CHAPTER 8

DIVERSITY AMONG PLANTS

Number of allotted teaching periods: 20

Major Concepts:

8.1 The Evolutionary Origin of Plans (1 Period)

8.2 Nonvascular Plants (4 Periods)

8.3 Seedless Vascular Plants (5 Periods)

8.3.1 Evolution of Leaf

8.4 Seed Plants (10 Periods)

8.4.1 Evolution of Seed

8.4.2 Gymnosperms

8.4.3 Angiosperms

The kingdom **plantae** or **plant kingdom** comprises hundreds of thousands of different species. They live in every type of habitat, from frozen Arctic tundra to tropical rain forests and deserts. These range in size from minute, almost microscopic duckweeds, to massive giant sequolas, some of them are the largest organisms that has ever lived.

8.1 THE EVOLUTIONARY ORIGIN OF PLANTS

In the beginning the plants were restricted only to aquatic conditions. The migration started towards land nearly 400 million years ago. Plants are thought to have descended from a common protistan ancestor, an ancient freshwater alga. Because of their common ancestory the living green algae and plants share a number of features.

Both contain the same photosynthetic pigments: **chlorophylls** a and b, **carotenes** and **xanthophylls**. Both store **carbohydrates** as starch inside chloroplast. Both have cellulose in cell wall. Both types of organisms form a cell plate during cytokinesis. Plants and some algae have a two-generation life cycle called **alternation of generation** that involves sporic meiosis.

Diagnostic Features of Plants

The diagnostic features of plants are :

(1) Plants are multicellular eukaryotes with well-developed tissue and have autotrophic nutrition.

(2) Plants are well protected from being dried up in air by their cuticle, formed from a waxy substance called **cutin**.

(3) The plant body has root, stems and leaves having vascular tissue xylem, phloem and **cellulose** rich **cell walls**,

(4) Plants show alternation of generation. It consists of the sporophyte the diploid generation that produces haploid spores by meiosis. Spores develop into a haploid generation. The gametophyte is the haploid generation, which produces gametes that unite to form a diploid zygote.

(5) The plants are oogamous; the gametes are eggs and sperms.

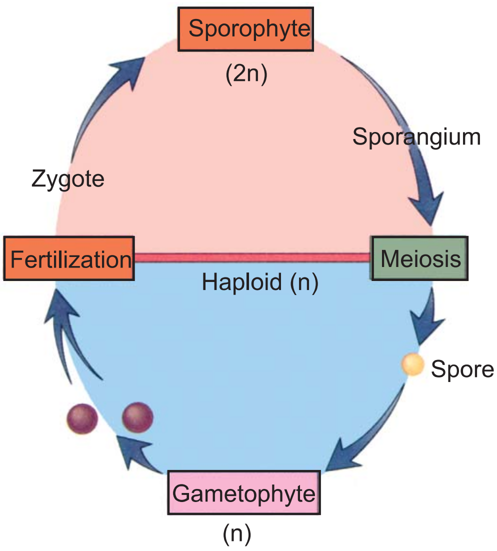


Fig: 8.1 Alternation of Generation

Four major groups of plants are living today. These are: (a) Bryophytes, (b) Seedless vascular plants, (c) Gymnosperms, (d) Angiosperms.

Bryophytes are small plants that lack vascular tissues and reproduce by spores. The other three groups of plants have vascular tissues xylem and phloem. Seedless vascular plants reproduce by spores like bryophytes. Gymnosperms are vascular plants and reproduce by forming seeds, borne exposed on a stem or cone. Angiosperms are vascular plants, which reproduce by forming seeds enclosed within a fruit.

8.2 NON-VASCULAR PLANTS

Plants are currently divided into two main groups: the nonvascular and the vascular plants. The nonvascular plants consist of three groups: hornworts (division Anthocerotophyta), liverworts (division Hepatophyta), and mosses (division Bryophyta).

The nonvascular plants lack vascular tissues specialized means of transporting water and organic nutrients. Although they often have a "leafy" appearance, these plants do not have true roots, stems, and leaves—which by definition must contain true vascular tissue. Therefore, the nonvascular plants are said to have rootlike, stemlike, and leaflike structures.

General Characteristics of Bryophytes

Bryophytes is considered as a phylum and also as a group or division. The bryophyta is a group of plants comprising of liverworts, hornworts and mosses are the only nonvascular plants. Bryophytes are typically quite small and a few exceed 2 centimetres in length.

They generally require a moist environment for active growth and reproduction, but some bryophytes tolerate dry areas. .

The gametophytes of bryophytes are green and manufacture their own food. They are relatively large and evident as compared to sporophytes. Some of their sporophytes are completely enclosed within gametophyte tissue, others that are not enclosed; turn brownish or straw coloured at maturity.

Fig: 8.2 Mosses Covering Several Rocks

The four main features of bryophytes are:

(1) They lack specialized vascular tissues.

(2) Multicellular sex organs produce embryo.

(3) Sporophytes are always smaller and obtain their food from the gametophyte.

(4) Their life cycles are similar to seed plants. Bryophytes are also called **amphibious plants** because they need water for development, existence and reproduction.

Life Cycle of Moss

The moss plants show two generations the sporophyte and the gametophyte, which regularly alternate with each other. It is known as **alternation of generation**. The life cycle is completed when the plant passes through these two generations.

The matured green shoot is the **gametophyte**. It produces gametes and reproduces by sexual method. The sex organ is at the apex of the shoot. The male sex organ is known as **antheridium** and the female sex organ as **archegonium** *(ar-keh-gonium)*. The sex organs are intermixed with some multicellular hair like structures, known as **paraphyses**. The two sex organs may occur on the same plant i.e., **monoecious** or on two separate plants i.e. **dioecious**. The **sporophyte** consists of a foot which is embedded in the tissue of the gametophyte and a **stalk** with a **sporangium**.

Spores are formed in the sporophyte by meiosis, thus the spores are haploid. The spore germinates into alga like structure called **protonema**, having bud and branches. The bud gives rise to gametophyte. In the antheridium the sperms are produced. In the **archegonium** the egg is produced. The flagellated sperms swim through the film of water to the egg. Fertilization is internal. The diploid zygote divides and forms the embryo. The embryo develops into a diploid sporophyte.

The Land Adaptations of Bryophytes

The land adaptive characteristics exhibited by nonvascular plants are:

(1) The Multicellular Plant Body and Conservation of Water: The plant body of liverworts is called thallus and is multicellular e.g. *Marchantia* (*Mar-kan-shia*). The **thallus** consists of hundreds of cells. Only the cells of the upper layer are exposed to the atmosphere. Some cells are photosynthetic and some are storage cells. Water cannot evaporate from these inner cells

Science Titbits

The name moss is often commonly used for plants that are not truly mosses. For example reindeer moss is lichen that is a dominant form of vegetation in the Arctic tundra, Spanish moss is a flowering plant and club moss is relative to ferns.

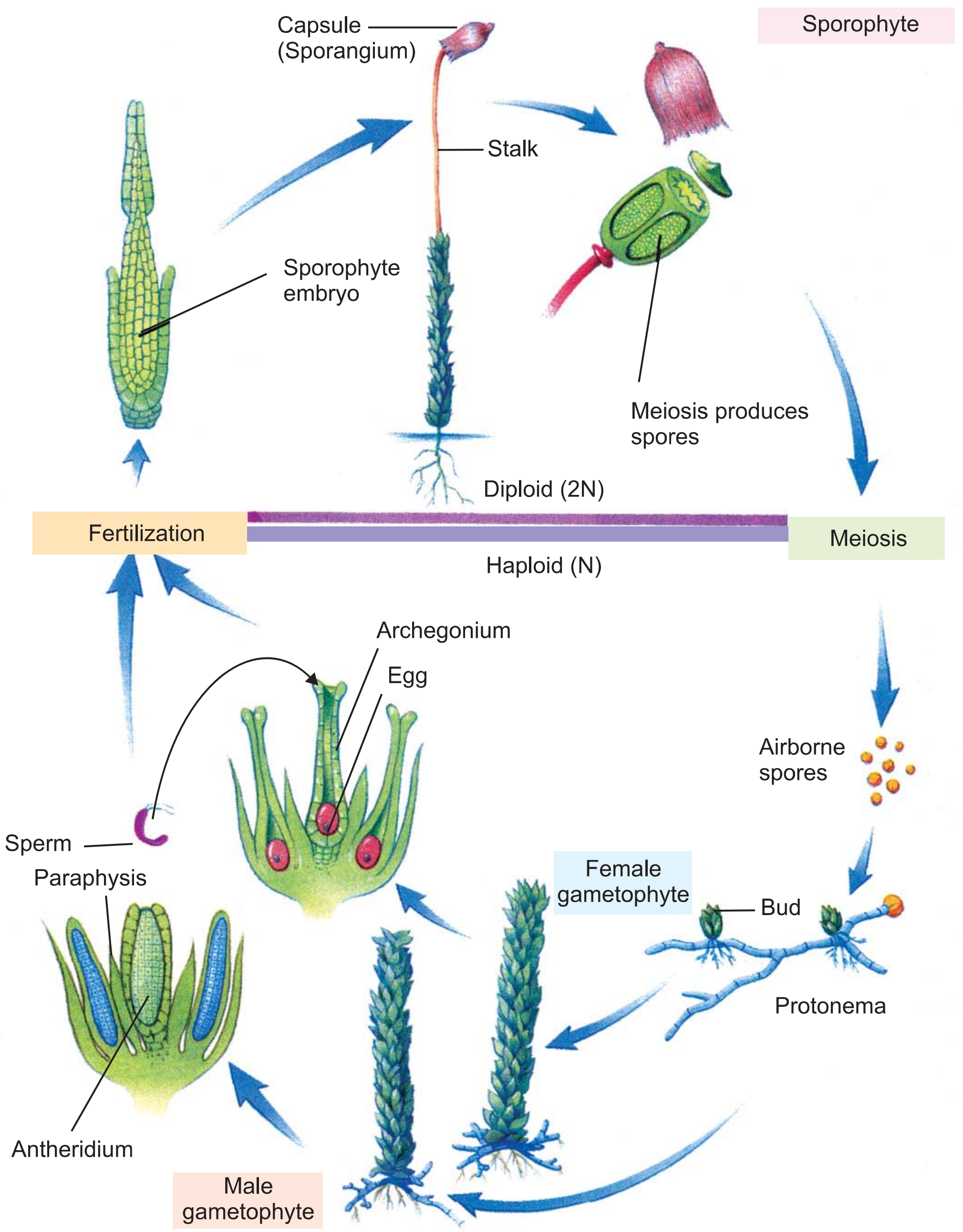


Fig: 8.3 Life Cycle of Moss (*Funaria*)

because the upper epidermis has covering of **cutin**, which is a wax like substance. It reduces the evaporation of water in some mosses and liverworts. The layer of cutin is called **cuticle**.

(2) Absorption of Carbon Dioxide: The upper epidermis in *Marchantia* has many **pores**. The pores open into the air chamber. The air chamber is surrounded with photosynthetic cells. CO_2 is absorbed by large amount of wet surfaces of the photosynthetic cells of the air chambers. CO_2 then diffuses into the cytoplasm. When CO_2 is being absorbed, evaporation of water may occur through the pores.

Fig: 8.4 Marchantia Thallus

(3) Absorption of Water: The structures for absorption of water in moss and liverworts are **rhizoids**. These are present on the lower surface of the *Marchantia* thallus. Rhizoids are long filamentous structures. They are unicellular and are extensions of the cell of the lower epidermis. Rhizoids increase the surface area for absorption of water from the soil and also help in anchorage.

(4) Heterogamy: When two types of gametes are produced, it is called heterogamy. Sperms and ova are produced by the nonvascular plants e.g. Moss, *Marchantia* etc. The **sperms** are flagellated and motile require water wedutus for reaching egg. The **egg** is large and nonmotile. It contains large amount of food. The food is used to nourish the early stages of the developing embryo after the fertilization of egg. Due to the water requirement for fertilization they cannot live away from water and are thus called **amphibious plants**.

(5) Protection of Reproductive Cells: The moss, *Marchantia* etc. can be distinguished as male and female plants. The sex organs are multicellular, (whereas in algae the sex organs are unicellular). In the moss plants the sex organs are at the tip of the green shoot. The male sex organ is called **antheridium** and it produces sperms. The female sex organ is called **archegonium** (ar-keh-gonium). It produces eggs. The sex organs are covered by sterile hairs to prevent the drying of the sex organs. Most of the cells of the sex organs are sterile which form a protective coat around the egg and sperms. Protection of spore is performed by sporangium.

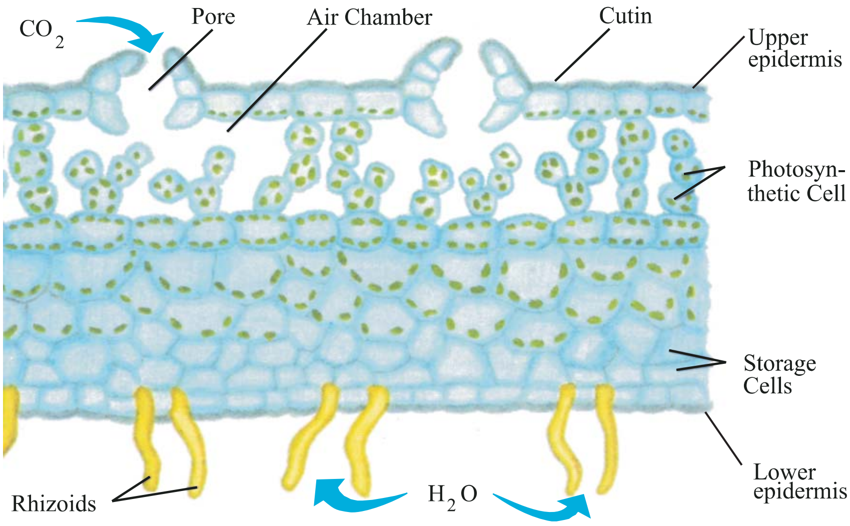


Fig: 8.5 Transverse Section of Marchantia Thallus

(6) Embryo Formation: Fertilization is inside the archegonium. The zygote divides to form the embryo and is retained inside the archegonium. The chances of survival of embryo are increased as it is protected by the wall of the archegonium. Embryo is present in all bryophytes and vascular plants.

Fig. 8.6 Disk shaped structures that bear antherida

Umbrella shaped structures that bear archegonia

(7) Alternation of Generations: The mosses and liverworts have a life cycle with alternating gametophyte and sporophyte generations. It increases the chances of survival of the plants on land.

Q. Where will you find bryophytes in Pakistan?

Uses of Bryophytes

Mosses play an important role in their environment. They hold the soil in place and help prevent erosion. They provide food for animals, especially birds and small mammals. Commercially the most important mosses are the **peat mosses**. Their leaves hold water and are beneficial as a soil conditioner. When added to sandy soils peat moss helps to hold and retain moisture.

8.3 SEEDLESS VASCULAR PLANTS

Because the seedless vascular plants are not closely related, each type is placed in its own division. The seedless vascular plants include whisk ferns (division Psilotophyta), club mosses (division Lycopodophyta), horsetails (division Equisetophyta), and ferns (division Pteridophyta).

General Characteristics of Vascular Plants

Vascular plants (L. *vasculum*, dim. of *vas*, vessel) include ferns and their allies, gymnosperms, and angiosperms. Vascular tissue in these plants consists of **xylem** (Gk. *xylon*, wood), and **phloem** (Gk. *phloios*, bark). The vascular plants have true roots, stems, and leaves. Xylem, with its strong-walled cells, supports the body of the plant against the pull of gravity. The leaves are fully covered by a waxy **cuticle** except where it is interrupted by **stomata.** The **sporophyte generation** is diploid and dominant in vascular plants. The vascular plants are complex, extremely varied, and widely distributed.

The **seedless vascular plants** (ferns and their allies) disperse the species by producing **windblown spores**. When the spores germinate, a relatively **large gametophyte** is formed which is independent of the sporophyte for its nutrition. In these plants, **flagellated sperm** are released by **antheridia** and swim in a film of external water to the **archegonia**, where fertilization occurs.

In **seed plants**, there is a separate **microgametophyte** (male) and

megagametophyte (female). The microgametophyte and megagametophyte are dependent on the sporophyte, which is fully adapted to a dry environment. The mature microgametophyte is the **pollen grain**. The megagametophyte retains the megaspores in the megasporangium. This modified structure is called **ovule**. The fertilized ovule becomes **embryo**, which is retained within the body of the sporophyte, becomes a **seed**. Seed dispersal occurs by wind and water or by animals to a new location.

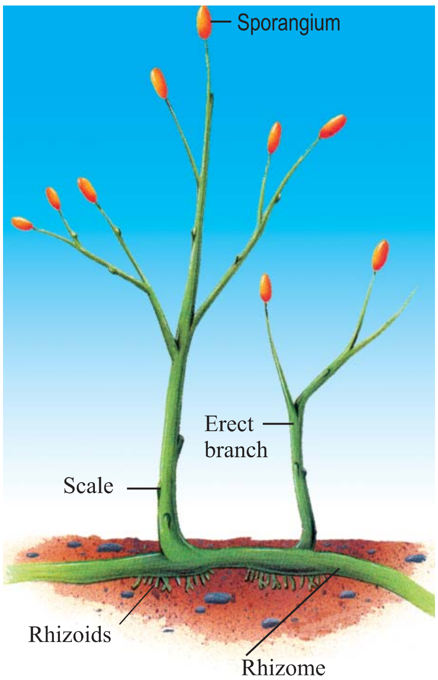


Fig : 8.7 ***Rhynia***

Characteristics of Seedless Vascular Plants

Psilopsida—Whisk ferns

The group psilopsida (division or phylum Psilotophyta/Psilophyta) includes the simplest known vascular plants known as **whisk ferns**, named for their resemblance to whiskbrooms. The whisk fern lack true roots but bear underground stems called rhizomes that bear **rhizoids**. Aerial stems have no leaves they have only tiny scales fork repeatedly and carry on photosynthesis. **Sporangia** are present at the tips of the branches. Most members of

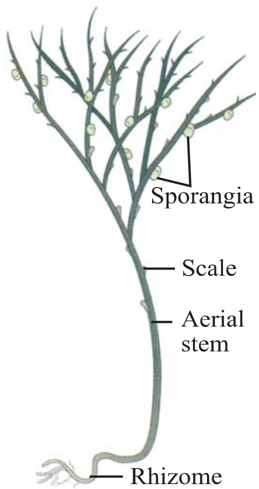



Fig : 8.8 Whisk Fern, *Psilotum*

this group are extinct and these fossil plants are known collectively as **psilophytes**. Examples of extinct group are *Rhynia*, *Psilophyton* and *Cooksonia*. *Psilotum* is the most common living genus. Another living genus is *Tmesipteris*.

Lycopsida – Club Mosses

Lycopsida or Lycodophyta includes the **club mosses**, **spike mosses** and **quillwort**. The plant body consists of a branching **rhizome** which sends up aerial stems less than 30 cm tall. Tightly packed scale like leaves cover the stem branches of the plants. The leaves are **microphylls**, having only one strand of vascular tissue. In club mosses the sporangia are born on terminal clusters of leaves called **strobili** (sing. strobilus) which are club shaped. They are only living plants to have microphylls. The familiar members of this group belong to genera *Lycopodium* and *Selaginella*.

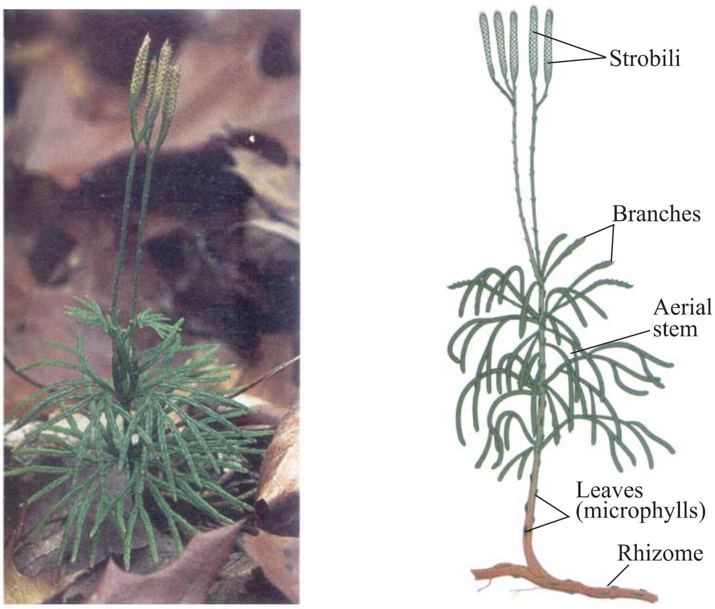


Fig : 8.9 Club Moss, *Lycopodium*

Sphenopsida - Horsetails

Sphenopsida (Equisetophyta or Sphenophyta) commonly known as horsetail, are found in waste and wet places round the world. Sphenopsida includes more fossil plants than living one. Today there is only one surviving genus *Equisetum*.

A rhizome produces aerial stem. The stems are slender, green, hollow structure, and appear jointed as slender green side branches are present at the nodes. The small and scale like leaves also form whorls at the **nodes**, the nodes are separated by **internodes**. Many horsetails have strobili at the tips of the stem.

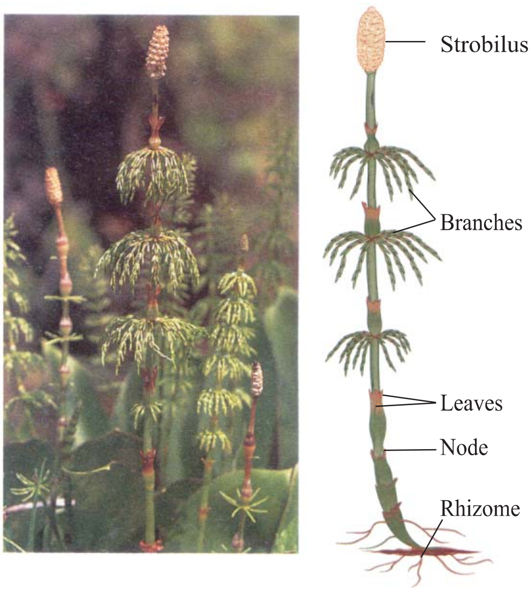


Fig : 8.10 Horsetail, *Equisetum*

Q. Why *Equisetum* is called Horse tail?

Pteropsida - Ferns

Ferns belong to the group pteropsida (division pterophyta/ pteridophyta), subgroup or class **filicinae**, which are most abundant group of seedless vascular plants. Ferns a wide-spread group of plants, are much more abundant in warm and moist tropical regions.

Ferns range in size from reduced aquatic forms less than a centimetre, to a tree fern that may have trunks more than 24 metres tall, with leaves up to 5 metres or more long. All but a few ferns are **homosporous**. Sporophyte generation is much larger, more conspicuous, and more complex than the

Fig : 8.11 Ferns

gametophyte. Sporophyte is completely independent. Sporangia is foliar i.e. attached to leaves or fronds. When the frond is young and immature, it is coiled. This pattern of development is called **circinate vernation**. It is an important feature of ferns.

The moss *Sphagnum* grows in bogy places that is low lowing, wet, spongy places forming dense and deep masses called peat bog. One of the distinctive features of this moss is a presence of large empty cells in the leaves, which apparently function to hold water. This feature makes peat moss particularly beneficial as a soil conditioner. When added to sandy soils, for example, peat moss helps to hold and retain moisture. In some areas as bogs, the dead *Sphagnum* accumulates and do not decay. This accumulated moss called **peat** can be used as fuel.

Peat bog

Peat mosses *Sphagnum*

Science, Technology and Society Connections

Describe the formation and importance of peat bogs.

8.3.1 EVOLUTION OF LEAF

Leaves are present in higher vascular plants. They have evolved from the primitive vascular plants. There are two main types of leaves in vascular plants: (a) One veined leaves. (b) Many veined leaves.

One veined leaves are small and scale like. They have single vascular bundle and vein. Therefore they are called single or one veined leaves or microphyllous leaves e.g. club mosses (*Lycopodium*).

Many veined leaves are large leaves having prominent blade. As many veins and vascular bundles are present, so they are called many veined leaves or megaphyllous leaves e.g. Ginkgo etc.

Evolution of Single Veined Leaves

There is no fossil record showing the evolution of microphyllous leaves. However two hypotheses (singular; hypothesis) have been proposed to explain their origin: (a) outgrowth hypothesis (b) reduction hypothesis.

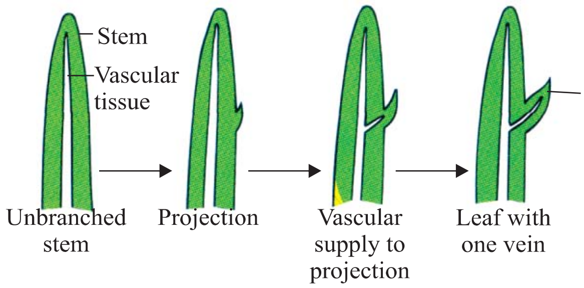


Fig: 8.12 Evolution of Single Veined Leaf, Outgrowth Hypothesis

Out-growth hypothesis: According to this hypothesis single veined leaf originated as simple outgrowth from the naked branches of the primitive plant. The outgrowths had no vascular tissues. With the increase in size, vascular tissues were needed for the transportation of food, water etc. and support. Thus vascular supply was extended from main vascular bundle of stem giving rise to a single veined leaf.

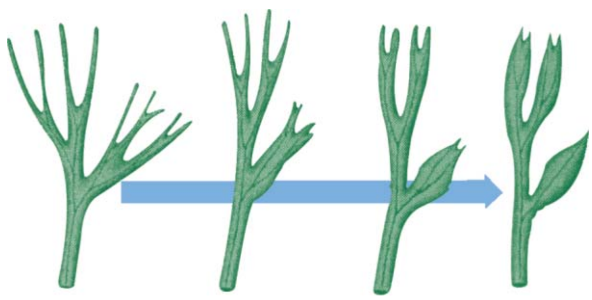


Fig: 8.13 Evolution of Single Veined Leaf, Reduction Hypothesis

Reduction Hypothesis: The early vascular plants had leafless branches. These branches were gradually reduced in size. Thus by simplification and reduction in size and flattening of the leafless branches the microphyllous leaves were evolved.

Evolution of Many Veined Leaf

It is evident from fossil record that these leaves have evolved through

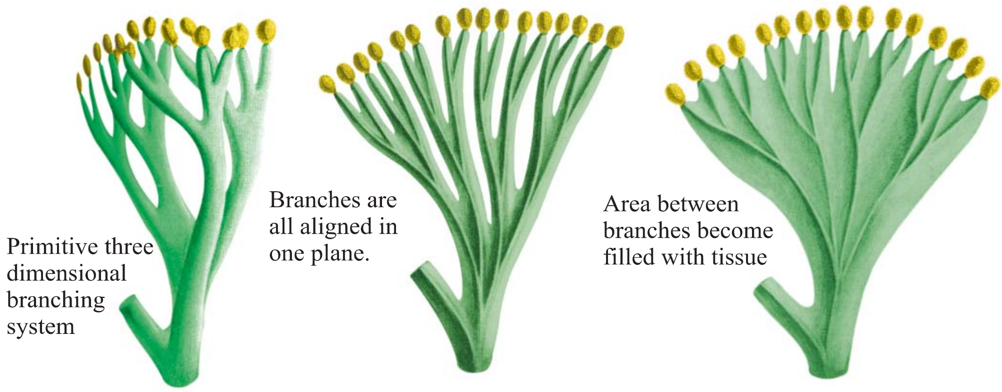


Fig: 8.14 Evolution of Many Veined Leaf

modification of the forked branches found in early vascular plants e.g. *Rhynia*. According to this view the following three steps have taken place.

Plannation: The forked branches were changed to a single plane.

Flattening: The branches became flat.

Webbing: The spaces between the bundles and branches of vascular tissues became filled with photosynthetic tissues. The structure resembles superficially to the webbed foot of the duck and thus a many veined leaf evolved.

Life Cycle of Fern

The life cycle of *Adiantum* (Maidenhair fern) shows heteromorphic alternation of generation. The gametophyte is small reduced, haploid and independent. It bears antheridia and archegonia which produce antherozoids (sperms) and eggs (ova) respectively.

Fertilization leads to zygote formation which develops into an embryo within the archegonium. Embryo develops into an independent **sporophyte**. The sporophyte is dominant, diploid plant body and produces on the underside of the leaflets of compound leaves (frond), number of sori. Each **sorus** contains a cluster of sporangia, producing **haploid spores**. The spores are dispersed by wind. When a spore falls on a moist soil it germinates under favourable conditions forming haploid gametophyte.

The fern life cycle differs from that of a moss primarily in the much greater development, independence and dominance of the fern's sporophyte. In addition, the fern's sporophyte is more complex than that of moss having vascular tissue and well differentiated roots, stem and leaves.

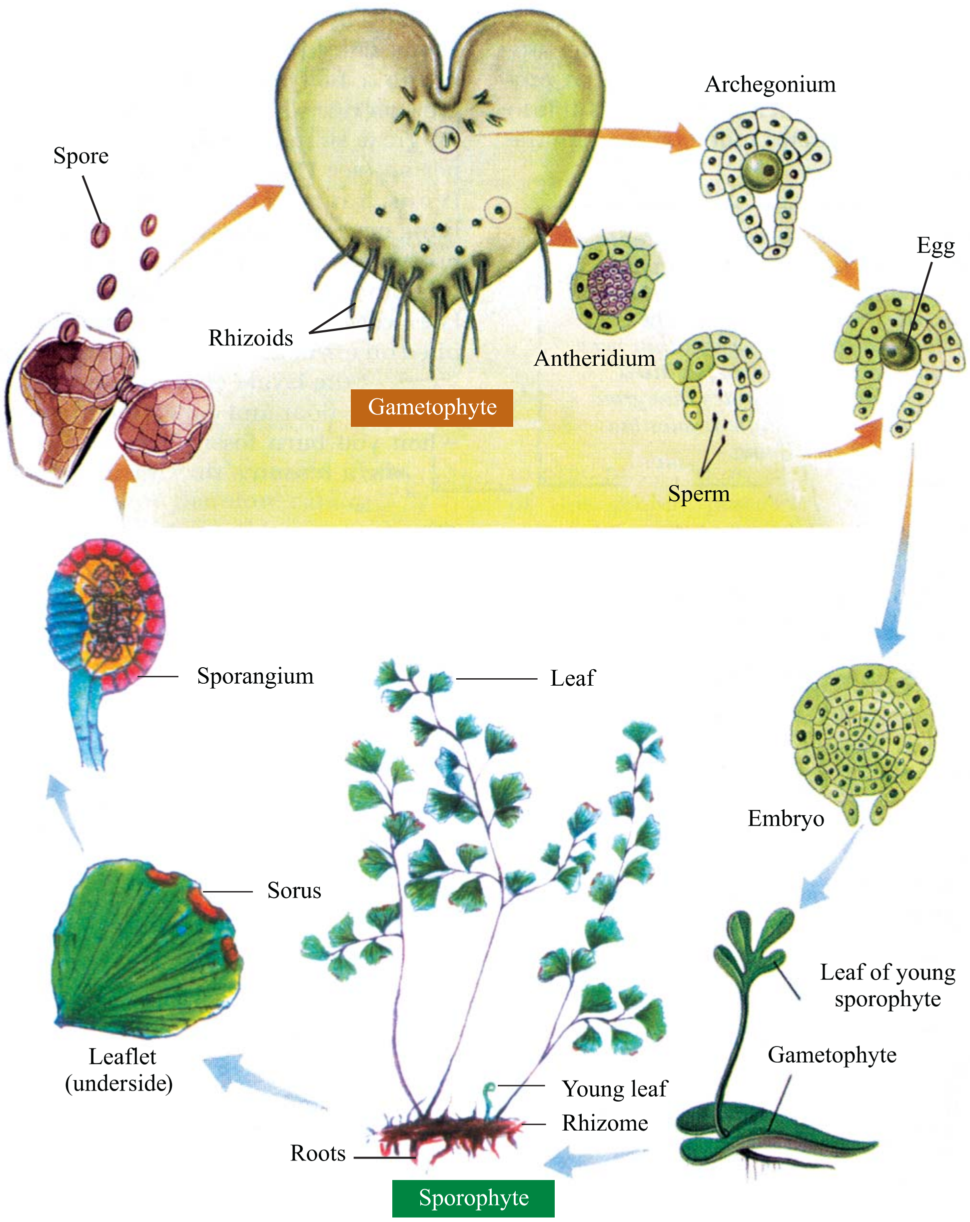


Fig : 8.15 Life Cycle of Fern (*Adiantum*)

VASCULAR PLANTS - Successful Land Plants

The three groups of vascular plants i.e. seedless ferns, naked seeded gymnosperm and covered seeded angiosperms show many adaptations to become the successful group of land plants.

Adaptations of Ferns: (a) Have true roots, stems and leaves. (b) Leaves are green photosynthetic. (c) Gametophyte lacks vascular tissue. (d) Gametophyte is separated from sporophyte. (e) Flagellated sperms require outside source of water for fertilization. (f) Some ferns e.g. bracken fern (*Petridium aquilinum*) can spread into drier areas by means of vegetative (asexual) reproduction. (g) Fern also spreads by means of rhizome.

Adaptations of Gymnosperms: Gymnosperms have well developed roots and stem. Many are tall trees that can withstand heat, dryness and cold. **Pollen grains** are transferred by wind, and the growth of the pollen tube delivers a sperm to an egg. Enclosure of the dependent **megagametophyte** in an ovule protects it during its development and shelters the developing zygote as well. Finally the **embryo** is protected within the seed. All these factors increase the chance for reproductive success on land.

Adaptations of Angiosperms: The evolutionary adaptations of flowering plants account for their success in terms of ecological dominance and large number of species. Angiosperms have true roots, stems and leaves. Roots are often modified for storage e.g. food or water. The vascular tissue is well developed. **Xylem tissue** in angiosperms is different from that of virtually all other vascular plant groups because it contains **xylem vessels** as well as **tracheids**. **Leaves** are generally broad, expanded blades and are very efficient in absorbing light for photosynthesis. Shedding of leaves during cold or dry spells is also an advantage for survival in harsh environment. **Angiosperms** are found in all sorts of habitats and some have even returned to water. The reproductive organs are in the **flowers**, which attract animal pollinators. Flowers are modified in wind pollinated plants.

Seeds are reproductively superior to spores for three main reasons. First a seed contains a multicellular, well-developed young plant with embryonic root, stem and leaves already formed, whereas a spore is a single cell. Second, a seed contains a food supply. After germination, the plant embryo is nourished by food stored in the seed until it becomes self-sufficient. Because a spore is a single cell, few food reserves exist for the plant that develops from a spore. Third a seed is protected by a well resistant seed coat, as compared to the thick wall of the spore. Along with primary growth **secondary growth** has also helped the survival of angiosperm (also gymnosperms) on land.

Importance of Seedless Vascular Plants

The seedless vascular plants are of economic importance. *Lycopodium* and *Selaginella* are chiefly grown as **ornamental plants** and are utilized in the preparation of christmas wreathes. Spores and stems of *Lycopodium* have got some medicinal importance. Ducks and other aquatic animals feed upon the corm of *Isoetes*.

The **ferns** are mostly ornamental plants of gardens and greenhouses. Some of them are used in the preparation of bouquets and are also placed in the buttonholes. In some tropical countries stems and leaves of tree ferns are used for **building purposes**, because the wood of the ferns resists decay particularly by termites. Some genera, like *Pteris*, *Ceratopteris* and *Marsilea*, are edible. The rhizome of the male fern yields a drug, which is utilized for removing the intestinal parasites. The maidenhair fern are the source of expectorant. Practically all the members of the seedless vascular plants have contributed extensively to coal formation.

8.4 SEED PLANTS

The two groups of seed bearing vascular plants are the gymnosperms and angiosperms. The seed of gymnosperm are produced exposed on the surface of the sporophylls that make up cones. The seeds of angiosperms are usually enclosed by a fruit produced from a flower.

8.4.1 EVOLUTION OF SEED

Botanists now generally agree that seed plants were derived from a single common ancestor. From ecological and evolutionary perspective seed represents an important evolutionary advancement. A seed may be considered as a fertilized **megasporanguim**. It has integument around the embryo. The seed is found in higher vascular plants i.e. gymnosperms and angiosperms. During evolution the seed has passed through the following stages.

Development of Heterospory

All seed plants are heterosporous produce microspore and megaspore. Microspores are formed in microsporangia and megaspores are formed in megasporangia. The megaspore grows into a female gametophyte and microspore grows into a male gametophyte. The megaspores of the seed plants are retained inside the sporangium, where the megaspore develops into a tiny female gametophyte.

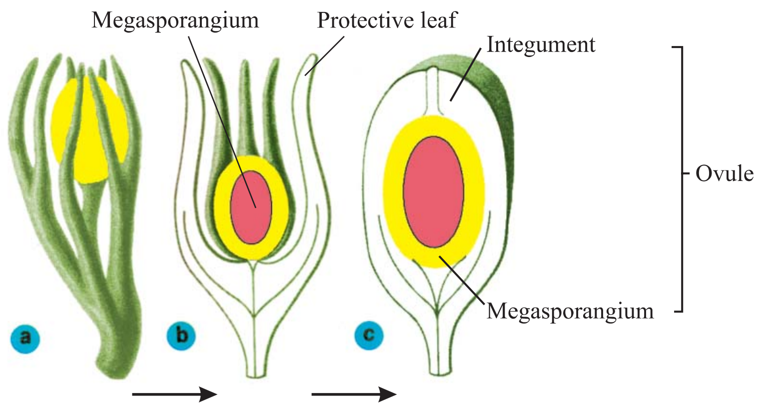


Fig: 8.16 Evolution of Seed

Evolution of Pollen Tube

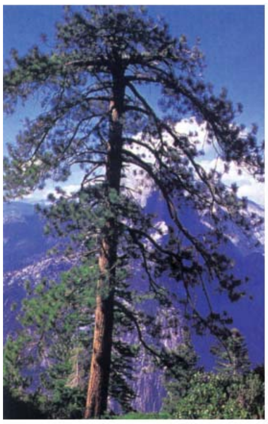
The evolution of pollen tube parallels the evolution of seeds. The egg produced inside an ovule is very well protected in the sporangium. It is so well protected that flagellated sperm would not have the slightest chance of ever reaching an egg. This obstacle has been overcome by the development of **pollen tubes**. Once the pollen grain reaches the cone or flower, it germinates. The germinated pollen grain is a tiny **male gametophyte**. It produces a long pollen tube, which grows to the ovule and then digests its way through the protecting layers to the enclosed egg.

Evolution of Integument Around the Megasporangium and Seed

In carboniferous period (geological period 280-350 millions years ago), fern like plants were present. The sporophyte of these plants had little protective branch like outgrowths, surrounding the megasporangium. During evolution the outgrowths fused together forming integument, enclosing the **megasporangium**. **Megaspore** is retained in the megasporangium. This modified structure is called an **ovule**. The fertilized ovule evolved into **seed** because of retention of developing embryo.

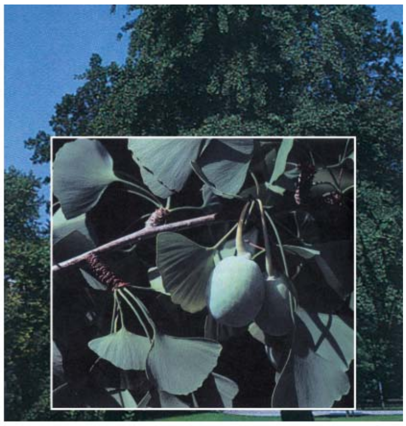
8.4.2 GYMNOSPERMS

General Characteristics: The plant body may be tall, woody, perennial trees or shrubs. The plant body is a sporophyte, differentiated into stem, leaves and root. Stem is branched with the exception of *Cycus*, which is rarely branched. There are two types of leaves. The foliage leaveas and the scalar leaves. Foliage leaves may be simple or compound. The leaves are evergreen with thick cuicle. Venation is simple. The arrangement of leaves may be spiral or cyclic. Leaves exhibit xerophytic features like thick and tough cuticle, stomata sunken in pits, presence of wax on the surface. Xylem consists of tracheids and xylem parenchyma. Vessels and wood fibres are generally absent with exceptions of Gnetales. Companion cell are absent in phloem. Cones are unisexual. Male and female sporophylls are arranged on straight axis. Gymnosperms are heterosprous i.e produce microspores and megaspores. There is alternation of generation i.e sporopohytic and gametophytic generation. Polyembryony is of common occurrence, but finally a single embryo matures.



Conifers*: Pinus*

Cycus



Ginkgo

Gnetophytes*: (a) Ephedra*

(b) Welwitschia

Fig: 8.17 Gymnosperms

Science Titbits

There are four groups of gymnosperms. Conifers, Cycads, Ginkgo and Gnetophytes. In gymnosperms, the seeds are not covered. Instead they are exposed on the surface of the sporophyll, leaves that bear sporangia. Reproductive organs are usually borne in the cones on which sporophylls are spirally arranged. Other than these features, the four groups of gymnosperms have little in common.

Uses of Gymnosperms

Pine seeds like chilghoza are eaten as dry fruits. Ephedrine, a drug from *Ephedra* is used for the relief of asthma and other respiratory ailments. Conifers are a source of soft wood for construction, packing, plywood, board and for making paper. **Cycads** are grown as ornamental plants. *Cycas circinalis*, which grows as a wild cycad, serves as a source of "sago". It is pure starch extracted in liquid state and then solidifies to form small granules. Resins, terpentine, tar and many oils are obtained from conifers.

8.4.3 ANGIOSPERMS

Angiosperms are the flowering plants. Their seeds are enclosed by fruits. The term angiosperms literary means "enclosed seed" (*angio*: closed, *sperm* seed). The leaves bearing ovules are folded and joined at the margins to form

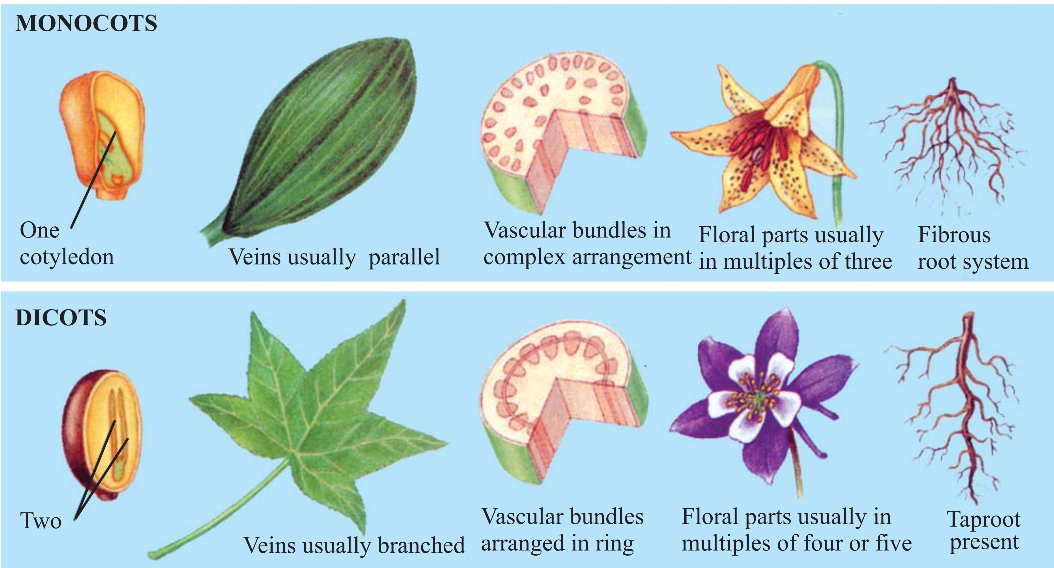


Fig: 8.18 Comparison: Monocots and Dicots

ovaries. The ovary after fertilization is changed into fruit. This is exceptionally a large and successful group of plants. Angiosperms live in all sorts of habitats, from fresh water to desert and from frigid north to the torrid tropics. Angiosperms have well developed vascular and supporting tissue. The xylem tissue consists of tracheids and vessels. Gametophyte generation is very small and inconspicuous. Pollen and ovules are produced in flowers. Sporophyte is the dominant generation. They vary in size e.g. *Eucalyptus* about 100 meters high and *Wolffia* (Duckweed) about 1 mm in length. Dicots and monocots have common characters, like, vascular tissues, differentiated plant body, flower, fruits, and seeds. The two groups may be differentiated as shown in table 8.1.

Table 8.1 Differences Between Dicots and Monocots

	Dicots	Monocots
LEAF	Broad, generally bifacial with reticulate venation	Long narrow, lanceolate, monoficial with parallel venation.
STEM	Vascular bundles in ring vascular cambium is present which gives secondary growth.	Vascular bundles scattered vascular cambium usually absent so no secondary growth occurs.
ROOT	Primary root is a tap root which develops lateral root. 2-8 patches of xylem, vascular cambium present, secondary growth occurs.	Adventitious roots arise from the base of stem, and give rise to a fibrous root system. Always more than 8 patches of xylem. Vascular cambium absent so no secondary growth.
SEED	Embryo has two cotyledons.	It has one cotyledon.
FLOWER	Typically tetra or penta-merous calyx and corolla usually differ from each other. Flowers are usually insect pollinated.	Parts usually in three i.e. trimerous. No distinction between calyx and corolla. Flowers are often air pollinated.
Example	Rose, pea, buttercup etc.	Lilies, orchids, grasses, wheat, rice.

Life Cycle of a Flowering Plant

There is an alternation of generations in the flowering plants. The sporophyte, a diploid dominant generation alternates with haploid inconspicuous gametophytic generation.

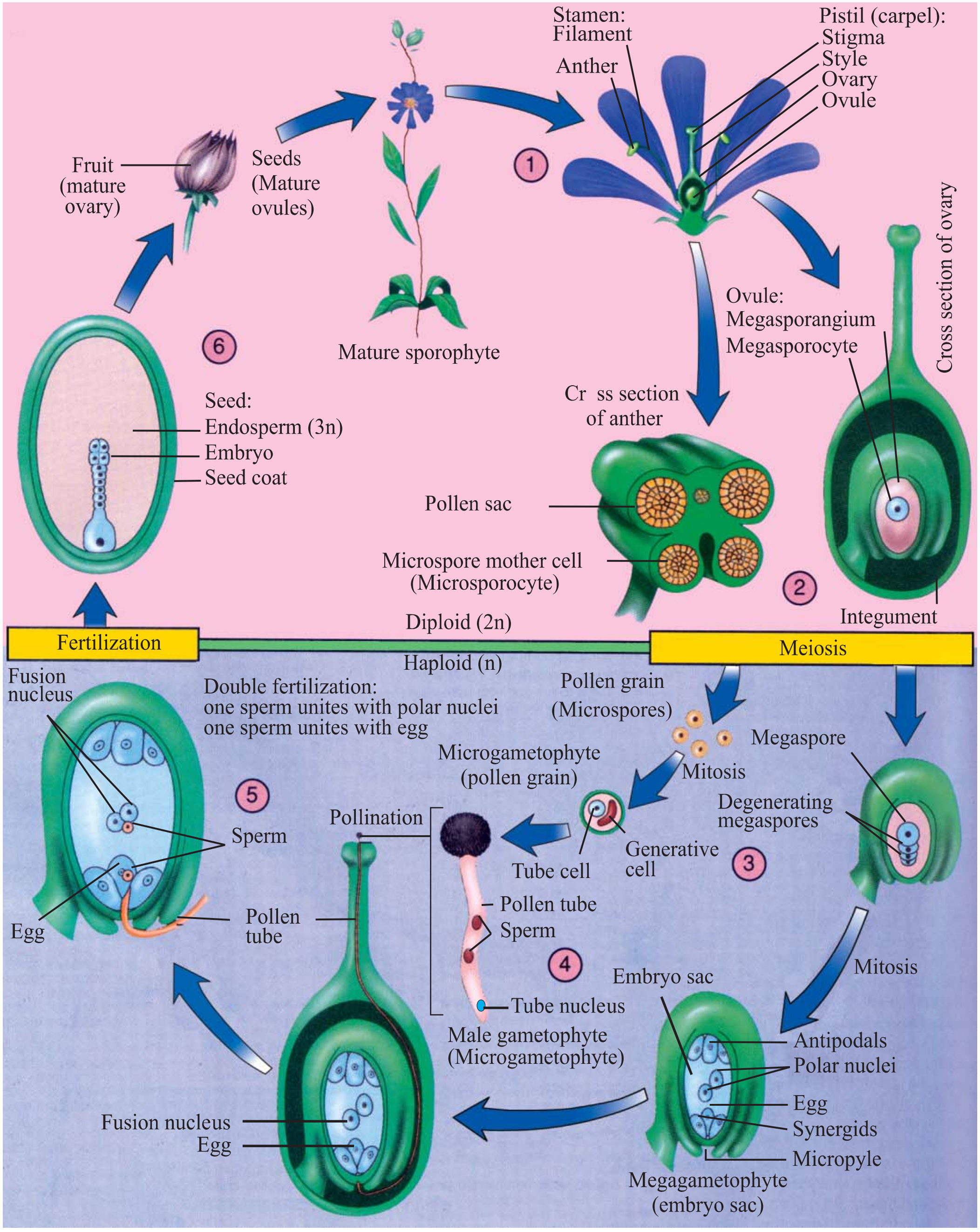


Fig: 8.19 Life Cycle of Angiosperm

Sporophyte

The main plant body is diploid sporophyte which produces haploid spores, Flower is the reproductive structure which bears anthers and carpels as male and female reproductive parts respectively.

Male Gametophyte

The anther when fully developed contains 2 to 4 elongated sacs called **pollen sacs**. The pollen sacs contain pollen grains.

Formation of Pollen Grains: When the anther is developing, mitotic divisions produce local masses called **microspore mother cells** (microsporocyte). Following meiosis in a diploid mother cell, four haploid microspores are produced. A **microspore** divides mitotically into a two celled, **pollen grain** (microspore). A tough wall develops around the pollen grain, which protects the contents of the pollen grain from drying out.

Pollen Tube: Cells on the surface of the stigma secrete a sticky nutrient fluid containing sugar and other substances. After pollination the pollen grains germinate on the stigma. Each pollen grain produces a slender, thin walled pollen tube. The pollen tube grows down, through the tissues of the stigma, style and ovary until it reaches the ovule.

Tube Nucleus: As the pollen tube develops, the two nuclei of the pollen grain move into it. The two nuclei are called generative nucleus and the pollen tube nucleus. Generative nucleus divides again to form two somewhat elongated **sperms**. The tube nucleus is located near the tip of the pollen tube with two sperms following behind. The pollen tube, containing tube nucleus and the two sperms (male gametes), is the **male gametophyte** (microgametophyte).

Q. Why is pollen tube called male gametophyte?

Female Gametophyte

The **ovule** is an egg shaped structure attached by a stalk, to the inside of the ovary. Depending upon the species of the plant involved, an ovary may have one, two, several or even thousand of ovules. The ovule has an opening called **micropyle**. Certain cells (megasporocyte) of the ovule undergo meiosis to produce four monoploid (haploid) cells. Only one of these cells survives. The surviving cell is called the **megaspore**, which means large spore. The megaspore nucleus divides by mitosis to form two haploid nuclei. Each of these nuclei divides two more times to produce a total of eight haploid nuclei. At the centre of the ovule is the microscopic structure called **embryo sac** having all these eight nuclei. Wall formation takes place and these nuclei are converted into cells.

The cells of embryo sac are: (a) Antipodal cells – 3 (b) Polar nuclei – 2 (c) Synergids – 2 (d) Egg - 1

Antipodal cells are three in number and are present at the opposite end of the micropyle, and have no function and sooner or later get disorganized. **Synergids** are two in number at the micropyler end. These help in fertilization by guiding the pollen tube and as soon as their function is over these get disorganized. **Polar nuclei** are two in number, placed in the centre. By the time egg has been fertilized, the two polar nuclei have combined to form a single **fusion nucleus**.

Egg is one in number and is present between the two synergids. Soon after the tip of the pollen tube enters the embryo sac, the end of the tube ruptures and releases the two sperms into the embryo sac. The first sperm fuses with the egg to form a **zygote**.

The zygote develops into an embryonic plant within the ovule. The second sperm deposited in the embryo sac by the pollen tube moves to the centre and unites with the fusion nucleus. Union of one sperm with the egg and the second sperm with the fusion nucleus is called **double fertilization**. It only occurs in the flowering plants.

Seed and Fruit Formation

Zygote develops into an **embryonic plant** within the ovule. After fertilization fusion nucleus develops into an **endosperm**. It is **triploid** i.e. consists of three sets of haploid number of chromosomes, as two polar nuclei, and one sperm nucleus fuses to form it. Endosperm divides, enlarges and is used as store of food for the young embryo.

After double fertilization the formation of **embryo** and endosperm tissue takes place. As a result the ovule increases in size. The embryo consists of: (i) one or two cotyledons (ii) epicotyl (iii) hypocotyl. Both epicotyl and hypocotyl are the parts of the rod like axis attached to the cotyledons. In some plants cotyledons digest and absorb endosperm as the ovule is maturing into seed.

The **cotyledons** become enlarge and store food for the development of the embryo. Such plants are called **nonendospermic** e.g. bean. In some plants the endosperm tissue continues to grow as the ovule matures into a seed. These plants are known as **endospermic** e.g. corn, castor, rice and wheat. The ovule matures into a seed. The protective covering (integument) of the ovule is transformed into seed coat. Seed coats of some seeds are tough and protect the embryonic plant from injury and dessication. The ovary wall enlarges and ripens to become the fruit.

The Life Cycle Demonstrates an Adaptation of Angiosperms on Land

Fertilization takes place through pollen tube independent of external water. Double fertilization increase reproductive success. Following fertilization the ovules located in ovaries develop into seed. An ovary wall is transformed into a fruit. Fruits provide protection for seeds and a mechanism for their wide dispersal.

Critical Thinking

How do the life cycles of seedless plants and seed plants differ? In what fundamental way are they alike?

Inflorescence

Flowers are borne either singly or in clusters. A flower is said to be **solitary** when occurring singly. e.g. *Hibiscus rosasinensis*.

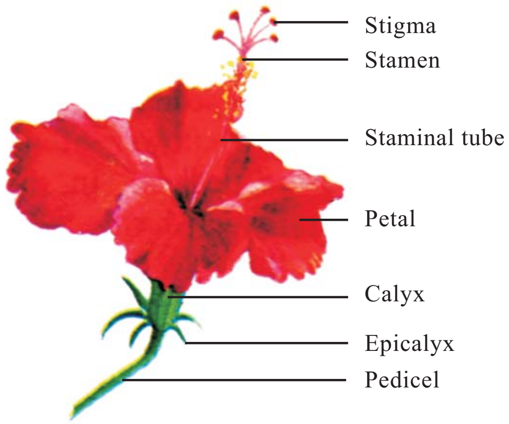


Fig: 8.20 A Solitary Flower, China-rose (*Hibiscus rosasinensis*)

Flowers borne in clusters along with the stem and associated whorls constitute **inflorescence**. The advantages of the aggregation of flowers in an inflorescence are: Makes the flowers in more conspicuous to attract insects for pollination. Many flowers get pollinated by a single insect. Inflorescence combines economy with greater chances of pollination and surety of abundant seed production. Depending upon the arrangement of flowers, inflorescence is classified as:

(a) Racemose (b) Cymose (c) Compound

Racemose Inflorescence

Here the main axis of inflorescence does not end in a flower but it continues to grow and give off flowers laterally. Some of the main types are as follows.

Fig: 8.21 Raceme of Mustard

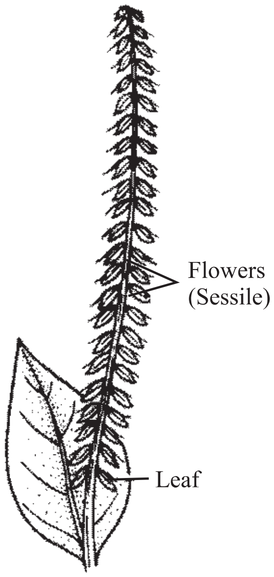


Fig: 8.22 Spike of *Achyranthes*

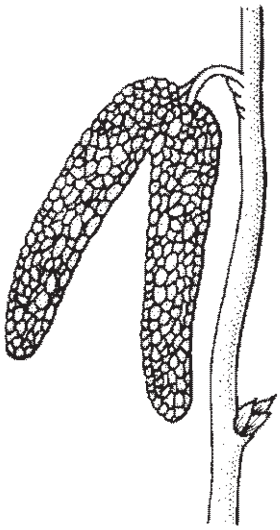


Fig: 8.23 Catkin of Mulberry (*Morus*)

Raceme: The main axis is elongated and bears flowers laterally. The flowers are stalked and arranged in acropetal succession, e.g., radish and mustard.

Catkin: It is also a spike with a long and pendulous axis. It bears unisexual sessile flowers, e.g., mulberry (*Morus*).

Spike: Here also the main axis is elongated but the flowers are sessile and arranged in acropetal succession, e.g., *Amaranthus*, *Achyranthes*.

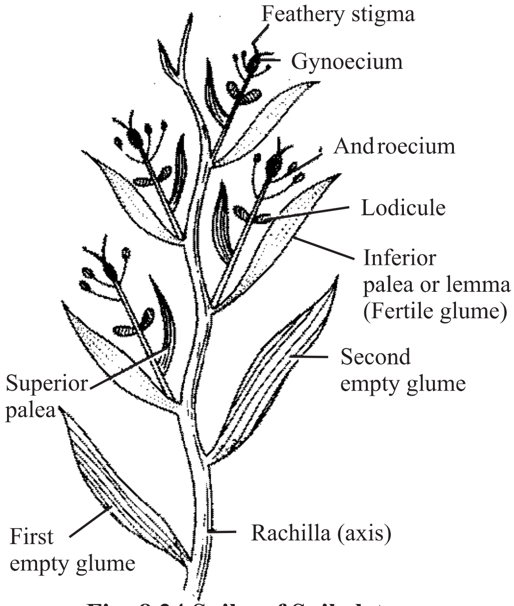


Fig: 8.24 Spike of Spikelets

Spikelet : This is a very small spike with reduced axis, hence called spikelet. It bears one or a few small flowers. The spikelets arise in a racemose manner on the main axis, e.g., wheat, sugarcane, paddy, etc.

Corymb: In this case the main axis is comparatively short and the flowers are pedicellate. The lower flowers have longer pedicels than the upper ones so that all the flowers lie more or less at one level, e.g., Candytuft (*lberis*), *Cassia*.

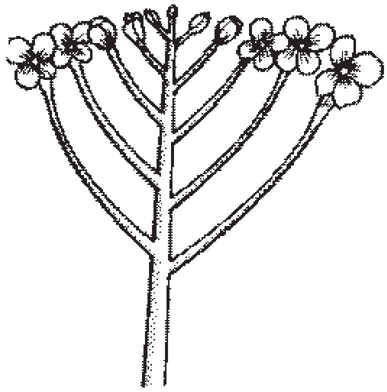


Fig. 8.25 Corymb of Iberis,

Head or Capitulum: Here the main axis is highly suppressed and becomes flattened forming a disc-like structure. It bears small sessile flowers of two types the **ray florets** and the **disc florets**. The ray florets are situated at the periphery and have a flat tongue-shaped corolla. The disc florets are situated at the disc or the receptacle. The florets are surrounded by a whorl of bracts called **involucre**. Sunflower and marigold are the common examples of this type.

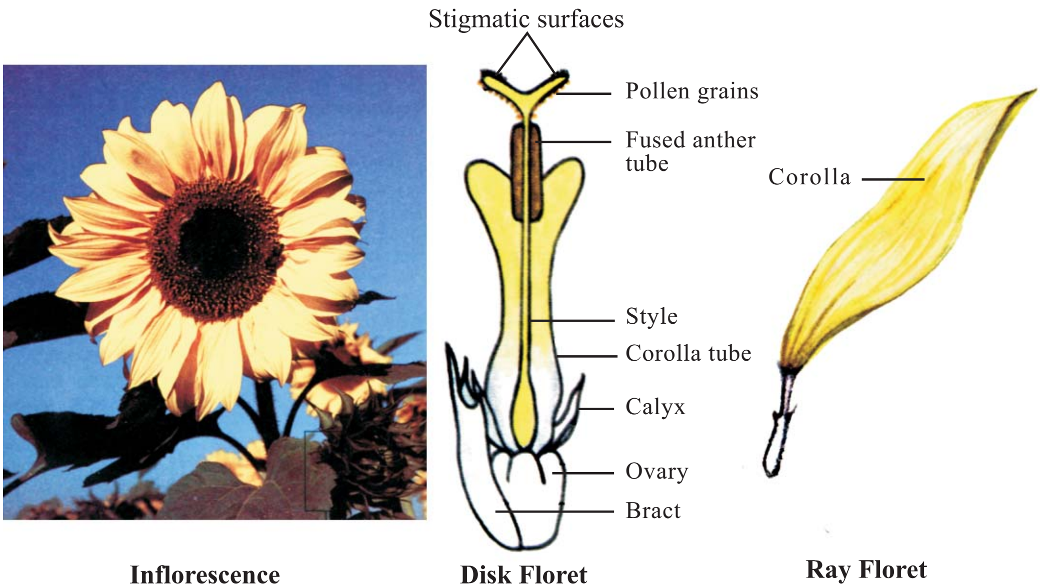


Fig: 8.26 Capitulum of Sunflower

Cymose Inflorescence

Here the primary axis terminates in a flower but the growth continues through the lateral buds. These buds give rise to lateral branches which bear flowers. The flowers are arranged in basipetal succession, i.e., the outer or basal flowers are younger and the upper flowers are older.

Compound Inflorescence

In a compound inflorescence the peduncle or main axis of the inflorescence branches repeatedly in racemose or cymose manner and the ultimate branches bear flowers in a racemose or cymose manner. Compound racemose e.g. Goldmohur (*Delonix regia*), Amaltas (*Cassia fistula*),. *Yucca*, etc. Compound Spike e.g. Wheat (*Triticum aestivuni*), rice (*Oryza sativa*).

Significance of Angiosperms to Humans

Food: Cereals constitute the staple food of man. Major cereals are wheat rice, maize, barley, oat, etc.

Pulses: These are seeds of leguminous plants. These are rich in proteins. Common pulses are lentil, arhar, urd, pea, gram, green gram, soyabean, black gram.

Vegetables and Fruits: The main vegetables obtained from angiosperms include carrot, radish, cabbage, cauliflower, potato, tomato, okra. The fruits are mango, apple, banana, guava, grapes, melon, mulberry, pears, etc. Nuts consumed as dry fruits are cashewnut, almonds, walnut, etc.

Edible Oils: Edible oils used for cooking are obtained from groundnut, mustard, cotton seeds, coconut and sunflower.

Spices: These include cinnamon, (vern. dalchini), cloves, (vern. laung), chillies, black pepper (vern. kali mirch), caraway (vern. zeera), coriander (vern. dhania), fennel (vern. saunf).

Beverages: Tea, Coffee and Cocoa are important beverages obtained from flowering plants.

Sugar: It is obtained from sugarcane and beet roots.

Fodder: Many plants yield fodder for the cattle. Important fodder giving plants are *Trifolium* (barseem), *Melilotus* (senji), etc.

Medicines: A large number of drugs are obtained from flowering plants. Some of the drugs are aconite, belladona, quinine, malathi, santonin, digitalis, asgandh, etc.

Timber: It is mostly obtained from dicotyledonous plants. The wood

Science, Technology and Society Connections

Justify plants as a medical treasure.

is called hard wood in contrast to soft wood of gymnosperms. Important timber yielding plants are teak, sal, oak and sisso (vern. sheeshum). Commercial cork is obtained from oak.

Fibres: Many plants provide us fibres for various uses. Textile fibres are obtained from cotton, rough fibres for making ropes and gunny bags are obtained from flax, hemp and sunn hemp, etc. Jute fibres are obtained from the husk of unripe fruits of coconut.

Ornamental Plants: A large number of flowering plants are grown in gardens and houses as ornamental plants. Common among them are bougainvilleas, roses, petunias, chrysanthemums, crotons, coleus, etc.

Exercise

SECTION I : MULTIPLE CHOICE QUESTIONS

Select the correct answer

1. Plants are thought to have descended from a common protistan ancestor ancient

   A) freshwater algae B) archaea
   C) cyanobacteria D) brown alga

2. Gametophyte in bryophytes is

   A) haploid B) diploid
   C) triploid D) pentaploid

3. Whisk ferns belong to the group

   A) pteropsida B) lycopsida
   C) psilopsida D) annelida

4. Sago grains are obtained from

   A) cycus B) pinus
   C) moss D) fern

5. These are highly evolved of all the plants on the earth
   A) bryophytes B) pteridophytes
   C) gymnosperms D) angiosperms
6. Moss plants develop from
   A) oospore B) protonema
   C) antherozoids D) diploid spores
7. Fern plant is
   A) diploid sporophyte B) diploid gametophyte
   C) haploid sporophyte D) haploid gametohyte
8. Gymnosperms are characterised by
   A) multiflagellate sperms B) naked seeds
   C) winged seeds D) seeds inside fruits
9. Seed habit originated in some
   A) bryophytes B) ferns
   C) gymnosperms D) angiosperms
10. Gametophyte generation is dominant in
   A) pterideophytes B) gymnosperms
   C) bryophytes D) angiospersms

SECTION II : SHORT QUESTIONS

1. How are cones and flowers are alike? How they are different?
2. What is the importance of alternation of generation, pollen tube and seed?
3. Write three main features of bryophytes.
4. Name the land adaptation features of bryophytes.
5. Write any four features of vascular plants.
6. Give one example of: Whisk ferns, club mosses, horsetails and ferns
7. What is the importance of seedless vascular plants?
8. Write any six features of gymnosperms.

9. Write any four uses of bryophytes and gymnosperms.
10. Define: angiosperms, inflorescence, and alternation of generation.
11. The majority of all plants are seed plants. What is the advantage of the seed?
12. What do monocots and dicots have in common? How do they differ?

SECTION III : EXTENSIVE QUESTIONS

1. Write the evolutionary origin of plants.
2. List the diagnostic features shared by all plants with the emphasis on alternation of generation.
3. Explain the land adaptations of bryophytes.
4. Describe the general characteristics of vascular plants.
5. Write the characteristics of seedless vascular plants and summarize their importance.
6. Explain the evolution of leaf in vascular plants.
7. Describe vascular plants as successful land plants.
8. Describe the evolution of seed.
9. Write the general characteristics and uses of gymnosperms.
10. Describe major types of inflorescence.
11. Write the significance of angiosperms to humans

ANSWER MCQS

1. A 2. A 3. C 4. A 5. D 6. B 7. A 8. B 9. B 10. C

SUPPLEMENTARY READING MATERIAL

3. Mauseth, J.D. Botany: An Introduction to Plant Biology. 2nd edition Saunders Collage Publishing, Philadelphia. 1995.

USEFUL WEBSITES

1. www.mhhe.com/sciencemath/biology/mader/ (click on biology).
2. www.prenhall.com/~audesirk