Chapter 9

THE KINGDOM PLANTAE

The terrestrial communities founded by plants transformed the biosphere. Consider, for example, that humans would not exist had it not been for the chain of evolutionary events that began when certain descendants of green algae first colonized land.

The evolutionary history of the plant kingdom is a story of adaption to changing terrestrial conditions.

All plants are multicellular eukaryotes that are photosynthetic autotrophs. However, not all organisms with these characteristics are plants: such characteristics also apply to some algae. Plant cells have walls made mostly of cellulose, and plants store their surplus carbohydrate in the form of starch. Plants share even more characteristics with their closest algal relatives, the green algae. For example, the chloroplasts of both green algae and plants contain chlorophyll-**b** as an accessory photosynthetic pigment. (All photosynthetic eukaryotes, remember, usechlorophyll-**a** as the pigment directly involved in conversion of light energy to chemical energy).

So, how do we distinguish plants from multicellular algae? First, plants as we are defining them are nearly all terrestrial organisms, although some plants, such as water lilies, have returned secondarily to water during their evolution. Living on land poses very different problems from living in water, and it is a set of structural, chemical and reproductive adaptations for terrestrial living that distinguishes plants from algae.

In terrestrial habitats, the resources a photosynthetic organism needs are found in two very different places: Light and carbon dioxide are mainly available above the ground, while water and mineral nutrients are found mainly in the soil. Thus the complex bodies of plants show varying degrees of structural specialization into subterranean and aerial organs—roots and leaf-bearing shoots, respectively. In most plants, exchange of carbon dioxide and oxygen between the atmosphere and the photosynthetic interior of leaves occurs via stomata, microscopic pores through the surfaces of leaves.

Terrestrial adaptations of plant structure are complemented by chemical adaptations. For example, aerial parts of most plants, such as leaves, have a waxy coating called a cuticle, which helps to prevent excessive water loss, a major problem on land.

Plants are multicellular photosynthesizers that are adapted to living on land. All plants protect their embryos from desiccation.

The waxes of the cuticle are examples of secondary products, so named because they are not produced by the primary, mainstream metabolic pathways common to all plant.

Another example of secondary products as terrestrial adaptations is lignin, the substance that hardens the cell walls of "woody" tissues in many plants.

A secondary product particularly important in the evolutionary move of plants onto land was **sporopollenin,** a polymer that is resistant to almost all kinds of environmental damage. In fact, the fossil record of plants is due mainly to the durability of sporopollenin, lignin, and the materials of cuticles.

The move onto land paralleled a new mode of reproduction. In contrast to theenvironment in which algae reproduce, gametes now had to be dispersed in a non-aquatic environment, and embryos, like mature body structures, had to beprotected against desiccation.

Early plants produced their gametes within gametangia, organs having protective jackets of sterile (nonreproductive) cells that prevent the delicate gametes from drying out during their development. The egg is fertilized within the female gametangium, where the zygote develops into an embryo that is retained and nourished for some time within thejacket of protective cells. In contrast, developing algae are not retained as embryos within a parent. This difference is so fundamental that plants are sometimes referred to as embryophytes, a term that emphasizes a key adaptation that contributed to success on land.

Now plants may be defined as multicellular eukaryotes that are photosynthetic autotrophs (Chlorophyllous) with cell wall primarily made up of cellulose, exhibiting heterophorphic alternation of generation and zygote retained and develops into embryo.

9.1 CLASSIFICATION OF PLANTS

Plant biologists use the term division for the major plant groups within the plant kingdom. This taxonomic category corresponds to phylum, the highest unit of classification within the animal kingdom. Divisions, like phyla, are further subdivided into classes, orders, families and genera.

The classification scheme used in this book recognizes two main groups called **bryophyta** (non vascular plants) and **tracheophyta** (vascular plants). This division is based on the presence or absence of vascular tissues.

> All plants have a life cycle that shows an alternation of generations; some have a dominant gametophyte and some have a dominant sporophyte.

An outline of classification of Plantae:

Division I: **Bryophyta** (Non-vascular plants)
Class Hepaticae (liverworts)
Class Musci (Mosses)
Class Anthocerotae (Hornworts)

Division II: **Tracheophyta** (Vascular plants)
Subdivision Psilopsida (Psilopsids)
Subdivision Lycopsida (Club mosses)
Subdivision Sphenopsida (Horse tails)
Subdivision Pteropsida (Ferns)
Subdivision Spermopsida (Seed plants)

9.2 BRYOPHYTES (Bryon = a moss; Phyton = Plant)

Bryophytes are non-vascular plants showingheteromorphic alternation of generation with dominant gametophytes having amphibious nature.

Gametophytes are chlorophyllous, photosynthetic autotrophs having thalloid body or differentiated inrhizoids, pseudo stemand leaves. Sporophytes are semi-parasite on gametophytes having a body differentiated in to foot, seta and capsule.

9.2.1 General Characteristics and Amphibious nature:

The nonvascular plants; liverworts, hornworts and mosses are grouped together in a single division bryophyta (Gr, bryon, "moss").

Bryophytes display a key adaptation that first made the move onto land possible: the embryophyte condition. Their gametes develop within gametangia. The male gametangium, known as an **antheridium**, produces flagellated sperm. In each female gametangium, or archegonium, one egg (ovum) is produced. The egg is fertilized within the archegonium, and the zygote develops into an embryo within the protective jacket of the female organ.

Even with their protected embryos, bryophytes are not totally liberated from their ancestral aquatic habitat. First of all, these plants need water to reproduce: their sperm, like those of most green algae, are flagellated and must swim from the

antheridium to the archegonium to fertilize the egg. For many bryophyte species, a film of rainwater or dew is sufficient for fertilization to occur.
Bryophytes lack the lignin-fortified tissue required to support tall plants on land. Although they may sprawl horizontally as mats over a large surface, bryophytes always have a low profile. Most are only 1-2 cm in height, and even the largest are usually less than 20 cm tall.
There is regular heteromorphic alternation of generation with gametophyte is the dominant generation in the life cycles of bryophytes.

The bryophytes include the inconspicuous liverworts and mosses, plants that have a dominant gametophyte. Bryophytes lack vascular tissue and fertilization requires an outside source of moisture. Windblown spores disperse the species.

9.2.2 Adaptation to Land habitat:

The first evidence that plants had invaded the land from the sea is found in fossils of the Silurian/Devonian periods. All the biologist agree that the land plants and animals evolved from aquatic ancestors. The conquest of the land must have been a long and difficult process. The plants had to become adopted by developing new structures.
Life for aquatic organisms is an easylife. Water is necessary for the growth of all living things and there is little danger in the sea of any lack of water. Carbon containing compounds, so essential for autotrophs, are present abundantly in solution. These autotrophs, in turn, provide a continuous supply of oxygen for all the living organisms in the sea. The temperature in the seas does not fluctuate as much as the temperature on land. Hence, the aquatic environment is more uniform and better supplied with some of the necessities of life than in the rigorous land environment.
When plants invaded the land from the sea, they faced many problems such as of obtaining and conserving water; of absorbing carbon dioxide from the atmosphere for photosynthesis.
To solve these problems, land invading plants adopted themselves first to amphibious-habit and later developed a complete terrestrial form of life. The amphibious form of land plants includes all the bryophytes. We will consider the following adaptive characters exhibited by them.

1. Rhizoids for water absorption
2. Conservation of water
3. Absorption of CO_2
4. Heterogamy
5. Protection of reproductive cells
6. Formation of embryos

1. Rhizoid for water absorption:

The study of Marchantia thallus and other bryophytes show that they have rhizoids for water absorption. These are long, filamentous extensions of the cells of the lower surface of the thallus. They greatly increase the surface for absorption of water from the soil.

2. Conservation of water:

The plant-body called thallus of all bryophytes is multilayered. **Marchantia** is one of the common liverworts. The cross section of this organism shows that its thallus is many cell thick (Fig. 9.1). Of the hundreds of thousands of cells comprising the thallus, only a small percentage have surfaces directly exposed to the drying effects of the atmosphere. Moreover, the outer and uppermost layer of cells is covered with cuticle. It is non-cellular layer of wax-like substance called cutin. This is very efficient in reducing the rate of evaporation and is also found in the stem and leaves of highly evolved land plants.

3. Absorption of CO_2:
Land plants need an efficient means for the exchange of gases with the environment in contrast to aquatic plants which exchange gases dissolved in water. The upper surface of the marchantia thallus is provided with a number of aerating pores. Each pore leads inside into an air-chamber. This is partially filled with branching filaments of photosynthetic cells, CO_2enters through the pores and absorbed by the wet surfaces of the photosynthetic cells in the air chambers and diffuses into the cytoplasm. Because of branching nature of the inner structure of the thallus, the cells present a very large surface area available for the absorption of CO_2. No doubt, at the same time, evaporation of water can occur from the wet surfaces of these cells. To replace this evaporating water, Marchantia has special structures called rhizoids as already mentioned.

4. Heterogamy:
Heterogamy is the most successful kind of reproduction that has evolved in bryophytes. It is defined as production of two different types of gametes, one is male (motile) and the other is female (non-motile) full of stored food.

5. Protection of reproductive cells:
The land environment requires special protection for the reproductive cells. In amphibious plants, reproductive cells are very well protected as in **Funaria** (moss) plant. The male gamete, (sperm) and female gamete, (ovum) are produced in multicellular reproductive sex organs called antheridia and archegonia respectively. These organs are present at the apices of leafy shoots. Moreover, together with these organs, hair like structures called **paraphyses** are also present which help to prevent drying of the sex organs.

6. Formation of embryos:
Embryo formation in amphibious plants is of universal occurrence. The fertilized egg called oospore (zygote) is formed inside the archegonium. An embryo develops from the oospore as it divides, still inside the protective coverings of the archegonia. Thus the coverings formed by the female organ protect the growing embryo from drying out and from mechanical injury.

9.2.3 The three classes of Bryophytes:

1. Hepaticae (Liverworts):
They have been named so because thallus has lobed structure resembling the lobes of liver. Also because the plants were once used to treat complaints of die liver.
Hepaticae have dorsoventrally differentiated, externally simple gametophytes. Sex organs are always formed from superficial cells on the dorsal side. Some time they may develop on special branches called **antheridiophores** and **archegoniophores** Sporophytes are simple having foot, seta and capsule e.g. Ricca, Marchantia, Porella.

2. Musci (Mosses):
The most familiar bryophytes are mosses. In contrast to other bryophytes they grow equally well in fairly dry places. However, water is essential in the reproduction. A mat of moss actually consists of many plants growing in a tight pack, helping to hold one another. Each plant of the mat grips the substratum with rhizoids.
The musci have a gametophyte with transitory prostrate stage called **protonema.** It bears erect sexual branches which continue to grow has independent plants after degeneration of protonema. The sexual branches are differentiated into pseudo stem and leaves. The sporophyte consists of foot, seta and capsule. Capsule has photosynthetic cells, e.g. Funaria, Sphagnum etc.

3. Anthocerotae (Hornworts):

Hornworts resemble liverworts but are distinguished by their sporophytes, which are elongated capsules that grow like horns from the matlike gametophyte (Fig. 9.3) e.g. anthroceros. This is the most advanced group. The sporophyte shows many advanced characters suited for land environment. The sporophyte has stomata and chloroplasts and can undergo photosynthesis. Further more, it has **meristem** which keeps on adding cells. Due to these characters, sporophyte can continue to survive even often the death of gametophyte.

9.2.4 Life cycle of bryophyte (Moss):

All bryophytes show heteromorphic alternation of generation with gametophytes as dominant generation including funaria hygrometrica (a moss). The gametophyte is haploid consisting of rhizoids, pseudo stem and leaves. Gametophytes may be uni or bisexual depending upon whether stem is branched or un branched, the sex organs called **antheridia** (male) and **archegonia** develop at the tips of stem which are always **diocuous** having either male or female sex organs. There is **protoandry** because antheridia mature earlier and liberate their anthrozoids, which start swimming with the help of their flagella in dew or rainwater. When archegonia mature, they have single ovum in the **venter** and few neck canal cells in the neck. Swimming sperms are attracted by scent of sugare cane secereted by mature archegonium but a single antherozoid fuses with the ovum to form **diploid** (2n) oospore (zygote). This is retained within archegonium and form an **embryo** (2n). This embryo undergo repeated mitotic-divisions to form sporogonium (a sporophyte) which is diploid. It consists of foot, seta and capsule. Within capsule spore mother cells are present. Each spore mother cell divides by meiosis to form four haploid spores. Each spore germinates into a filamentous body called **protonema.** Later on gametophyte (haploid) develops from protonema to complete life cycle (fig: 9.4).

9.3 TRACHEOPHYTES

9.3.1 Tracheophyta (The Vascular Plant):

Though most bryophytes live on land, in a sense they are not fully terrestrial. The tracheophytes, by contrast, have evolved a host of adaptations to the terrestrial environment that have enabled them to invade all the most inhospitable land habitats. In the process they have diverged sufficiently from the one another.

9.3.2 Major Groups of Vascular plants:

The major groups of vascular plants are as follows:

1. Subdivision Psilopsida (psilopsids)
2. Subdivision Lycopsida (club mosses)
3. Subdivision Sphenopsida (horse tails)
4. Subdivision Pteropsida (ferns)
5. Subdivision Spermopsida (seed plants)

The subdivisions psilopsida, lycopsida, spheynopsida and pteropsida are non flowering plants and placed under a group called **pteridophyta** (Pteridos = pteris like; phyton = plant). **Spermopsids** have flowers and all have seeds and thus called spermatophyte (Sperma = seed; phyton = plant). Spermopsida are further divided into **gymnosperms** and **angiosperms**.

All members of Tracheophytes (with a few minor exceptions) possess four important characters; i) a protective layer of sterile **jacket** cells around the reproductive organs; ii) multicellular embryos retained within the archegonia, iii) culticles on the aerial parts and iv) xylem. All are four fundamental adaptations for a terrestrial existence. Many other such adaptations, absent in the earliest tracheophytes, appear in more advanced member of the division; a history of the evolution of these adaptations is a history of the increasingly extensive exploitation of the terrestrial environment by vascular plants. Let us briefly trace the history of adaptation to life on land.

1. Psilopsida:

The oldest undisputed fossil representatives of the vascular plants can be placed late in the Silurain period, which means that they lived more than 395 million years ago, they are classified in the psilopsida, most of whose members lived during the Devonian period and then became extinct for example Rhynia. Two living genera Psilotum and Tmespteris, have traditionally been regarded as members of this ancient group. But recent evidence from, embryology andmorphology ofthe Gametophytes D.W. Bierhorst of the university of Massachusetts has pointed out that they may actually be very primitive ferns. If this is so, then **Psilopsida** contains only extinct species. Whether **Psilotum** and **Mesipteris** should be retained in Psilopsida despite the differences between them and the ancient members of that class, from which they are separated by about 400 million year with no intervening fossils.
The psilopsid sporophytes are simple dichotomously branching plants that lack leaves and have no true roots, although they have underground stems that bear unicellular rhizoids similar to root hairs (Fig. 9.5). The aerial stems are green and carry out photosynthesis. There is no cambium and hence no secondary growth. Sporangia develop at the tips of some of the aerial branches. Within the sporangia meiosis produces haploid spores.

Rhynia Illustrating Vascular Organization:

One of the most primitive vascular plant is Rhynia, which is pteridophyte. Rhynia an extinct-genus, was named often the village Rhynia of Scotland, where the first fossils of Rhynia were discovered. It belongs to Devonian period which started about 400 million years ago. The fossils of this plant are so well preserved that the stomata are still intact.
The plant-body (Sporophyte) of Rhynia was simple (Fig. 9.6-a), it consisted of slender, dichotomously branched creeping rhizome, bearing erect, dichotomously branched aerial stem. Instead of roots, rhizoids were given out from rhizome. The aerial branches were leaf-less having terminal fusiform naked sporangia.
The internal structure of branches show a solid central core of vascular tissue surrounded by Cortex. The outer most layer is Epidermis having stomata. The vascular tissue is differentiated into centrally placed xylem and surrounded by phloem (Fig. 9.6-b).
In**Psilotum** and **Mesipteris** the spores give rise to minute subterranean gametophytes. Each gametophyte bears both archegonia and antheridia and thus produces both eggs and sperm. When the gametes unite in fertilization, they form diploid zygotes that develop into the sporophyte plants described above, thus completing the life cycle. Note that although the diploid sporophyte (stages) is more prominent in the modem genera and hence may be said to be dominant, the haploid gametophyte (stage 2) is still relatively large e.g. Psilophyton (fossil).

EVOLUTION OF THE LEAF

The leaf is the most important organ of a green plant because of its photosynthetic activity. It is very interesting to trace the origin of leaf in the green plants.
The evolution of one-veined leaf (microphyllous) can be explained by assuming that a thorn like outgrowth (Enation) emerged on the surface of the naked stem. With an increase in size of the out growth, the vascular tissues were also formed for the supply of water and support to the leaf. Another possibility is that a single veined leaf originated by a reduction in size of a part of the leafless branching system of the primitive vascular plant. This is how the leaf of Lycopodium (club mosses) and equistium (horse tail) came into existence (Fig. 9.7).

Many veined leaf (megaphyllous) originated much later. These are the evolutionary modifications of the forked branching system in the primitive plants. The first step in the evolution of this leaf was the restriction of forked branches to a single plane. The branching system became flat. The next step in the evolution was filingthe space between the branching and the vascular tissue. The leaf so formed looked like the web foot of a duck (Fig. 9.8).

2. Lycopsida (The Club Mosses):

The first representative of Lycopsida appeared in the middle of the Devonian period, almost 10 million years after the first psilopsida. During the late Devonian and the Carboniferous periods these were among the dominant plants on land. Some of them were very large trees that formed the earth's first forests. Toward the end of the Paleozoic era, however, the group was displaced by more advanced types of vascular plants, and only five genera are alive today. Two of these, Selaginella and Lycopodium (often-called running pine or ground pine), are common in many parts of the Pakistan (Fig. 9.9-a).

The vascular plants evolved during the Silurian period. They are the most diverse and widely distributed of the plants.

Unlike the Psilopsids, Lycopsids (Fig. 9.9-b) have true roots. It is generally supposed that these arose from branches of the ancestral algae that penetrated the soil and branched underground. Lycopsids also have true leaves, which are thought to have arisen as simple scale like outgrowth (emergence) from the outer tissues of the stem.

Certain of the leaves that become specialized for reproduction bear sporangia on their surfaces. Such reproductive (fertile) leaves are called sporophylls. In many Lycopsids the sporophylls are congregated on a short length of stem and form a cone like structure (strobilus) (Fig. 9.9-c). The cone is rather club-shaped; hence the name "Club Mosses" for the Lycopsids, though Lycopsids are not related to the true mosses, which are bryophytes.

The spores produced by **Lycopodium** are all alike, and each can give rise to a gametophyte that will bear both archegonia and antheridia. However, some Lycopsids (e.g. **Selaginella**) have two types of sporangia, which produced different kinds of spores. One type of sporangium produces very large spores called megaspores, which develop in female gametophytes bearing archegonia; the other type produces small spores called microspores, which develop into male gametophytes bearing antheridia. Plants like Lycopodium that produce only one kind of spore, and hence have only one kind of gametophyte that bears both male and female organs, are said to be **homosporous**. Plants like Selaginella that produces both magaspores (female) and microspores (male) i.e. in which the sexes are separate in the gametophyte generation are said to be **heterosporous**.

Evolution of Seed:

We have studied in Selaginella that two types of spores are present. One is smaller in size called microspore and the other bigger in size called megaspore. This type of condition is known as **heterospory**. These spores have different functions to perform. Instead of growing into a gametophyte of similar structure, the heterosporous plants produce two different gametophytes. Microspore grows into a sperm forming gametophyte. The other kind megaspore, grows into egg forming gametophyte. The two kind of spores are formed in two different kinds of sporangia. These like the sporangia of club mosses, horse tails and ferns have become protected as a result of the evolution of various enveloping structures. The carboniferous era reveals some fern like plants that bore scale like structures. Each of their sporangia containing one or more spores was nearly surrounded by outgrowth from the sporophyte. These outgrowth were little

branch like structures which during evolution have become fused as an envelop or integument around the sporangia.
In contrast with other green plants, in the seed plants megaspores are retained and protected inside the integumented sporangia. They develop into active female gametophyte protected by integument. There are three steps in the evolution of seed: (1) Origin of heterospory, (2) Development of integument for the protection megasporangia of and (3) Retention of the mature megaspores in the sporangia to develop female gametophyte. The examination of immature seed reveals, that integument is not only a protective covering but also a food supplying organ to the female gametophyte. The development of seed has given the vascular plants better adaptation to their environment.

3. Sphenopsida (The Horse tails):

The Sphenopsides first appeared in the fossil record late in the Devonian period. They became a major component of the land flora during the Carboniferous period and then declined. Members of the one living genus, **Equisetum** (Fig. 9.10-a), are commonly called horse tails. Though most of these are small (Less than one meter), some of the ancient sphenopsids were large trees (Fig.9.10b). Much of the coal we use today was formed from the dead bodies of these plants.
Like the lycopsids, sphenopsids possess true roots, stems and leaves. The stems are hollow and are jointed. Whorls of leaves occur at each joint (Fig.9.10-a). Many of the extinct sphenopsids had cambium and hence secondary growth, but the modern species do not. Spores are borne in terminal cones (Strobili). In Equisetum all spores are alike (i.e. the plants are homosporous) and give rise to small gametophytes that bear both archegonia and antheridia (i.e. the sexes are not separate) e.g. Sphenophyllum.

4. Pteropsida (The Ferns):

In the opinion of many biologists, the ferns evolved from the Psilosida. They first appeared in the Devonian period and greatly increased in importance during the Carboniferous, period. Their decline late in the Paleozoic era was much less severe than that of the Psilopsids, Lycopsids and Sphenopsids. There are many modem species belonging to this group. The ferns are fairly advanced with a very well developed vascular system and with true roots, stems and leaves. The leaves are thought to have arisen in another way than those of the Lycopsids. Instead of emergence, they are probably flattened and web branched stems, i.e. a group of small terminal branches probably became arranged in the same plane and the interstices filled with tissue. Such leaves are large and provide a muchgreater surface area for photosynthesis, than the emergence leaves of the Lycopsids and Sphenopsids.
The leaves of ferns are sometimes simple, but more often they are compound being divided into numerous leaflets. In a few ferns (e.g. the large trees ferns of the tropics), the stem is upright, forming a trunk. But in most modern ferns, specially those of temperate regions, the stems are prostrate on or in the soil, and the large leaves are the only parts normally seen.

In the non seed vascular plants, such as fern, there is a dominant vascular sporophyte, which produces windblown spores. These plants have an independent nonvascular gametophyte, and flagellated sperm swim in external water to reach the egg.

The large leafy fern plant is the diploid sporophyte phase (Fig. 9.1 l-a).Spores are produced in sporangia located in clusters on the underside of some leaves (Sporophylls) (Fig. 9.11-b). In some species the sporophylls are relatively little modified and look like the nonreproductive leaves. In other species the sporophylls look quite different from vegetative leaves. Some times they are so highly modified that they do not look like leaves at all forming spike like structures instead.

Most modern ferns are homosporous i.e. all these spores are alike. After germination, the spores develop into gametophytes that bear both archegonia and antheridia (Fig. 9.11-c), these gametophytes are tiny (less than one centimetre wide), thin and often more less heart-shaped.

In some respect, the ferns (and also the three primitive groups of vascular plants discussed above) are no better adapted for life on land than the bryophytes. Their vascularized sporophytes can live in drier places and grow bigger, but for a number of reasons-because their non-vascularized free-living gametophytes can survive only in moist places, their sperms are flagellated and must have a film of moisture through which to swim to the egg cells in the archegonia, and because the young sporophyte develops directly from the zygote without passing through any protected seed like stage—these plants are most successful only in those habitats where there is at least a moderate amount of moisture e.g.Pteris.

Life cycle of a fern:

The life cycle of fern (Adiantum) or dryopteris shows heteromorphic alternation of generation in which sporophytic-phase is dominant. All ferns are homosporous producing single types of spores.

The sporophyte (2n) which is diploid, consist of adventitious roots, underground stem a rhizome and pinnately compound leaves.

Reproduction takes place by means of haploid-spores formed from the spore-mother cells after meiosis inside sporangium. A number of sporangia develope inside single **sorus.**

The **sori** (plural of sorus) are green but when ripe, they become dark brown. The leaves of bearing sori are called sporophyll.

Each sporangium consists of a stalk called **sporangiophore** and a biconvex capsule consisting of **annulus** and **stomium**. The annular cells are thickened whereas stomial cells are thin-walled. Within sporangium spore mother cells are present. Each spore mother cell divides by meiosis to form four haploid spores. The spores are liberated through stomium.

Each spore on germination gives rise to miniature bisexual gametophyte called **prothallus.**

The prothallus is independent autotropic, heart shaped, dorsoventrally flattened lying prostrate on some wet substratum. It is fixed to soil whit the help of rhizoid which absorb water and nutrients. The prothallus is monoecious having archegonia and antheridia on the same prothallus.

Archegonium consists of venter with an ovum and a neck and secrete malic acid at maturity. Each antheridium produces a number of antherozoids (sperms): A number of sperms, by making chemotactic movement in water reach to the archegonium. Only one sperm fuses with ovum to form oospore (zygote) which is diploid. Young sporophyte develops from the oospore. In the meantime, prothallus degenerate, in this way life cycle is completed (Fig. 9.12).

5. Spermopsida (The Seed plants):

The seed plants have been by far the most successful in fully exploiting the terrestrial environment. They first appeared in the late Devonian, and in the Carboniferous they soon replaced the lycopsids and sphenopsids as the dominant land plants, a position they still hold today. In these plants the gametophytes are even more reduced than in the ferns, they are not photosynthetic or free-living, and the sperms of most modern species are not independent free-swimming flagellated cells. In addition, the young embryo, together with a rich supply of nutrients, is enclosed within a desiccation-resistant seed coat and can remain dormant for extended periods if environmental conditions are unfavourable.

The seed plants have traditionally been divided into two groups, the Gymnospermae and the Angiospermae.

i) The Gymnosperms: (Gymnos = Naked; Sperma = Seed)

They have naked seeds because ovules are not covered by ovary. The first gymnosperms appeared in the fossil record in the late Devonian, some 350 million years ago. Many of those first seed plants had bodies that closely resembled the ferns, and indeed for many years their fossils were thought to be fossils of ferns. Slowly, however, evidence accumulated that some of the "ferns" that were such important components of the coal-age forests produced seeds, not spores. Today these fossil plants, usually called the seed ferns, are grouped together as the class Pteridospermae of the subdivision Spermopsida. No members this class survive today.

Another ancient group, the cycads and their relatives, may have arisen from the seed ferns. These plants first appeared in the Permian period and became very abundant during the Mesozoic era. They had large palm like leaves; the palm like plants so often shown in pictures of the dinosaur age are usually cycads, not true palms. The cycads declined after the rise of angiosperms in the cretaceous period, but nine genera containing over a hundred species are in existence today (Fig. 9.13). They are generally called sago palms and are fairly common in some tropical regions.

The Ginkgoae are still another widespread group now nearly extinct. There is only one living species, the Ginkgo (Fig. 9.14) or maidenhair tree, often planted as a lawn tree, but almost unknown in the wild.

By far the best-known group of gymnosperms is the conifers. The leaves of most of these plants are small evergreen needles or scales with an internal arrangement of tissues that differs somewhat from that in angiosperms.

Gymnosperms:	
Cycads (division Cycadophyta)	Ginkgo (divisionGinkgophyta)
Gnetae (division Gnetophyta)	Conifers (division Coniferophyta)

Let us follow in some detail the life cycle (Fig. 9.15) of **Pinus longifolia** (pine tree) as an example of the seed method of reproduction. The large pinus tree is the diploid sporophyte stage. This tree produces reproductive structures called **cones**, of which there are two kinds: large female cones (Fig. 9.16), in whose sporangia meiosis gives rise to haploid megaspores, and small male cones, in whose sporangia meiosis gives rise to haploid microspores (Fig. 9.17). (Production of distinctive male and female spores, heterospory is characteristic of all seed plants, both gymnosperms and angiosperms.) In both kinds of cones the sporangia are produced by highly modified leaves (sporophylls).

Each scale (megasporophyll) of a female cone bears two sporangia on its upper (adaxial) surface. Meiosis takes place inside the sporangium, producing four haploid megaspores, three of which soon disintegrate. Next, the single remaining megaspore gives rise, by repeated mitotic divisions, to a multicellular mass, which is the female gametophyte (megagametophyte). When mature, the female gametophyte produces two to five tiny archegonia at its micropylar end. Egg cells develop in the archegonia. Note that the megaspore is never released from the sporangium, and that the female gametophyte derived from it remains embedded in the sporangium, which is still attached to the cone scale. The composite structure consisting of integument, sporangium, and female gametophyte is called an **ovule**.

Each of the many microspores produced by meiosis in a sporangium of a male cone becomes a **pollen grain** (Fig. 9.18). It develops a thick coat, which is highly resistant to loss of water, and wing like structures on each side, which helps its dispersal by wind. Within the pollen grain the haploid nucleus divides mitotically, walls develop around each daughter nucleus. In this manner the pollen grain becomes four-celled (Fig. 9.18). Two of the cells soon degenerate; the two cells that remain are called the generative cell and the tube cell. The mature pollen grain is released from the cone when the sporangium bursts. A single male cone may release millions of tiny pollen grains, which may be carried many miles (sometimes as many as a hundred) by the wind. Note that the pollen grains are multicellular haploid structures (if four cells may be said to be "multi") and that they constitute the male gametophyte (microgametophyte) in (Fig. 9.18).

Among the first seed-producing plants were the gymnosperms, which produce naked seeds. The 4 divisions of these plants are probably not closely related.

Most of pollen grains released by a pine tree fail to reach a female cone. But of the few that sift down between the scales of a female cone, some land in a sticky secretion near the open micropylar end of an ovule. As this secretion dries, it is drawn through the micropyle, carrying the pollen grains with it. The arms of the integument around the micropyle then swell and close the opening. When a pollen grain comes in contact with the end of the sporangium just inside the micropyle, it develops a tubular outgrowth, the **pollen tube**. The nucleus of the tube cell enters the tube, followed by the generative cell. The generative cell then divides, and one of the daughter cells thus produced divides again, producing two sperm cells. Thus a germinated pollen grain contains four active nuclei plus the two nuclei of the degenerated cells; this six-nucleate condition is the male gametophyte.

The pollen tube grows down through the tissue of the sporangium and penetrates into one of the archegonia of the female gametophyte. There it discharges its sperm cells, one of which fertilizes the egg cell. The resulting zygote then divides mitotically to produce a tiny embryo sporophyte consisting of a hypocotyl and an epicotyl. The embryo is still contained in the female gametophyte, which is itself contained in the sporangium. Finally, the entire ovule is shed from the cone as a **seed**, which consists of three main components: a seed coat derived from the old integument stored food material derived from the tissue of the female gametophyte, and an embryo.

A conifer it the most typical example of a gymnosperm. In the conifer life cycle, windblown pollen grains replace swimming sperm. Following fertilization, the seed develops from the ovule, a structure that has been protected with in the body of the sporophyte plant. The seeds are uncovered and dispersed by the wind.

ii) The Angiosperms: (Angion = Cup or Vessel (Fruit) Sperma = Seed)

They have their seeds enclosed in fruit because ovules are covered by ovary. These plants became the dominant land flora of the Cenozoic era. The reproductive structures of angiosperms, are flowers and the ovules are enclosed within modified leaves called carpels

Flower may be described as compressed reproductive shoot with four whorls of modified (floral) leaves called sepals, petals, stamens and carples; and which often pollination and fertilization produces seeds within fruits.

The angiosperms became the dominant land plants in the Cenozoic era. They have flowers, which attract pollinators and produce seeds enclosed by fruits. Also, their vascular tissue is more complex than that of the gymnosperms.

A flower is generally interpreted as a short length of stem with modified leaves attached to it The modified leaves of a typical flower (Fig. 9.20) occur in four sets attached to the enlarged end thalamus (receptacle) of the flower stalk: (1) The **sepals** enclose and protect all the other floral parts during the bud stage. They are usually small, green, and leaf like, but in some species they are large and brightly coloured. All the sepals together form the **calyx**. (2) Internal to the sepals are the **petals,** which together form the **corolla**. In flowers pollinated by insects, birds, or other animals, the petals are usually quite showy, but in those, pollinated by wind they are often reduced or even absent (3) Just inside the circle of the corolla are the **stamens**, which are the male reproductive organs: i.e. they are the micro-sporophylls that produce the microspores. All the stamens together form the androecium. Each stamen consists of a stalk, called**filament,** and a terminal ovoid pollen-producing structure called an **anther**. (4) In the centre of the flower is the female reproductive organ, the **pistil** or **carpel** (some species have more than one pistil per flower). All the carpels together form the gynoecium. Each pistil consists of an **ovary** at its base, a slender stalk (more than one in some species) called **style,** which arises from the ovary, and an enlarged apex called **stigma**. The pistil is derived from one or more sporophylls, which in flowers are called **carpels.** All four kinds of floral organs, sepals, petals, stamens and carpels are present in so-called complete flowers, but some flowers, which are said to be incomplete, lack one or more of them.

Within the ovary are one or more (at least one for each carpel) mega sporangia, called **ovules,** which are attached by short stalks to the wall of the ovary. Meiosis occurs once in each ovule, with the formation of four haploid megaspores, three of which usually soon disintegrate. The remaining megaspore then divides mitotically three times, producing, in most species, a structure composed of seven cells, one of which is much larger than the others and contains two nuclei, called polar nuclei (Fig. 9.23). This haploid seven celled eight-nucleate structure is the much-reduced female gametophyte (often called an embryo sac). One of the cells located near the micropylar end will act as the egg cell.

Each anther has four micro sporangia in each of which many cells undergo meiosis, producing numerous haploid microspores. The wall of each microspore thickens, and the nucleus divides mitotically, producing a generative nucleus and a tube nucleus. The resulting thick-walled two-nucleate structure is a pollen grain, a male gametophyte, which is released from the anther when the mature micro sporangium splits open.

In angiosperms, the reproductive structures are located in the flower, which consists of highly modified leaves.

A pollen grain germinates after pollination (transfer of pollens from anther to stigma) when it falls (or is deposited) on the stigma of a pistil, which is usually rough and sticky. A pollen tube begins to grow, and the two nuclei of the pollen grain move into it. The generative nucleus (which is surrounded by a plasma membrane and is thus technically a cell, though with virtually no cytoplasm) then divides, giving rise to two sperm cells. The pollen tube grows through the tissues of the stigma and style and enters the ovary with tube nucleus at its tip. When the tip of the pollen tube reaches an ovule, it enters the micropyle and then discharges the two sperm cells into the female gametophyte (embryo sac). One of the sperm fertilizes the egg cell, and the zygote thus formed develops into an embryo sporophyte. By the time fertilization occurs, the two polar nuclei of the female gametophyte have combined to form a diploid **fusion nucleus,** with which the second sperm unites, to form a triploid nucleus. This nucleus undergoes a series of division, and a triploid tissue, called **endosperm**, is formed. The endosperm functions in the seed as a source of stored food for the embryo.

Double fertilization is a special type of fertilization which occurs only in angiospermic plants. During this process a sperm fuses with the ovum to form oospore. The other sperm fuses with secondary nucleus to form triploid endosperm nucleus.

After fertilization, the ovule matures into a seed, which, as in pine, consists of seed coat stored food, and embryo. However, the angiosperm seed differs from that of pine in being enveloped by the ovary. It is the ovary that develops into the fruit, usually enlarging greatly in the process. Sometimes other structures associated with the ovary, such as the receptacle, are also incorporated into the fruit. The ripe fruit may burst, expelling the seeds, as in peas (where the pod is the fruit). Or the ripe fruit with the seeds still inside may fall from the plant, as in tomatoes, squash, cucumbers, apples, peaches. The fruit not only helps to protect the seeds from desiccation during their early development, before they have fully ripened, but often also facilitates their dispersal by various means, the wind, say or an animal, which, attracted by the fruit, carries it to other locations or eats both fruit and seeds and later releases the unharmed seeds through its faeces. The life cycle of an angiosperm is shown in Fig. 9.22.

9.4 SPERMOPSIDA AS SUCCESSFUL GROUP OF LAND PLANTS

Having studied representatives of the major groups of land plants we can return to consider why the conifers and angiosperms are so well adapted to life on land. Their major advantage over other plants is related to their reproduction. Here they are better adapted in three important ways.

(1) The gametophyte generation is very reduced. It is always protected inside sporophyte tissue, on which it is totally dependent. In mosses and liverworts, where the gametophyte is conspicuous, and in ferns where it is a free-living prothallus, the gametophyte is susceptible to drying out.

(2) Fertilization is not dependent on water as it is in other plant groups, where sperms swim to the ovum. The male gametes of seed plants are non-motile and are carried within pollen grains that are suited for dispersal by wind or insect. Final transfer of the male gametes after pollination is by means of pollen tubes, the ova being enclosed within ovules.

(3) Conifers and flowering plants produce seeds. Development of seeds is made possible by the retention of ovules and their contents on the parent sporophyte.

Other ways in which spermatophytes are adapted to life on land are summarised below:

(a) Xylem and sclerenchyma are lignified tissues providing support in all vascular plants. Many of these show secondary growth with deposition of large amounts of wood (secondary xylem). Such plants become trees or shrubs.

(b) True roots, also associated with vascular plants to absorb soil water efficiently.

(c) The plant is protected from desiccation by an epidermis with a waterproof cuticle, or by cork after secondary thickening has taken place in dicot stems.

(d) The epidermis of aerial parts, particularly leaves, is perforated by stomata, allowing gaseous exchange between plant and atmosphere.

(e) Plants show many other adaptations to hot dry environment.

9.5 GENERAL ACCOUNT OF ROSACEAE, SOLANACEAE, LEGUME FAMILIES(FABACEAE, CAESALPINLACEAE, MIMOSACEAE) POACEAE WITH EMPHASIS ON FLORAL PARTS

1. ROSACEAE: Rose Family

It has about 100 genera and 2000 species, found growing all over the earth. 213 species of about 29 genera are reported from Pakistan.

Inflorescence: Variable, solitary flowered to racemose and cymose cluster.

Flowers: Bisexual and actinomorphic, hypogynous to epigynous.

Calyx: Sometimes epicalyx is present-sepals 5 free or fused.

Corolla: Petals 5, or numerous in multiple of 5, free imbricate rosaceous, large and showy and usually conpicuous.

Androecium: Numerous stamens, sometimes only 5 or 10 free usually bent inward in the bud state; anther small.

Gynoecium: A simple pistil of 1 to numerous separate carpels or 2 to 5 carpels, united into a compound pistil, often adinate to the calyx tube; ovary superior to inferior; ovules usually 2 or more per carpel; plancentation basal when the carpel is one or apocarpous, but axile when the carpels are many and syncarpous; style simple, as many as the carpels, free or united, stigma linear, spathulate or capitate.

Diagnostic characters: Rosaceous corolla, stamens numerous, polyandrous, monocarpellary or polycarpellary syncarpous may be apocarpous.

Economic importance:
Economic importance of this family is great in providing the pleasure and welfare of mankind. The members of this family are important in temperate regions for fruit and ornamentals. Perhaps, they rank third in commercial importance in the temperate zone among the families of flowering plants.
A large number of plants are ornamental and all grown in gardens for their beautiful and scented flowers. Perhaps the most widely cultivated genus for decorative purpose is Rosa. Many others genera are also grown for their beautiful flowers in the parks and gardens.
The branches of crataegus and cotoneaster provide excellent walking sticks and wood. The wood of Pyruspastia is used for making tobacco pipes.
In Asian countries the petals of common rose usually called gulabs are used in making gulkand, and are also used in extraction of an essential oil, rose oil, used as perfume when distilled with water the petals give Rose-water or Ark-Gulab, which is used in eye disease, and for many other purpose.

Familiar Plants:

	Botanical names	**Common names**	**Local names**
1.	Pyrus malus	Apple	Seb
2.	Pyrus communis	Pear	Nashpati
3.	Prunus persica	Peach	Aru
4.	Prunus amygdalus	Almond	Badam
5.	Rosa indica	Rose	Gulab

2. SOLANACEAE: Night shade or Potato family
It has about 2000 species belonging to about 90 genera found growing in tropical and temperate regions. 52 species belonging to about 52 genera have been reported from Pakistan.

Inflorescence: Typically an axillary cyme.

Flowers: Bisexual usually actinomorphic or weakly zygomorphic bracteate or ebracteate, hypogynous, usually penatamerous.

Calyx: 5 united sepals, usually persistant.

Corolla: 5 united petals, corolla rotate, tubular or infundibuliform.

Androecium: 5 Stamens, polyandrous, epipetalous inserted on the corolla tube and alternate with its lobes, filament usually of unequal length.

Gynoecium: Bicarpellary syncarpous, ovary obliquely placed, superior bilocular or Imperfectly tetra-locular by false septum, style terminal, simple or lobed, placentation axile, ovule numerous.

Diagnostic characters: Flower actinomorphic penta-merous, stamen 5, epipetalous ovary bi-locular, obliquely placed, placentation axile, fruit berry or capsule.

Economic importance:
Members of the family solanaceae provides drugs and food, some are weedy, some are poisonous, and others are handsome ornamentals. The most important plants in the family are potato and tomato.
Other important food plants are egg plant or brinjal vern; bengan, the fruit of capsicum and capsicum frutenscens are rich in vitamin C and A, are used as condiment. Physalis (Ground-cherry vern. Rasbhari) produces an edible fruit enclosed in a bladder-like persistant calyx the husk, hence the name husk tomatoes.
Another plants of great commercial value is tobacco plant leaves of which are dried and made into tobacco, which is used in making cigarettes. Many members of this family yield powerful alkaloids, e.g. Atropa belladonna, Datura (james town weed) which are rich in atropine and daturine respectively, which are used medicinally.
Many plants are cultivated in the gardens for their beautiful flowers, these includes Petunia, Nicotiana, Cestrum Schizanthus, Brunfelsia Solanum etc.

Familiar Plants:

	Botanical names	**Common names**
1.	Solanum tuberosum	Potato
2.	Solanum melongena	Brinjal
3.	Lycopersicumesculentum	Tomato
4.	Capsicum annum	Red-pepper
5.	Petunia alba	Petunia
6.	Solanum nigrum	Black Night shade
7.	Datura alba	Thorn apple
8.	Nicotiana tabacum	Tobacco
9.	Atropa belladonna	Deadly Nightshade
10.	Cestrum nocturnum	Lady of the night

3. LEGUME FAMILIES

(A) FABACEAE: Papilionaceae / Pea family
It has about 9000 spectra belonging to 400 genera found distributed to all parts of the world, 587 species of 82 genera have been reported from Pakistan.

Inflorescence: Racemose or solitary axillary.

Flowers: Bisexual, isomorphic, bracteate, pedicellate, hypo-to perigynous.

Calyx: 5 sepals, more or less united in a tube, mostly hairy.

Corolla: Papilionaceous, Petals 5, the odd outer petal is large and conspicuous and is called standard orvexillum, two lateral ones fire called wings and 2 anterior inner most that fuse to form a boat-shaped structure called the keel or carina, descendingimbricate.

Androecium: 10 stamens, mostly diadelphous nine fused to form sheath round the pistal, while 10th posterior one is free.

Gynoecium: A simple pistil 1- carpeled, with 1 - locule; ovary superior; ovule 1 or more;style long, bent at its base flattened and hairy, stigma simple.

Diagnostic character: Papilionanaeous corolla, 10 stamens, diadelphous, monocarpellary.

Economic Importance:
The family is of considerable importance as a source of high-protein food, oil and forage as well as ornamentals and other uses. Main importance lies in the pulses, belonging to this family, and are used as food, some important and common species of pulse yielding plants are:-
Cicer arietinum (gram or thick Pea vern. Channa), Pisum Satinvum (Pea vern. Muttor), Lens esculanta (ver. Masure), Phaseolus aureus (mung beans vern. Mung), Phaseolus mung (vern. Mash or urad), Phaseolus vulgaris (kidney bean). These pulses are rich in protein contents.
Medicago Sativa Alfalfa vern. Lusan is one of the worlds best forage crop for horses. Vicia, Melilotus and Trifolium are also cultivated as main fodder crops. Many trees of this family provide excellent timber for building, furniture and fuel. Main timber plants are butea, Dilburgia etc.
The seed of Arachis hypogea Peanut or moong phali are edible and also used for extraction of Peanut oil which after hydrogenation is used as a vegetable oil. Indigo dyes are obtained from indigofera tinctoria (vern. Neel) and Butea monosperma, yielding yellow dye from flowers.
Many plants of this family are important for medicines, these include Glycyrrhiza glabra for cough and cold, clitoria termatea used against snake bite. The red and white seeds of Abrus precatorious are used by jewellers as weights called ratti. Some important ornamental plants includes Lathyrus, Lupinus, Clitoria, Butea etc.

Familiar Plants:

	Botanical names	**Common names**
1.	Lathyrus odoratus	Sweet-pea
2.	Arachis hypogea	Pea-nut
3.	Cicer arietinum	Gram
4.	DalbergiaSisso	Red-wood
5.	Pisum sativum	Edible-pea
6.	Sesbania aegyptica	Sesbania

(B) CAESALPINIACEAE: Casia family
It has about2300 species belonging to 152 genera have been reported all over the world. 60 species belonging to 16 genera have been reported from Pakistan.

Inflorescence: Axillary or terminal raceme.

Flowers: Bisexual, zygomorphic, rarely actinomorphic, perigynous.

Calyx: Of 5 sepals free, or connate at base, imbricate or rarely valvate, often coloured.

Corolla: Of mostly 5 petals, free, imbricate, the posterior petal inner most in bud.

Androecium: Of 10 stamens or fewer, rarely numerous free or variously connate, extra staminal disc sometimes present; sometimes staminodes present.

Gynoecium: A simple pistil of 1 carpel; ovary superior, unilocular placentation marginal; ovule 1-many;-style 1 simple, long; stigma simple.

Diagnostic characters: 5 polysepalous, 5 polypetalous, 10 stamens, polyandrous few stamenodous, monocarpellary.

Economic Importance:
The family is of great importance. Some plants are ornamental, some have medicinal importance, a few have food and other values.
The leaves of cassia fistula are used to cure ring worm and skin diseases.C.senna and C.obovata are cultivated for the leaves which yield the drug senna, which is the base for a laxative. Oil extracted from the seeds of cynometera cauliflora is applied externally for skin diseases.
Common ornamental plants are Bauhinia variegata (Kachnar) cassia fistula (Amaltas), Parkinsonia, poinciona regia.
The leaves and flowers bud of Bauhinia varigata are used as vegetable. The acidic fruit of Tamarindus indica are edible and are rich in tartaric acid. The bark of Bauhinia perpurea Tamarindus indica are used in tanning. The heart wood of Haematoxylon (Long wood) yield the dye hematoxylin.

Familiar Plants:

	Botanical names	Common names	Local names
1.	Tamarindus indica	Tamarind	Imli
2.	Cassia fistula	Amaltus	
3.	Bauhinia verigata.	Camel's foot	Kachnar
4.	Poinciana regia	Flame of the forest	Gul-e-mohar
5.	Parkinosia roxburgai	Vilayati Kikar	

(C) MIMOSACEAE: Acacia Family
It has about 3000 species belonging to 56 genera are found growing in the world. 49 species of 11 genera have been reported from Pakistan.

Inflorescence: Racemose.

Flowers: Actinomorphic, bisexual, Hypogynous, bracteate; bract small.

Calyx: Usually of 5 sepals imbricate or valvate, generally fused toothed or lobed, mostly green.

Corolla: 5 petals, valvate, free or fused, corolla lobed.

Androecium: 5 to numerous stamens, free monadelphous, adnate to the base of corolla; anther versatile often crowned by a decidous gland.

Gynoecium: A simple pistil of I carpel, ovary unilocular superior ovules many, placentation marginal, style long filiform, stigma terminal minute.

Diagnostic characters: 5 fused sepals, 5 free or fused petals, androecium monoadelphous monocarpellary.

Economic importance:
Many trees of this family including species of Acacia, Albizzla and Xylia provide commercially important wood, which is used for construction purpose or for

furniture or as a fuel. The wood of Albizzla lebbek is used in cabinet work and railway carriages.
Arabic gum is obtained from Acacia nilotica and A. Senegal Katha a dye is obtained from Acacia catechu. The tender leaves of Accacia nilotica are used as blood purifier.
Some common garden Plants grown for their beautiful flowers Mimosa Pudica, Acacia melanoxylon. A few species of Prosopis are planted in the arid zones for breaking the wind pressure.

Familiar Plants:

Botanical names	Common names	Local names
1. Acacia nilotica	Gumtree	Bauble, Kikar
2. Albizzia lebbek	Siris	
3. Mimosa pudica	Touch-me-not	Chhui mui
4. Prosopisglandulosa	Prosopis	Devi
5. Acacia catechu	Katha plant	

(D) POACEAE/GRAMINAE: Grass family
It has about 3000 species belonging to 56 genera are found growing in the world. 49 species of 11 genera have been reported from Pakistan.

Inflorescence: Composed of units called spikelets, variously arranged, spikelets consisting of bracts, distichoisly arranged along a slender axis (rachilla) the two lower bracts (glumes) which are empty.

Flowers: Bisexual or unisexual, zygomorphic, hypogynous, protected by palea. Perianth is represented by to minute scales called the **Lodicules** (may be absent).

Androecium: It has usually 3, or 6 stamens, anthers versatile and pendulous.

Gynoecium: It is tricarpellary syncarpous or monocarpellary, ovary unilocular superior, styles may be 2, stigmas feathery.

Diagnostic characters: Perianth, 3 to 6 stamens free, versatile anthers, gynoecium monocarpellary flowers are unisexual.

Economic Importance:
This family has the great economic importance as it provides food, fodder, ornamentals etc. Cereals and millets which are chief food stuff of mankind belong to this family, like Wheat, Oats, Rice, Corn, Barley, Millets-Jawar, Bajra, Guar etc. Sugar is obtained from sugar-cane, bamboo-shoots are eaten as a vegetable or soup dish. Nearly all the cereal and millet crops are given to animals as fodder.

Familiar plants:

Botanical names	Common names
1. Triticum indicum	Wheat
2. Avena sativa	Oats
3. Zeamays	Indian Corn
4. Oryza sativa	Rice
5. Saccharum officinarum	Sugar-cane
6. Hordeum vulgare	Barley
7. Pennisetum typhoideum	Bajra

KEY POINTS

- Plants may now be denned as multicellular eukaryotes that are photosynthetic autotrophs where the zygote develops into an embryo.
- The gametophyte is the dominant generation in the life cycles of bryophytes.
- Heterogamy is the most successful kind of reproduction that has evolved in bryophytes. It is defined as production of two different types of gametes, one is male (motile), and the other is female (non-motile) full of stored food.
- The first representative of Lycopsida appeared in the middle of the Devonian period, almost 10 million years after the first psilopsida.
- The Sphenopsides first appeared in the fossil record late in the Devonian period. They became a major component of the land flora during the Carboniferous period and then declined. Members of the one living genus, **Equisetum.**
- In the opinion of many biologists, the ferns evolved from the Psilosida. They first appeared in the Devonian period and greatly increased in importance during the Carboniferous period. Their decline late in the Paleozoic era was much less severe than that of the Psilopsids, Lycopsids and Sphenopsids.
- The seed plants have been by far the most successful in fully exploiting the terrestrial environment. They first appeared in the late Devonian, and in the Carboniferous they soon replaced the lycopsids and sphenopsids as the dominant land plants, a position they still hold today.
- The first gymnosperms appeared in the fossil record in the late Devonian, some 350 million years ago.
- In the centre of the flower is the female reproductive organ, the pistil or carpel (some species have more than one pistil per flower).

EXERCISE

1. Encircle the correct choice:

(i) Tamarind belong to taxonomic family:
(a) Poaceae (b) Brassicaceae
(c) Solanaceae (d) Caesal pinaceae

(ii) Filament is a part of:
(a) Sepal (b) Petal
(c) Stamen (d) Carpel

(iii) Stigma is the part of:
(a) Sepal (b) Petal
(c) Stamen (d) Carpel

(iv) Pollen grain are produced in:
(a) Stigma (b) Ovary
(c) Anther (d) Ovule

(v) Which one is not a group of conymnosperms.
(a) Pteridospermae (b) Ginkgoae
(c) Cruciferae (d) Coniferae

(vi) Club mosses are placed in:
(a) Musci (b) Hepaticae
(c) Lycopsida (d) Bryophyta

(vii) Which one is mis-match:
(a) Musci __________________ Mosses
(b) Lycopsida _______________ Lycopodium
(c) Sphenopsida _____________Selaginella
(d) Anthcerotae _____________ Anthoceros

(viii) Group of plants in which each spore germinates into protonema:
(a) Bryophyta (b) Hepaticae
(c) Musci (d) Anthocerotae

(ix) Group of Tracheophytes having neither roots nor leaves:
(a) Psilopsida (b) Sphenopsida
(c) Lycopsida (d) Pterropsida

(x) Taxonomic family in which ovary is obliquely placed:
(a) Rosaceae (b) Solanaceae
(c) Poaceae (d) Caesalpinaceae

2. Write detailed answers of the following questions:

(i) Give general characteristics and amphibious nature of Bryophytes.
(ii) Give salient features of major groups of Tracheophytes.
(iii) What do you know about Kingdom Plantae? Give characteristics, adaptation to land habit and three main divisions of bryophyta.
(iv) What are tracheophytes? Describe briefly the five major groups of them.
(v) What are spermopsida? Describe angiospermic flower.
(vi) Describe life cycle of funaria or fern.
(vii) Give floral characters of any one angiospermic family.
(vii) Give two familiar plants with botanical names from each of the six taxonomic families that you have studied.

3. Write short answers of the following questions:

(i) Explain the term Heterogamy.
(ii) Name the four types of floral leaves.
(iii) Name the different parts of a stamen.
(iv) Explain the term rotate and papilionaceous corolla.
(v) Give economic importance of Poaceae.
(vi) What are the three steps in the evolution of seed?
(vii) Why hornworts are so called?
(viii) Why gymnosperms have nacked seeds but not angiosperms?
(ix) What is double fertilization?

4. Define the following terms:

(i) Kingdom plantae (ii) Bryophyta
(iii) Tracheophyta (iv) Heterospory
(v) Gymnosperm (vi) Angiosperm
(vii) Flower (viii) Rosaceous corolla
(ix) Perianth (x) Floral formula

5. Distinguish between the following:

(i) Gynoecium of Rosaceae and Solanaceae
(ii) Algae and Plants
(iii) Bryophyta and Tracheophyta
(iv) Homospory and Heterospory