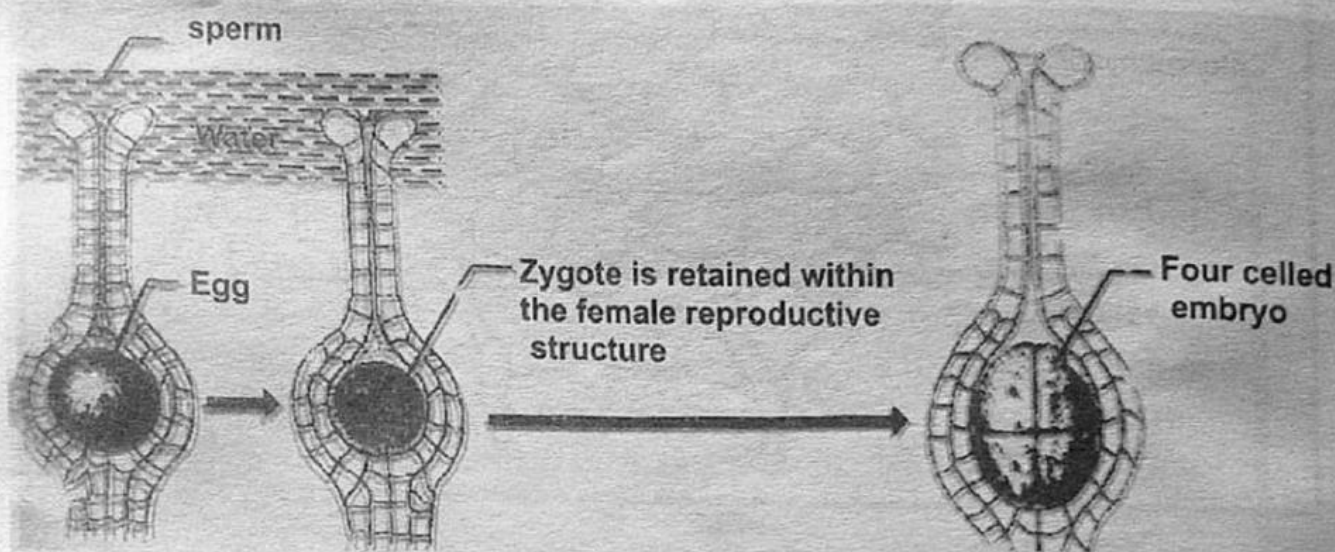


Fig: 8.6 Formation of Embryo

g. Alternation of generation

The life cycle of bryophytes shows clear alternation of generation for its survival on land. Alternation of generation is an adaptation to land habitat which ensures diversity and variations in characters. These variations help the plant to adjust and survive the land habitat.

8.2.4 Uses of Bryophytes

Bryophytes have many useful economic values e.g.

1. A kind of moss - *Sphagnum* or peat moss is used (when fresh) as a packing material by the horticulturists, for it can take up and hold large quantities of water. Remains of this moss become peat which is used extensively as a fuel.
2. Through their chemical and physical actions, rocks are broken down into simple soil - constituents.
3. The decay of their dead bodies builds up the much needed organic matter of the soil.
4. Make habitat suitable for new plants.

8.3 General Characters of Vascular Plants (Tracheophytes)

Tracheophytes form a large and diverse group of the present day land plants. They include most of the dominant land plants. They are called vascular plants because of the presence of vascular tissues. They are called tracheophytes because all of them have cells called Tracheids.

Tracheids are water - conducting cells of xylem. In tracheophytes the sporophyte generation is dominant and the gametophyte small reduced and short lived. Tracheophytes form successful group of land plants because they can adapt themselves even to rough land as well. They can save themselves from high temperature by transpiration and can gain a large height without facing any problem of water supply. Vascular plants are divided into two major sub - divisions namely lower vascular plants and higher vascular plants. In the lower vascular plants seeds are not produced. They reproduce by spores e.g. *Rhynia*, *Psilotum*, club mosses, horse tails and ferns.

The higher vascular plants are seed producing plants i.e. gymnosperms and angiosperms.

Tracheophytes furnish us with the very necessities of life --- namely all of our food, wood for construction of our houses, fibers for clothing, medicines and fuels such as coal. The herbs shrubs, and trees are tracheophytes.

The phylum tracheophyta is further divided into the following four sub - divisions or sub - phyla, or major groups.

1. Sub - Phylum: Psilopsida
2. Sub - Phylum: Lycopsidea
3. Sub - Phylum: Sphenopsida
4. Sub - Phylum: Pteropsida

1. Sub - Phylum: Psilopsida

This is the oldest group of most primitive rootless, leafless vascular plants. The sporophyte body shows little organ differentiation. The stem is differentiated into an underground rhizome and an aerial part. The rhizome grows horizontally in soil and may bear rhizoids but no roots.

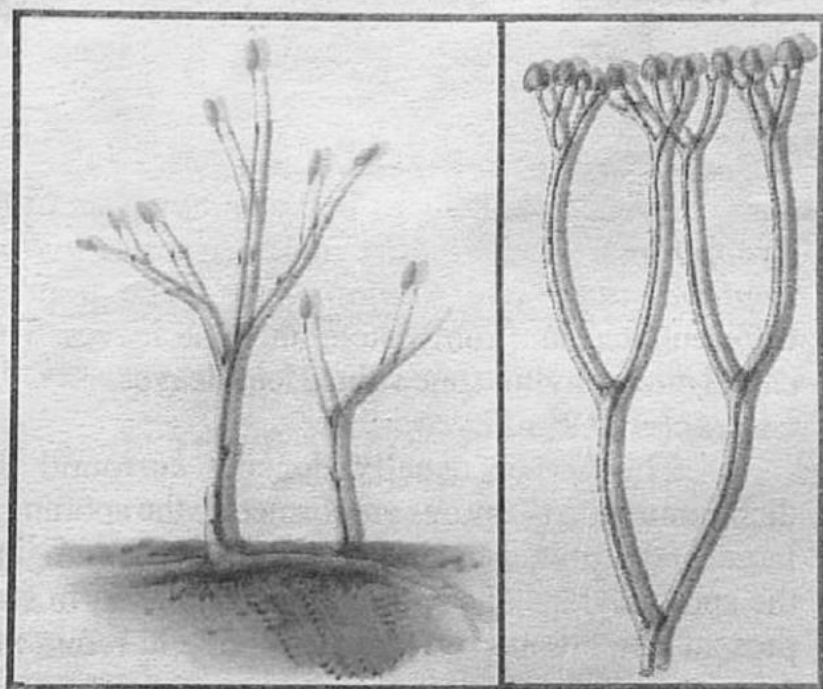


Fig: 8.7(A) a. *Rhynia*

b. *Cooksonia*

The upright stem shows dichotomous or forked (Y - shaped) branching. The reproductive organs are sporangia (singular: sporangium) which are produced at the tips of the branches. The spores are formed in the sporangia. The two living genera are *Psilotum* and *Tmesipteris*.

Examples of *Psilopsida* are *Rhynia*, *Cooksonia*, *Psilophyton* (*Psilopsidom*), *Psilotum* and *Tmesipteris*.

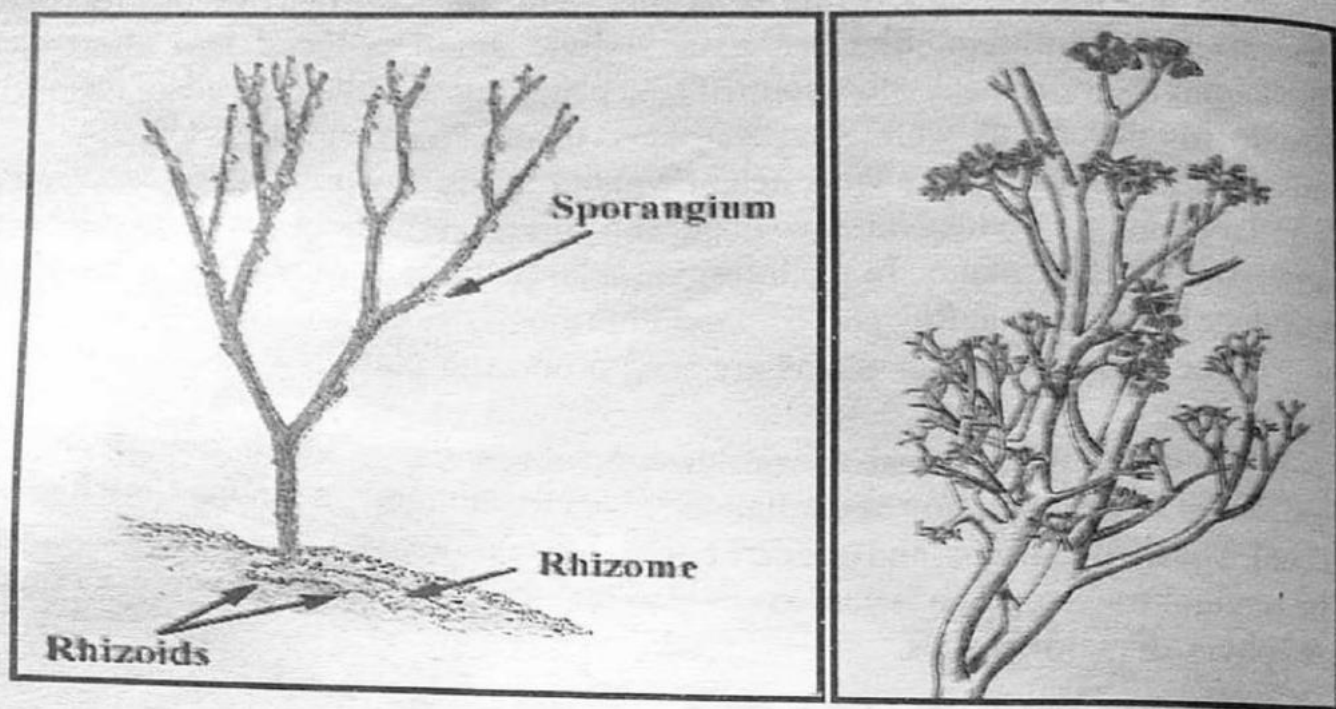


Fig: (B) 8.7 a. *Psilotum*

b. *Psilophyton*

2. Sub - Phylum: Lycopsidea (clubmoss)

Lycopsidea includes both the living and fossil genera. The living genera are *Lycopodium*, *Selaginella*, *Isoetes* and *Phylloglossum*. The fossil genera are *Lepidodendron* and *Sigillaria* etc. The plants of lycopsidea are sporophytes, differentiated into roots, stem and true leaves. The leaves are small simple and are called microphyllus (one veined leaf) leaves.

Characteristics of Lycopsidea

The leaves usually densely surround the stem. Branching is basically dichotomous. The spores are formed in the sporangia. The gametophyte of lycopsidea is large, underground and independent. The sporangia develop singly on the upper side of the sporophylls. The sporophylls usually form strobili. At the base of sporophylls is present a small outgrowth called ligule to retain moisture. In some lycopsidea such as *Lycopodium*, the ligule is absent.

Lycopsidea are commonly called club mosses. They are not mosses but called club mosses because their strobili are club shaped and their leaves resemble the mosses. One example is *Selaginella*.

Selaginella

General Characters

Selaginella comprises over three hundred species, most of which are tropical and grow abundantly on hills. *Selaginella* grows in damp places in the hills and in the plains. It is a slender, much-branched plant, either creeping on the wall or on the ground.

The slender stem bears four rows of leaves--two rows of small leaves on the upper surface and two rows of larger leaves at the two sides. A long slender, root-like organ is given off from the stem which is known as the **rhizophore** (root-bearer).

Selaginella plant is the **sporophyte**. It bears two kinds of sporophylls - **microsporophylls** and **megasporophylls**. Both kinds of sporophylls may occur together in the same cone, or they may be borne in two separate cones either on the same plant or on two separate plants. All the sporophylls are nearly of equal size and spirally arranged, usually in four rows, round the apex of the reproductive shoot, in the form of a more or less distinct four-angled cone, called the **sporangiferous spike** or **strobilus**. The sporophylls are similar to the vegetative leaves in appearance, but are smaller in size.

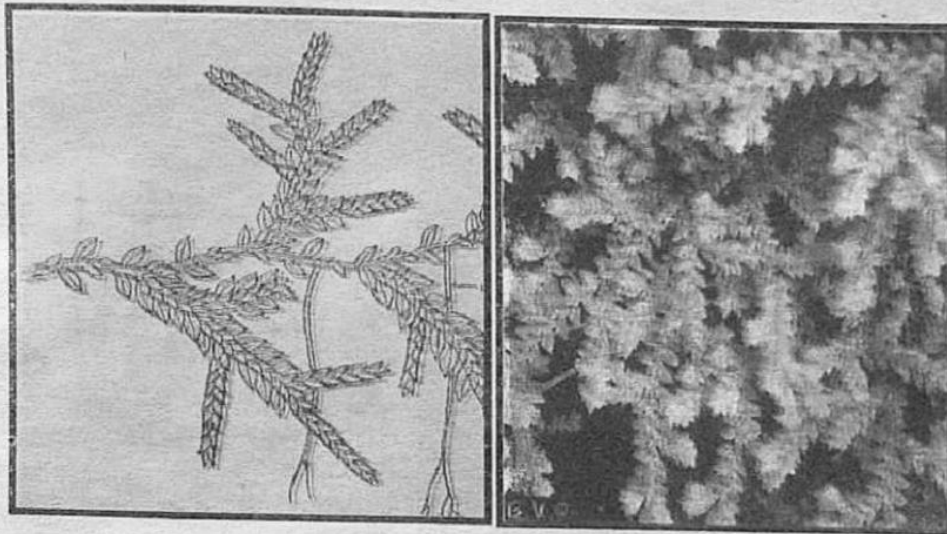


Fig: 8.8 *Selaginella denticulata*

3. Sub - Phylum: Sphenopsida (horse tails)

This group includes both extinct (e.g. *Calamites*) and living plants e.g. *Equisetum*, the only surviving genus. In this group, the individual plant is seldom more than a few feet high. The plant is sporophyte, distinguished into roots, stem and leaves. The stem is not smooth but has ridges, furrows or ribs, and divided into joints, nodes and internodes. Therefore these plants are also called arthrophytes. The leaves are reduced to scales and arranged into whorls at each node. Sporangia are closely packed to form terminal cone or strobilus.

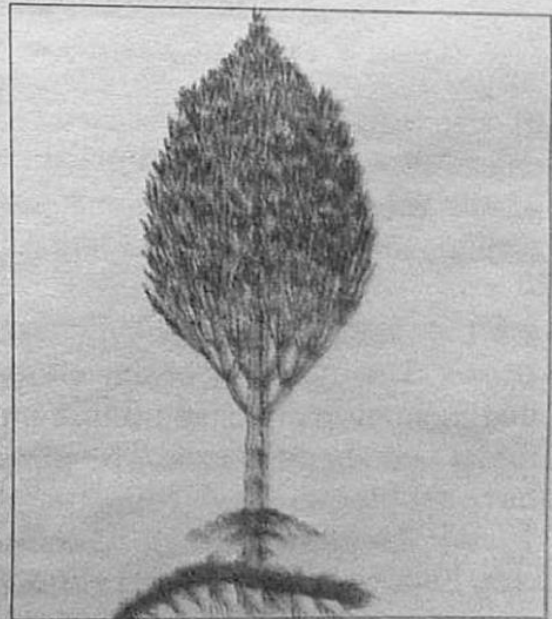


Fig: 8.9 *Calamites*

The underground stem or rhizome branches frequently and is anchored by adventitious roots usually formed at the node. The upright green branches are numerous. Special lateral appendages called sporangiophores are developed which bear sporangia. Spores are produced in each sporangium.

The mature gametophyte body is more or less flattened, irregularly shaped structure called a Prothallus. It is held to the substrate by slender root like rhizoids. The antheridia and archegonia are borne on the upper surface. There is a distinct alternation of generation.

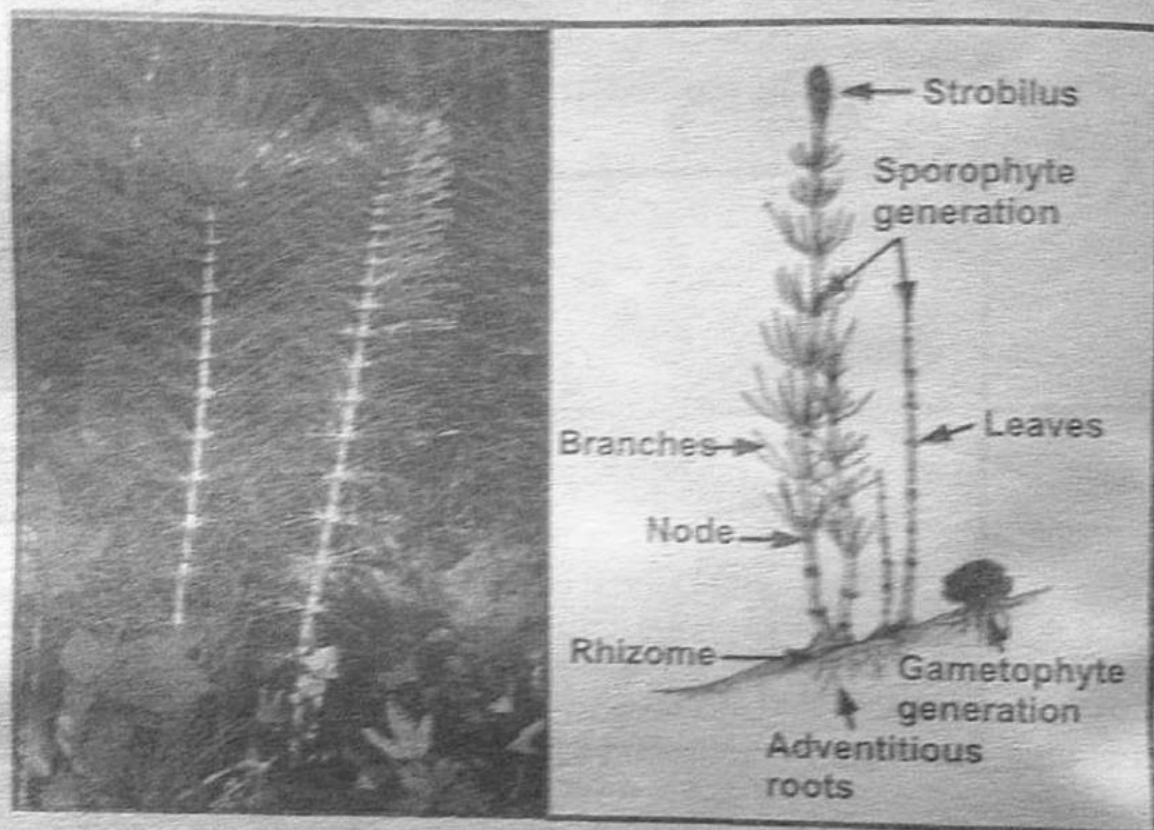


Fig: 8.10. *Equisetum*. A vegetative shoot with whorls of branches.

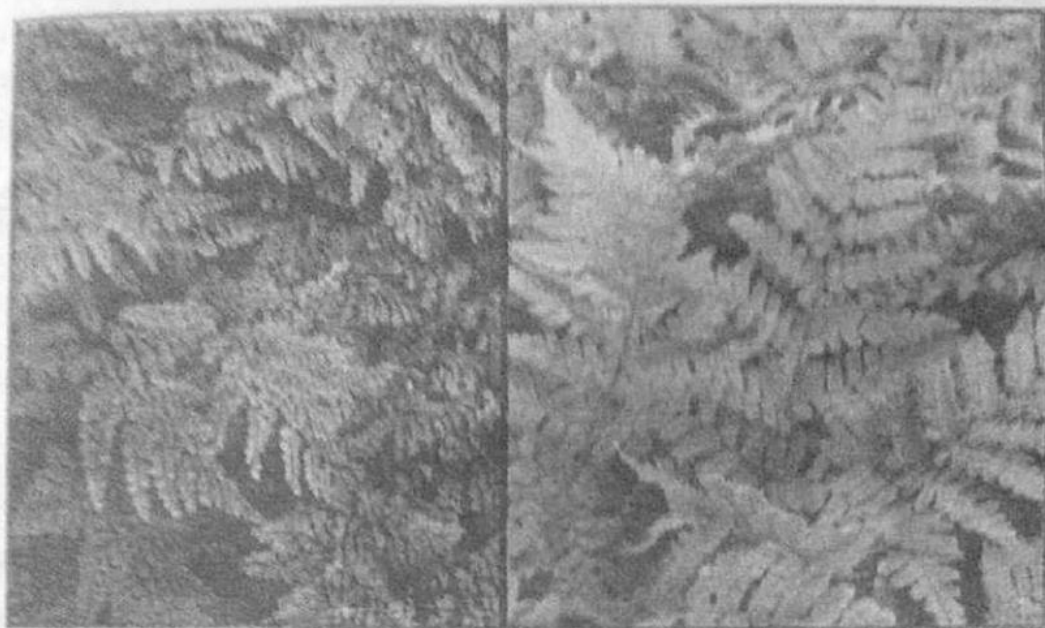
4. Sub Phylum: Pteropsida (ferns and seed plants)

Sub phylum pteropsida constitutes a group of the best known plants on the earth. Pteropsida is a heterogeneous group, consisting of three classes namely Filicineae, Gymnospermae and Angiospermae.

8.3.1 Class I. Filicineae

The members of this class includes ferns. Ferns have the prostrate plant body that bears numerous sporangia on the leaves called fronds. They are mostly found in moist and shady places. The plant body is divided into root, stem and leaves. Plants have a subterranean rhizome.

Roots are developed from the base of rhizome. Leaves are megaphyllous i.e. they have branched veins. Leaves or fronds are simple with a petiol or compound with a central axis or rachis. The immature and young frond is coiled, one of the important character of this group.



a: Maiden-hair fern (*Adiantum*)

b. *Dryopteris* (*Aspidium*)

Fig: 8.11 Some representative of ferns)

Sporangia are grouped to form sori on the under surface of leaves. Most of the plants are homosporous. Gametophyte is small, heart shaped and photosynthetically independent. The sex organs are antheridia or archegonia, produced on the under surface of gametophyte. The class filicineae comprises nearly 10000 species, which are widely distributed. Common example of this class are *Adiantum*, *Pteris*, *Dryopteris* and *Pteridium*.

8.3.1.1 Evolution of leaf

Leaf is a green mostly flat structure borne at the node on the stem or on its branches in all the vascular plants. The primary function of the leaf is photosynthesis. It also helps in transpiration. Another activity of the leaf is respiration which involves the absorption of oxygen and liberation of carbon dioxide. The primitive vascular plants lacked leaves. The stem being green was photosynthetic. It is the evolution of leaf which resulted in efficient photosynthesis.

How did this important organ of the plants arise, when none was present in the primitive vascular plants? Before we answer this question, we must distinguish between two basic types of leaves occurring among vascular plants. One kind is microphyllous leaf with a single vein and the other is megaphyllous leaf with many veins.

a. Evolution of microphyllous leaf

Microphyllous leaf is present in club moss and horse tails. The interpretation of the fossil record does not permit a clear answer as to how the microphyllous leaf evolved. However, there are two possibilities about the origin of microphyllous leaf.

One possibility is that this leaf originated as an outgrowth, lacking vascular tissue, from the naked branches of the primitive plant. With increase in size, it needed support and transport so vascular tissue in the form of one vein appeared in it and in this way microphyllous leaf was formed.

Another possibility is that the microphyllous leaf originated by the reduction in size of a part of the leafless branching system of the primitive vascular plant.

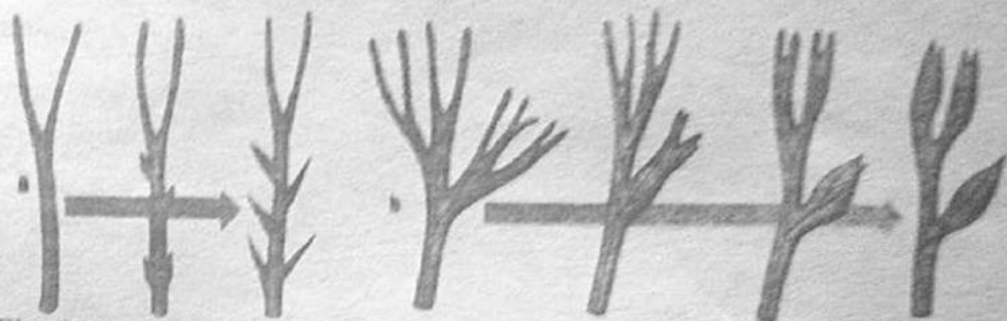


Fig: 8.12a,b: A diagrammatic summary of two different theories of the evolution of single veined leaves.

In any possibility, this simple kind of leaf became well established in groups of primitive plants such as club moss and horse tails.

b. Evolution of Megaphyllous leaf

Megaphyllous leaf is found in many plants such as leaf of *Ginkgo*. When we examine the leaves, we find that they are evolved by the evolutionary modification of the forked branching system. Therefore, this hypothesis of the evolution of megaphyllous leaf is called forked branching reduction hypothesis. The branching system became flate during the evolution of megaphyllous leaf. This step of evolution of megaphyllous leaf is called planation.

Next in evolution, the spaces between the bundles and branches of vascular tissue became filled with photosynthetic tissue. This process is called **webbing**. The organ, now a leaf, looked superficially the webbed foot of a duck. The branches changed into veins which resulted in many veined leaf or megaphyllous leaf.

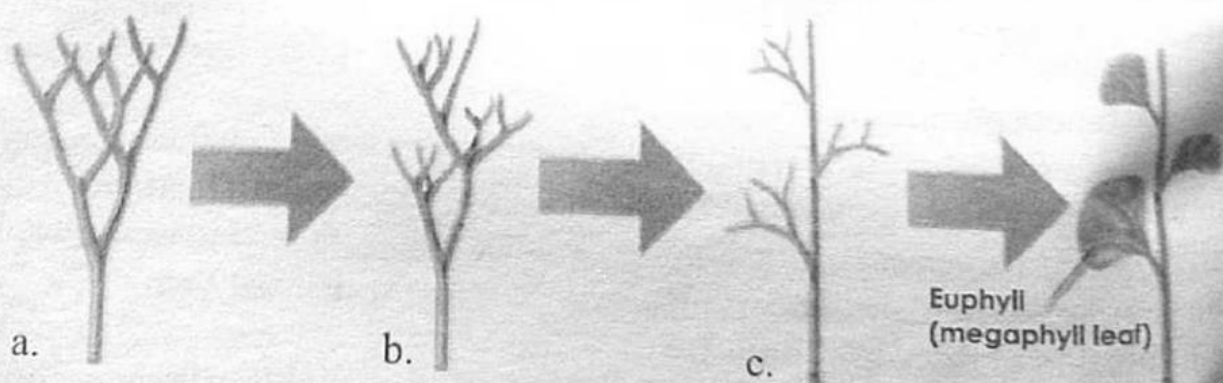


Fig:8.13(a) Primitive three dimensional (b) Branches are all aligned in (c) Areas between branches become filled with tissue. The Principal steps in the evolution of a many veined leaf. Much evidence from fossils of ancient vascular plants supports the steps illustrated here.

8.3.1.2 *Adiantum* (Maiden-hair Fern)

a. Vegetative structure

Adiantum is a common fern, growing wild in places along the walls of wells and water courses. It is a small herb; consisting of a stem, roots and leaves. The stem is a short, thick rhizome, lying horizontally in the soil. It is usually unbranched and is covered by persistent leaf bases. The stem and the petiole are covered with numerous brownish scales known as **ramenta**.

The roots are fibrous adventitious and arise from the lower side of the rhizome. The leaves or fronds are large and compound. They arise from the upper side of the rhizome. Each leaf consists of leaflets or pinnae. The pinnae are further divided into pinnules. Each leaf consists of a stalk like portion, the stipe, which is continued above into the rachis.

b. Life Cycle of *Adiantum*

Adiantum is sporophyte. It has asexual reproductive organs called sporangia which contain spores. Sporangia are arranged in groups called sori. The spores are small and light, and are liberated from the sporangia in dry weather. When a spore falls on a suitable soil, it begins to germinate in about a week's time and produces a haploid gametophyte called **prothallus** which is capable of manufacturing its own food.

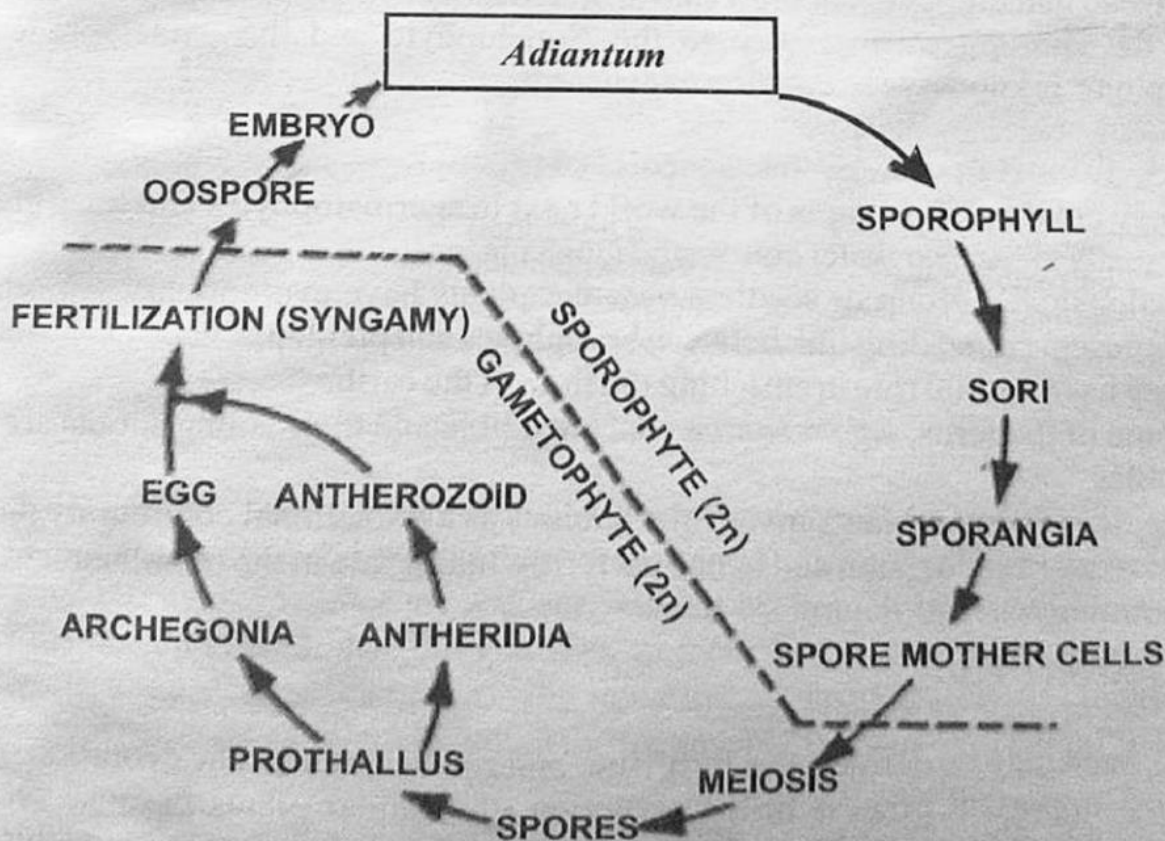


Fig: 8.14 Life cycle of *Adiantum*

The prothallus is green, small, flat and heart shaped structure. From the under surface of the prothallus arise a number of rhizoids. The rhizoids fix the prothallus to the soil and absorb water and mineral salts from the soil. The prothallus is hermaphrodite, bearing both the antheridia and archegonia on its under surface. Each antheridium contains sperm mother cells or spermatocytes which gives rise to a male gamete or sperm. Each archegonium is a flask shaped body consisting of a tube like neck and a basal swollen venter. The venter contains a single long naked cell called egg or oosphere. Fertilization occurs when the soil is thoroughly wet with water. A number of sperms cluster round the open mouth of the archegonium and one of them passes down to the venter fuses with oosphere to form oospore or zygote which begins to divide to produce an embryo which develops into a young sporophyte of *Adiantum*.

Alternation of Generation in *Adiantum*

The life history of *Adiantum* includes two quite distinct generations, the sporophyte generation and the gametophyte generation. The sporophyte produce spores which on germination gives rise to a heart - shaped gametophyte or prothallus. The gametophyte develops antheridia and archegonia, which contain sperms and eggs respectively. The oospore resulting from the fusion of the sperm with the egg does not give rise to gametophyte but grow into an independent young sporophyte of *Adiantum*. Thus the sporophyte gives rise to the gametophyte and the gametophyte to the sporophyte is known as alternation of generation.

8.3.1.3 Importance of seedless vascular plants

1. They are dominant plants of the world next to spermatophytes and have colonized major shady areas near water course and moist places.
2. Psilopsida, a group of seedless vascular plants have evolutionary importance as they represent connecting link between bryophytes and pteridophytes.
3. They have special role in enriching the flora of the earth.
4. Some of the ferns, e.g. *pteridium* etc., are edible and their young shoots are used as vegetables.
5. Seedless vascular plants invade the habitats as a transitional community during the process of plant succession and hence perform a major role in the establishment of plant communities.

8.4 Seed Plants

8.4.1 Evolution of Seed

Seed may be defined as a fertilized and ripened ovule. The evolution of seed is the most important process in the evolution of vascular plants because seed is the structure which can survive under unfavorable conditions. It is responsible for the preservation of species. Seeds have made the plants dominant vegetation on land. The evolution of seed involve the following steps:

a. Development of heterospory

All the seed plants are heterosporous. They produce two types of spores namely microspores and megaspores. The microspores produced in the microsporangia (pollen sac) germinate into male gametophyte and megaspore produced in the megasporangia (ovules) germinate into female gametophyte (embryo sac).

b. Retention of megaspore inside the sporangium

Instead of being shed from the sporangium like the spores of the lower plants, the megaspores of the seed plants are permanently embedded and protected inside the megasporangium. Here the megaspore develops into a small female gametophytes.

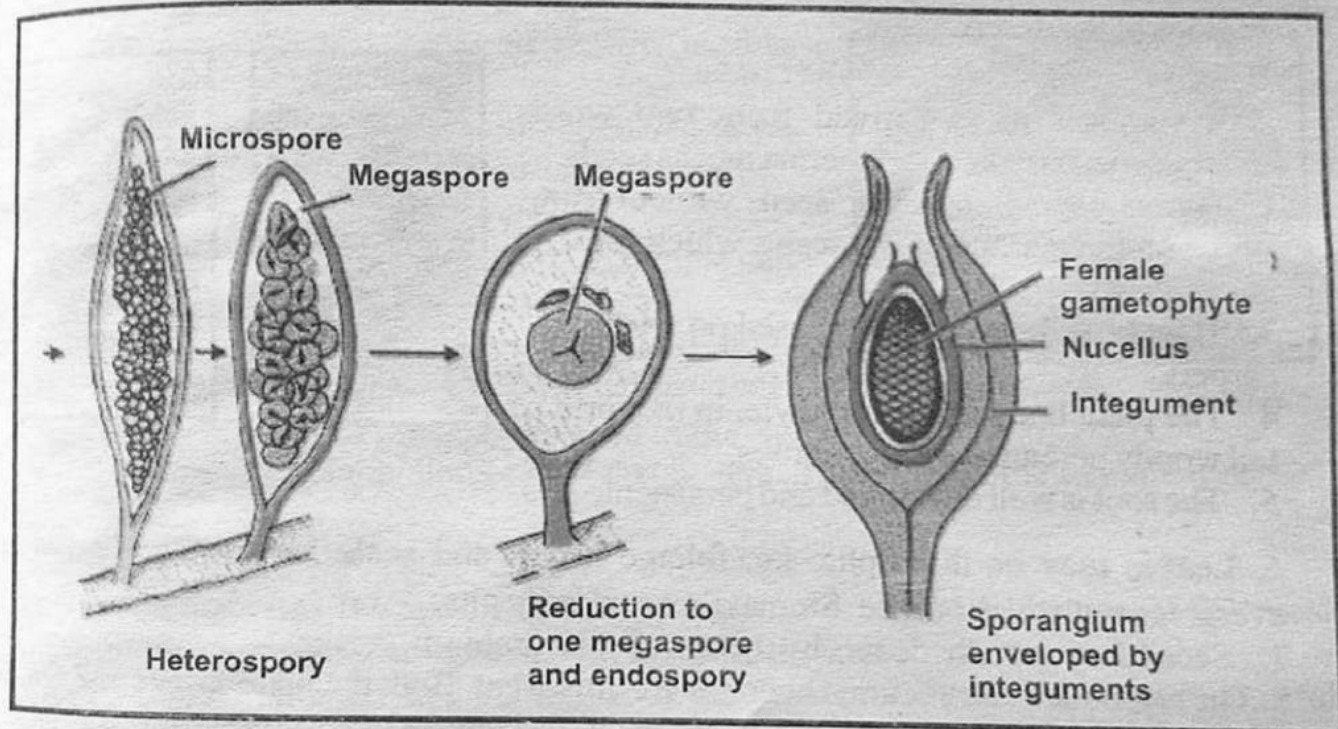


Fig: 8.15 Main steps in the evolution of seed

c. Formation of integument around the megasporangium and evolution of ovule

The fossil record shows that there were certain fern like plants that bore seeds. In this case the megasporangium was surrounded by branch like outgrowths. These outgrowths became fused, during evolution, to form an envelope like structure called integuments, around the sporangium. The integuments form protective covering. The integumented megasporangium in which the megaspore is retained is called an ovule or unripe seed.

The ovule also contains large quantity of food for the developing embryo. These two characters protection and food are the best adaptive characters of land plants to their environment to make them prominent on earth.

d. Evolution of pollen tube

The non vascular plants and the lower vascular plants require water for fertilization. They produce motile flagellated sperms that reach the non motile egg through water from rain or dew etc. However the seed plants do not depend on water for fertilization. The evolution of pollen tube parallels the evolution of seed.

The egg produced in the ovule is enclosed and protected by the integuments and the sperms would not be able to reach the egg. This obstacle is overcome by the development of pollen tube that acts as a vehicle for the transport of sperms to the eggs inside the ovule ensure fertilization. Thus the seeded plants can grow in a variety of terrestrial environments from the alpine environments of the mountains to the arid regions of the desert.

8.4.2 Class 2 Gymnospermae

1. Gymnosperm is derived from two words, gymnos means naked and sperma means seeds.
2. Gymnosperms produce seeds without fruit, borne on the surface of the scales which form a cone.
3. They bear their ovules exposed on open carpels.
4. The plant body is a sporophyte, in the form of tall woody perennial trees or shrubs.
5. The root is well developed and persistent.
6. Leaves may be dimorphic i.e. foliage leaves and scale leaves. The leaves are evergreen with thick cuticle. Stomata are sunken in pits.
7. Secondary growth occurs by the activity of cambium.
8. The reproductive structures or cones are unisexual. Both the male cones and female cones lie on the same plant (monoecious plants).
9. The plants are heterosporous i.e. producing microspores or pollen grains and megaspores or embryo sacs.
10. Fertilization is single and development of embryo is partial because only $\frac{1}{4}^{\text{th}}$ of oospore is concerned with the development of embryo.
11. Polyembryony (the production of many embryos simultaneously) is of common occurrence but finally a single embryo matures.
12. The number of cotyledons in the seed is variable from one to many.
13. There is a clear alternation of sporophytic and gametophytic generation.
14. The significant character showing advancement over the pteridophytes is the permanent retention of the megaspore in the megasporangium fertilization and development of embryo inside it. This feature has given rise to seed habit.



Fig: 8.16 Male Cone

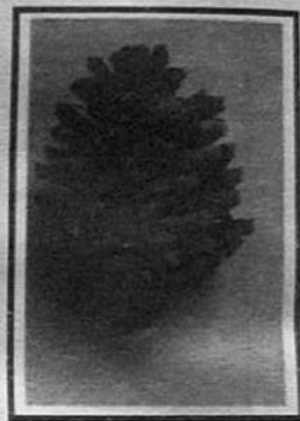


Fig: 8.17 Female cone

a. Main groups of Gymnosperms:

The two main groups of the living gymnosperms are the cycads and the conifers or cone bearing trees. The cycads are tropical and sub tropical plants showing many fern like characters. Examples are *Cycas circinalis* and *C. revoluta*.

The conifers constitute the largest and most important group of gymnosperms. They are mainly the natives of temperate regions, well represented in the hills where they form big forests. The conifers of Pakistan include Pines, Firs, Cedars, spruce etc.

b. Uses of Gymnosperms

1. They are the best source of timbers used in building constructions.
2. They are the best wood source utilized in the construction of boats, railway lines etc. example *Cedrus deodara* etc.
3. They are the sources of resins. Example chir pine (*Pinus roxburgii*).
4. They are the best source as food item. Example chilghoza pine (*Pinus gerardiana*).
5. Leaves of *Taxus baccata* are used in the synthesis of compounds called taxols, which are used in the treatment of breast cancer.

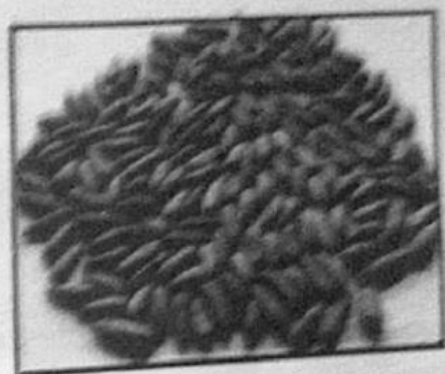


Fig: 8.18 Chilghoza pine nuts

8.4.3 Class 3: Angiospermae

Angiosperms (Greeks: angio = sac, sperma = seeds) form one of the most highly evolved group of spermatophyta (seed plants). As the name shows the seed of angiosperms are enclosed in the fruits. They are flowering plants. The most successful and important of these plants belong to grass family which have colonized great areas of the earth surface in practically all sort of soil and climatic conditions. They constitute the main source of man's food supply.

a. Differences between monocots and dicots

- Class Angiosperm are further divided into 2 sub-classes i.e monocotyledonous and dicotyledonous. Following are the differences between monocot and dicot.
1. In dicotyledons, the embryo bears two cotyledons; whereas in monocotyledons, it bears only one.
 2. In the dicotyledonous embryo, the plumule is terminal and the two cotyledons lateral, but in the monocotyledonous embryo, the plumule is lateral and the cotyledon terminal. This is, however, not true in all cases.
 3. In dicotyledons, the primary root persists and gives rise to the tap root; while in monocotyledons, the primary root soon perishes and is replaced by a group of adventitious roots.

4. As a rule venation is reticulate in dicotyledons, and parallel in monocotyledons. Among monocotyledons, *sarsaparilla*, *Smilax* and yam (*Dioscorea*), however, show reticulate venation and among dicotyledons, Alexandrian laurel (*Calophyllum*) shows parallel venation.

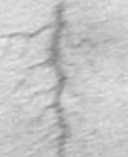
Monocots				
				
One cotyledon	Veins usually parallel	Vascular bundles usually complexly arranged	Fibrous root system	Floral parts usually in multiples of three
Embryos	Leaf venation	Stems	Roots	Flowers
Dicots				
				
Two cotyledons	Veins usually netlike	Vascular bundles usually arranged in ring	Taproot usually present	Floral parts usually in multiples of four or five

Fig: 8.19 Differences between monocot and dicot plants

- The dicotyledonous flower has commonly a pentamerous symmetry; while the monocotyledonous has trimerous symmetry.
- In the dicotyledonous stem, the vascular bundles are arranged in a ring and they are collateral and open. In the monocotyledonous stem, the bundles are scattered in the ground tissue and they are collateral and closed. Also the bundles are more numerous in monocotyledons than in dicotyledons. Further, the bundles are more or less oval in monocotyledons and wedge-shaped in dicotyledons.
- In the dicotyledonous root, the number of xylem bundles varies from 2 to 6, seldom more, but in the monocotyledonous root, these are numerous, seldom a limited number (5 to 8).
- Cambium soon makes its appearance in the dicotyledonous root as a secondary meristem and gives rise to the secondary growth, but in the monocotyledonous root cambium is altogether absent, and hence there is no secondary growth.

8.4.4 Life Cycle of Angiosperms

The angiospermic plant is a diploid sporophyte which is composed of root, stem, leaves and flowers. Flower is the reproductive organ, while stamens and the carpels are its reproductive parts. Stamens are male reproductive parts while the carpels are the female reproductive parts. Each stamen consists of an anther with four pollen sacs. A large number of microspores are produced by meiosis in each pollen sac. The wall of microspore becomes thick and is known as pollen grain.

During pollination the pollen grains are transferred to the stigma of the carpels. The pollen grain germinates and develops into male gametophyte or microgametophyte. The nucleus of the pollen grain divides into a generative nucleus and vegetative or tube nucleus. The generative nucleus divides into two male gametes. The pollen grain sends down a tube called the pollen tube which contains two male gametes and tube nucleus. The pollen tube together with the two male gametes and a tube nucleus constitutes the male gametophyte.

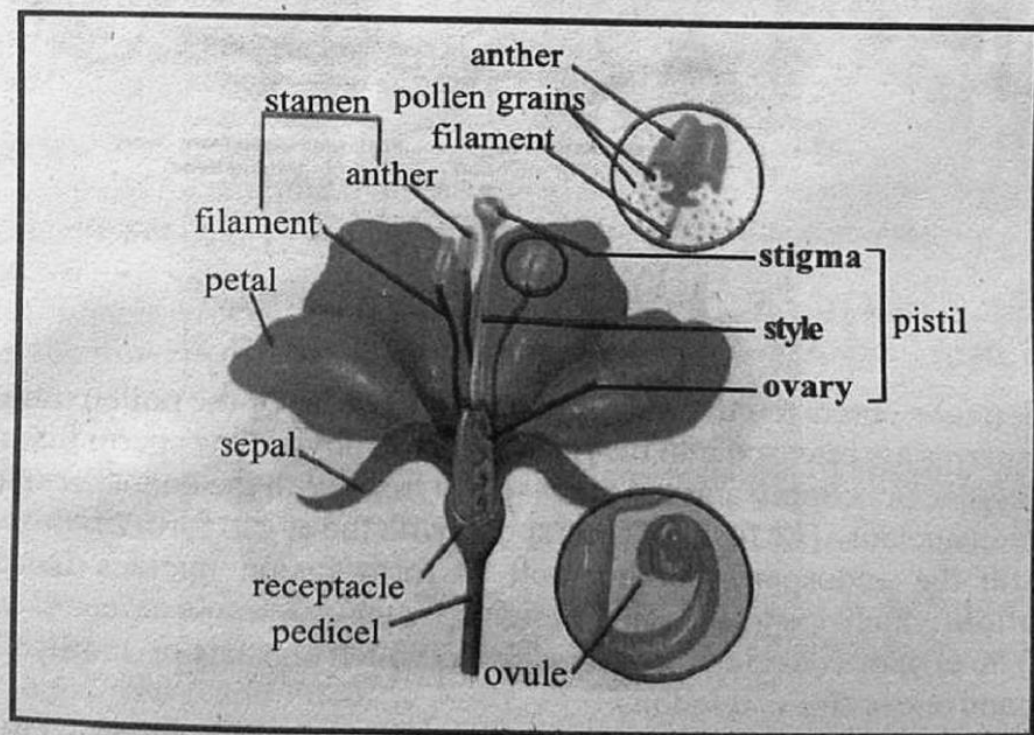


Fig: 8. 20 Structure of a typical flower

The carpel consists of a basal swollen part, the ovary, which contains one or many ovules. The ovule consists of a tissue called nucellus, which is covered by the integument. Certain changes occur in the ovule, leading to the formation of megaspore. The megaspore generally develops into seven celled female gametophyte or embryo sac. One of these seven cells is the egg or oosphere, one as endosperm mother cell (diploid in nature), two synergid cells and three antipodal cells.

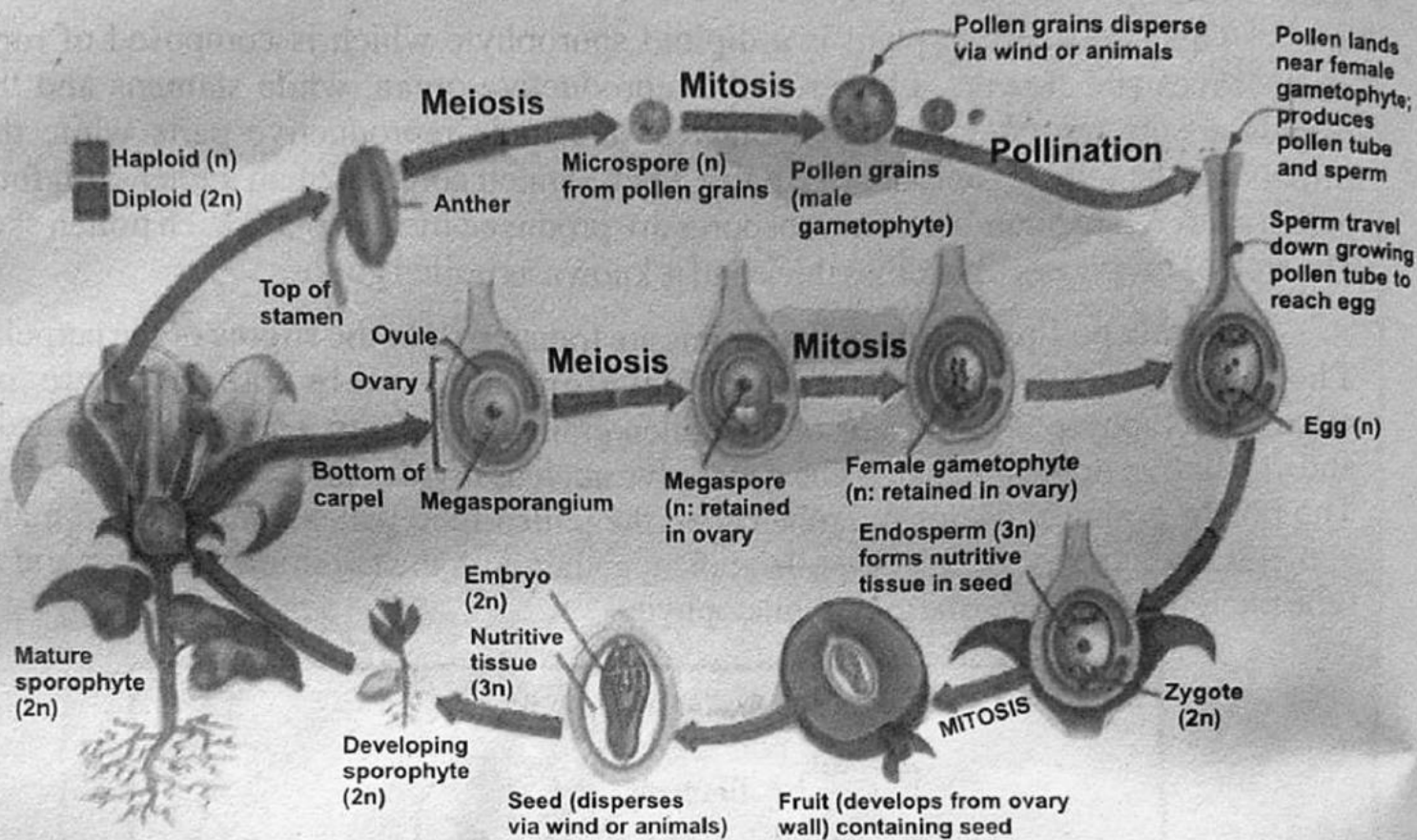


Fig: 8.21 Life cycle of an angiospermic plant.

The pollen tube enters the female gametophyte. The tip of the pollen tube ruptures and the two sperms are released into the female gametophyte. One sperm fuses with the egg to form zygote or oospore and the other sperm fuses with the endosperm mother cell to form fusion nucleus. The fusion of one sperm with the egg to form zygote and that of the other with the endosperm mother cell to form fusion nucleus is called **double fertilization**, which occurs only in the angiosperms.

The oospore develops into an embryo which consists of a radical, hypocotyle, plumule and one or two cotyledons.

The fusion nucleus develops into a nutritive tissue called endosperm. After fertilization in ovule matures into seed. The integuments of the ovule form the seed coats called testa and tegmen. The walls of the ovary develop into fruit on ripening. Under favourable conditions, the seed germinates to produce seedling which on development becomes sporophyte. The two kinds of generation i.e. gametophyte and sporophyte, one after the other show alternation of generation.

Angiosperms are successful because they can adapt themselves to almost all kinds of environments. Moreover they produce flowers, fruits and seeds which show

various adaptations for dispersal over large areas. Double fertilization is of common occurrence. They range in size from 1mm up to 100 m (*Wolfia* = 1mm, *Eucalyptus* = 100 m). They possess broad leaves and may be annual, biennial or perennial.

c. Inflorescence and its major types

In some angiosperms individual flowers are quite large and are borne singly on the pedicel. Such flowers are termed as solitary flowers. In most angiosperms the flowers are small and occur in groups. Such cluster of flowers arranged on the floral axis is called an inflorescence. Cluster of flowers in some way ensures pollination, fertilization and thus the reproductive success of the species.

The inflorescence may be racemose or cymose. In a racemose inflorescence the main axis continues to grow indefinitely until the last flower is formed at its apex. The oldest flowers are toward the base of the inflorescence and the youngest ones toward the apex. In a cymose inflorescence the main axis soon ends in a flower. One, two or more lateral branches develop below the terminal flower, each ending in a flower like the main axis. In this case the terminal flower is the oldest and the lateral flowers are younger.

Chief types of racemose inflorescence are:

1. Typical Raceme

In a typical raceme the main axis is elongated and bears laterally a number of flowers. Each flower has a pedicel or stalk e.g. *Cassia fistula* (amaltas)

2. The spike

The spike is a racemose inflorescence in which the main axis is elongated like raceme but the flowers are sessile i.e. without stalk e.g. *Achyranthus* (puth kanda) and bottle brush.

3. Catkin

It is a spike that usually bears only pistillate or staminate flowers. Examples are mulberry and willow.

4. Corymb

In this case the main axis is comparatively short and the stalks of the lower flowers are longer than those of the upper younger ones. As a result, all the flowers lie at about the same level e.g. *Iberis* (candytuft).

5. Umbel

In umbel the main axis is shortened. Flowers are stalked. Due to shortening of main axis, the flowers appear to arise at one level e.g. *Hydrocotyl* (brahmi booti). In some cases a number of umbels are present on the tip of the main axis. Such a compound inflorescence is called umbel of umbels or compound umbel e.g. carrot.

6. Panicle

A branched raceme is called panicle e.g. grapes, mango and oat.

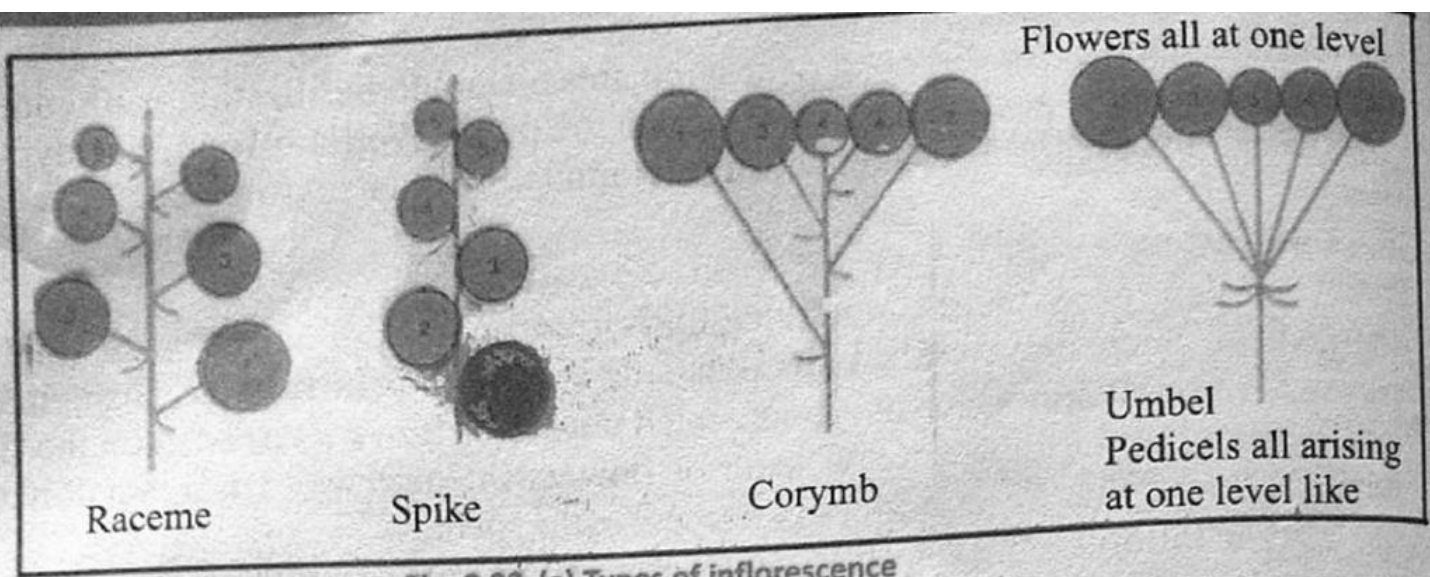


Fig: 8.22 (a) Types of inflorescence

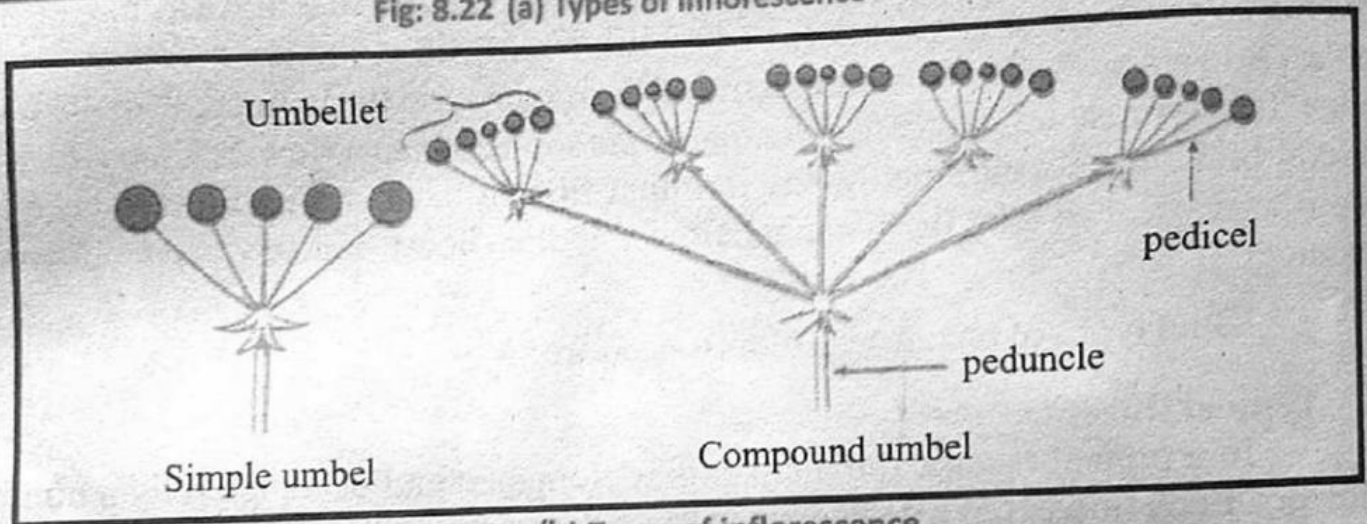


Fig: 8.22 (b) Types of inflorescence

7. Capitulum

In capitulum or head, the flowers are sessile and are crowded together on a very short axis. It looks like a single flower e.g. sunflower.

Chief types of cymose inflorescence are:

1. Uniparous Cyme (Monochasial Cyme)

In this case the main axis ends in a flower below which it produces one daughter axis only. The daughter axis as well as each succeeding one again end in flower and gives rise to one daughter axis only e.g. *Begonia*, *Tradescantia*.

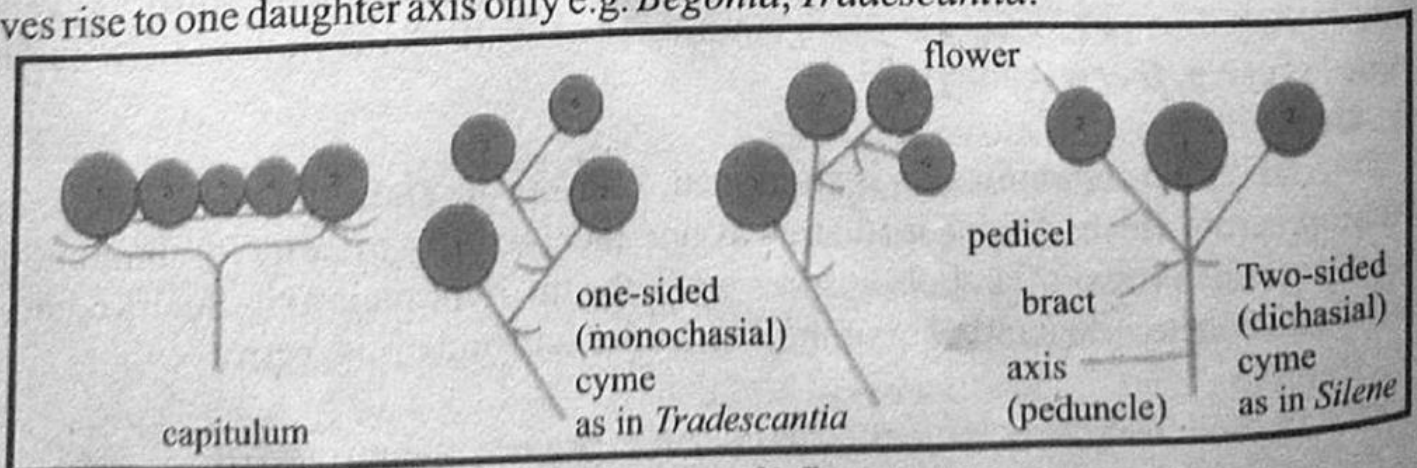


Fig: 8.22 (c) Types of inflorescence

2. Biparous Cyme (Dichasial Cyme)

In biparous cyme the main axis ends in a flower and produces two daughter axis. Each of the two daughter axis again ends in a flower and produces two daughter axis which may continue the branching in the same manner e.g. *Silene*, *Ipomoea*.

3. Multiparous Cyme

In multiparous cyme the main axis ends in a flower and produces three or more daughter axis each of which continues the branching in the similar manner e.g. *Euphorbia*.

d. Benefits of Angiosperms for Humans

Angiosperms contribute huge quantities of food and of great variety, e.g. cereals such as corn, wheat, barley, rye, rice; legumes like beans, peanuts, soybeans; fruits, vegetables and nuts, etc., Besides food, they also supply fibres such as cotton, linen (flax), jute, Indian hemp, Manila hemp, Sisal hemp, etc., which are used in the manufacture of rope, string nets and bags. The most important of these fibres are the cotton fibres, used in the manufacture of clothing. Uses of plants in various industries and as medicines contribute to the well-being of mankind. Various articles of daily use and of economic importance are obtained from the flowering plants. Some of these, such as wood for building and furniture, fats and oils, fibres, cereals, fruits, sugar, drugs, (e.g. quinine, digitain, morphine, cocaine, etc.), dyes (indigo, haematoxylon, saffranin, chlorophyll, etc.), tea, coffee, spices, tobacco, paper, tannins, resins, gums, essential oils, rubber, fuel, alcohol, etc. Green flowering plants are also responsible for purifying the atmosphere as they absorb carbon dioxide and give out oxygen during photosynthesis.

One of the important aspect of angiosperms is their medicinal nature. Some of the more prominent plants in this regard are discussed below:

1. Cannabis (*Cannabis sativa*)

Used medicinally for thousands of years, today it is used in the treatment of sleeping disorders, autoimmune diseases and glaucoma.

2. Coca (*Erythroxylon coca*)

Cocaine was widely used as a local anaesthetic in the 19th century and coca leaf tea is taken for altitude sickness in South America.

3. Daffodil (*Narcissus spp.*)

Galantamine hydrobromide, a compound derived from daffodil bulbs, is being used to treat Alzheimer's disease.

4. Deadly nightshade (*Atropa belladonna*)

All parts of this plant, especially the berries, contain the extremely toxic chemical atropine. Atropine is used to relax the muscles of the eye and to stop muscular spasms.

5. Fever tree (*Cinchona succiruba*)

A native of Latin America, the bark of the fever tree produces quinine, which is used to treat malaria.

8.5 Vascular plants as successful land plants

Angiosperms form one of the most highly evolved sub-classes of Spermatophyta (Seed plants), the other being gymnosperms. The spermatophyta have been recently estimated to include about 300 families, 12500 genera and 300000 already known species. New species are being added each year by the extended survey of the vegetation of the earth and by a more critical examination of the older materials. Evidently, the angiosperms constitute a rapidly expanding group which dominates the world of plants today.

To this vast assemblage of flowering plants must also be added thousands of new varieties, races or strains, etc. which owe their origin as also their perpetuation to man and to the care be bestowed upon them on account of their economic or commercial importance. The most successful and important of these plants belong to Gramineae or the grass family with 7500 species, which have colonized great areas of the earth surface in practically all sorts of soil and climatic conditions and constitute the main source of man's food supply.

The factors responsible for the success of angiosperms are;

1. Their adaptability to all kinds of environments.
2. The production of flowers, fruits and seeds which show various adaptations for dispersal over large areas.

The conifers (gymnosperms) and other vascular plants (Pteridophytes) though widely distributed are, however, not found to flourish in such diverse habitats as do the angiosperms.

DO YOU KNOW?

Deodar or Himalayan Cedar (*Cedrus deodara*) is the National tree of Pakistan.



KEY POINTS

- The fossil records of different organisms show the time period on the geological time scale when they were present abundantly on earth
- Phyletic lineage provides a link between the present day organisms with their remote past ancestors.
- In plants such as mosses and liverworts, the gametophytic generation is larger, dominant and autotrophic due to the presence of chlorophyll, while the sporophytic generation is smaller, less complex and heterotrophic, being partially or totally dependent upon the gametophyte.
- Bryophytes are the first plants which migrated to land. Bryophytes comprise the small and simplest non flowering land plants which usually occur in moist shady places.
- Bryophytes had invaded the land from water and therefore, they are called the first invaders of land among the plants.
- Tracheophytes have cells called tracheids which are water - conducting cells of xylem.
- The phylum tracheophyta is further divided into the Sub - Phylum: Psilopsida, Lycopsidea, Sphenopsida and Pteropsida.
- Microphyllous leaf is with a single vein and megaphyllous leaf is with many veins.
- Psilopsida, a group of seedless vascular plants have evolutionary importance as they represent connecting link between bryophytes and pteridophytes.
- Seed may be defined as a ripened and fertilized ovule.
- In most angiosperms the flowers are small and occur in groups. Such cluster of flowers arranged on the floral axis is called an inflorescence.
- Angiosperms constitute a rapidly expanding group which dominates the world of plants today.

A.

- In bryophytes the male reproductive organ is known as:
a. Stamen b. Antheridium
c. Carpel d. Archegonium
- The plants in which the seeds are enclosed in the fruit are:
a. Gymnosperms b. Angiosperms
c. Bryophytes d. Tracheophytes
- The flower in which both the male and female reproductive parts are present is termed as:
a. Staminate b. Pistillate
c. Hermaphrodite d. Heterogamous
- The microspore produced in the microsporangia germinates to form:
a. Male gametophytes b. Female gametophytes
c. Sporophyte d. Embryophyte
- Gymnosperm is characterized by:
a. Having fruits b. Having seeds
c. Lacking ovaries d. Having vessels
- Male gametophyte of angiosperm is represented by:
a. Pollen grain b. Anther
c. Microsporangium d. Pollen mother cell
- Which one of the following is triploid structure?
a. Integuments b. Pollen grain
c. Antipodals d. Endosperm
- Embryo sac is termed as
a. Megasporangium b. Megaspore
c. Female gametophyte d. Female gamete
- The plants which have naked seeds belong to the group:
a. Tracheophytes b. Gymnosperms
c. Angiosperms d. Pteridophytes
- Double fertilization is the characteristic feature of only the:
a. Angiosperms b. Gymnosperms
c. Pteridophytes d. Bryophytes

EXERCISE ?

11. The inflorescence of mulberry and willow is called
 - a. Catkin
 - b. Corymb
 - c. Umbel
 - d. Panicle
12. The female gametophyte of the flowering plants is also known as the
 - a. Ovule
 - b. Endosperm
 - c. Embryo sac
 - d. Placenta
13. Which of the following characteristics differentiates pteridophytes from gymnosperms?
 - a. Production of seeds
 - b. Formation of archegonia
 - c. Production of pollen tube
 - d. Alternation of generation
14. The liverwort and mosses belong to which group of plants?
 - a. Thallophytes
 - b. Bryophytes
 - c. Pteridophytes
 - d. Gymnosperms
15. The Tracheophytes include which of the following groups of plants?
 - a. Thallophytes and Bryophytes
 - b. Bryophytes and Pteridophytes
 - c. Pteridophytes and Spermatophytes
 - d. Thallophytes and Spermatophytes
16. Which one of the following vascular plants is said to be a living fossil?
 - a. Rhynia
 - b. Psilotum
 - c. Selaginella
 - d. Equisetum
17. Mycorrhiza is a common feature of the sporophytes of:
 - a. Psilotum
 - b. Selaginella
 - c. Pinus
 - d. Rhynia
18. The most highly evolved plants are the:
 - a. Angiosperms
 - b. Gymnosperms
 - c. Bryophytes
 - d. Pteridophytes
19. Catkin type of inflorescence is found in:
 - a. Mulberry
 - b. Grapes
 - c. Candytuft
 - d. Euphorbia

B. Write answers to the following short questions.

1. Define alternation of generation and give its importance.
2. What is the role of heterospory in the evolution of seed?
3. Differentiate between an antheridium and an archegonium.
4. Give two differences between bryophytes and tracheophytes.
5. Write three examples of sub phylum psilopsida.
6. Write four differences between angiosperms and gymnosperms.
7. What is the difference between microphyllous leaf and megaphyllous leaf?

EXERCISE



C. Answer the following questions in detail.

1. Describe the adaptations shown by bryophytes to land life.
2. Explain the life cycle of flowering plant.
3. Write detailed note on any two of the following.
 - a. Psilopsida
 - b. Sphenopsida
 - c. Lycopsida
4. Give important characters of liverworts and hornworts.

Projects

- Teacher may plan a trip to nearby area with natural vegetation and ask his/her students to collect plants in the following manner.
 1. Two examples of bryophytes.
 2. Two examples of fern.
 3. Five examples of angiospermic plants.
 4. Three examples of gymnospermsTake guidance from the teacher for proper preservation of plants.
- Make a medicinal plant collection present in your local environment. Paste them on cards and write their taxonomic classification for every collected plant. Take guidance from your teacher for identification and classification of your plant collection.

- Describe the general characteristics of animals.
- Classify animals on the base of presence and absence of tissues.
- Differentiate the diploblastic and triploblastic levels of organization.
- Describe the types of symmetry found in animals.
- Differentiate pseduocoelomates, acoelomates and coelomates.
- Classify coelomates into protostomes and deuterostomes.
- Describe the general characteristics, importance and examples of sponges, cnidarians, platyhelminths, aschelminths (nematodes), mollusks, annelids, arthropods and echinoderms.
- Describe the evolutionary adaptations in the concerned phyla for digestion, gas exchange, transport, excretion, and coordination.
- Describe the characteristics of invertebrate, chordates and vertebrates.
- List the diagnostic characteristics of jawless fishes, cartilaginous fishes and bony fishes.
- Describe the general characteristics of amphibians, reptiles, birds and mammals.
- Differentiate among monotremes, marsupials, and placentals.
- Describe the evolutionary adaptations in concerned groups for gas exchange, transport and coordination.