5.0 ALGAE

Algae are autotrophic, aquatic or semi aquatic non vascular plants. The simplest forms are unicellular; the complex sea weeds grow to great lengths and complexity. Some may occur as groups of cells loosely attached to each other or surrounded by slimy sheath and are thus termed colonial algae. While others are filamentous; whereby cells are attached end to end forming a long chain of cells. Filamentous algae are either branched or unbranched and have either one or several nuclei per cell.

5.1 Classification of Algae

Algae are divided into seven divisions namely;

Chlorophyta (green algae)

Phaeophyta (brown algae)

Rhodophyta (red algae)

Chrysophyta (diatoms, yellow-green and golden-brown algae)

Euglenophyta euglenoids)

Pyrrhophyta (dinoflagellates)

Cryptophyta (cryptomonads)

5.1.1 Division Chlorophyta (green algae)

- Photosynthetic pigments are chlorophyll a and b and carotenoids.
- Cell wall components are polysaccharides, including cellulose and they store food in the form of starch.
- They may be colonial or filamentous, although unicellular forms with 1 – 8 whiplash flagella abound.
- Examples of chlorophyta are *Volvox, Spriogyra,Ulothrix, Chara, Oedogonium, Euastrum, Cosmarium* etc.

5.1.2 Division Phaeophyta (brown algae)

- The brown algae are almost all marine, although a few freshwater species are present.
- Photosynthetic pigments are chlorophylls a and c, fucoxanthin and carotenoids.
- Cell wall components are cellulose, alginic acid and sulfated polysaccharides.
- They store carbohydrates in the form of laminarin and mannitol.
- The life cycle of kelps is dominated by a large sporophyte plant, which consists of a thallus comprising of stipe, blades, and branching hold fast- that anchors them to the ocean floor or rocky substratum. The leafy blades often have air bladders that enable them to keep afloat.
- Examples are *Ectocarpus, Fucus, Laminaria* and *Macrocystis*.

5.1.3 Division Rhodophyta (red algae)

- They are either microscopic filament or macroscopic leafy branches.
- Their cell wall components are cellulose, pectin and calcium salts. Because their cell walls are impregnated with calcium and magnesium carbonates, which makes the walls hard and crusty, some of the red algae are an important part of coral reefs.
- Photosynthetic pigments are chlorophyll a, carotenoids and phycobilins.
- They are reddish in color because of the abundance of phycoerythrin- a red phycobilin. They store carbohydrate in the form of floridean starch. They lack flagellated cells.
- Examples are *Polysiphonia* and *Batrachospermum*.

5.1.4 Division Chrysophyta (yellow-green, golden-brown algae and diatoms)

- The chrysophyta forms the largest division of algae with more than 11,000 species.
- Majority of them are diatom, almost all of which are unicellular, and either bilaterally or radially symmetrical. Diatoms lack flagella.
- They are referred to as the "grasses of the sea" because they are the most important primary producers in marine and many aquatic ecosystems where they are found.
- They have chlorophyll a and c, food reserve chrysolaminarin and oils, no starch and their cell wall components are silica and pectic substances.
- They are unique because of their exquisitely ornamented glass shells.
- Examples are *Coscinodiscus, Pinnularia, Lauderia, Aulacoseira* and *Tabellaria*

5.1.5 Division Euglenophyta

- These are also known as euglenoids, mostly found in marine and freshwater habitats.
- Photosynthetic pigments are chlorophylls a and b and carotenoids as in chlorophyta.
- Cell wall component are absent and they store carbohydrate in the form of paramylon granules.
- They are simple, unicellular organisms with 1 – 3 tinsel flagella that are anteriorly positioned.
- Examples are *Euglena* and *Phacus*.

5.1.6 Division Pyrrhophyta (dinoflagellates)

- These are the dinoflagellates and they are mostly marine; although some may be found in freshwater.
- They contain chlorophylls a and c, peridin and other carotenoids.
- Cell wall component may be absent but in some species their cellulose cell wall are modified into armor-like arrangements that are important for identification.
- They may bear 2 tinsel flagella.
- Examples include *Peridinium*, *Protoperidinium* and *Gymnodinium*.

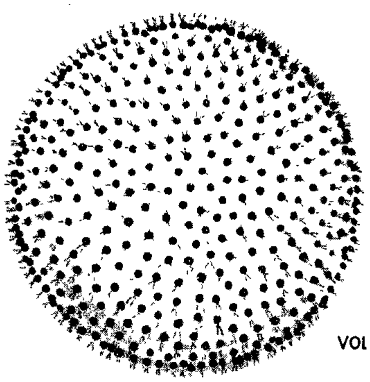
5.1.7 Division Cryptophyta

- There are about 100 species in this group and they are also known as cryptomonads.
- They are mostly marine with a few freshwater species.
- Their photosynthetic pigments are chlorophylls a and c, carotenoids and phycobilins.
- Cell wall components are absent and starch is their food reserve.

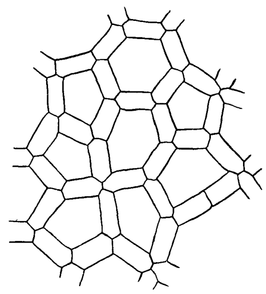
5.2 Economic Importance of Algae

1. As plankton, algae serve very significant ecological role as primary producers in the aquatic environment. About 50-70% of the earth's atmospheric oxygen comes from the photosynthetic activities of marine unicellular algae.
2. Diatom cell walls harvested from large deposits known as diatomaceous earth have various industrial uses.
   (i) as an abrasive in metal polish
   (ii) few brands of tooth paste
   (iii) filter for swimming pools
   (iv) beer and wine clarifier
   (v) reflective paint on highways, road signs and license plates.
3. Carrageenan from red algae like Irish moss is used to stabilize or emulsify paints, cosmetics, cream- containing food and chocolates.
4. Agar-agar from species of *Gracillaria* is a very important culture medium to grow bacteria and other microorganisms for laboratory research.
5. Many algae have been used traditionally as food; most sea weeds are rich in iodine which is an important mineral in the thyroid gland. *Porphyra tenra* and *Spirulina* are examples of edible algae.
6. Some algae and cyanobacteria recently have been found to be good sources of vitamins, industrial chemicals, food additives and fertilizers
7. Algae have increasingly important role in treating sewage and industrial wastes. Example *Chlamydomonas reinhardii* (Chlorophyta) is useful in cleaning up toxic wastes.
8. Blooms of some dinoflagellates (known as "red tides") lead to the death of millions of fish annually in seas and some coastal areas. Ingestion, and in some types, just skin contact, can be dangerous as they release toxins that kill fishes and can have severe consequences to human and other animals.
9. Algae have been used extensively in medicine, especially in the Asian countries for their purported powers to cure and or prevent illnesses as varied as cough, gallstone, goiter, hypertension and diarrhea. Recently algae have been surveyed for anticancer compounds, with several cyanophyta

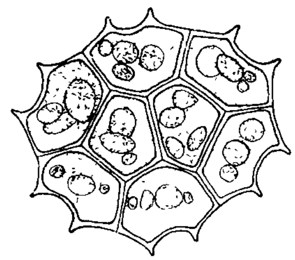
appearing to contain promising candidates. Diatoms also have been used in forensic, medicine as their presence in the lungs can indicate a person died due to drowning.



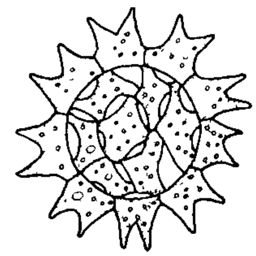
Volvox aureus



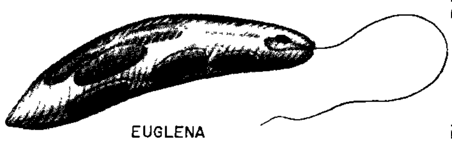
Hydrodictyon reticulatum

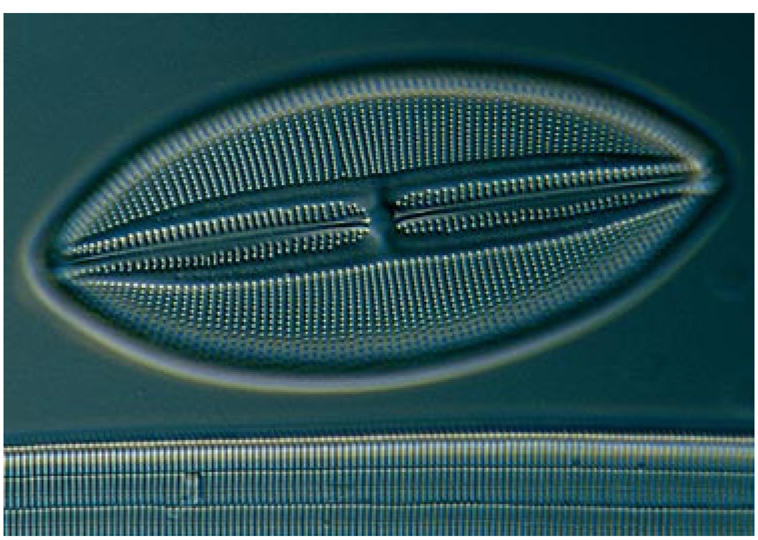


Pediastrum boryanum



Pediastrum duplex





6.0 BRYOPHYTES

- The bryophytes are small, seedless, non vascular plants consisting of liverworts, hornworts and mosses.
- They evolved from aquatic to terrestrial ecosystems.
- Bryophytes live in almost all places that plants can grow and in many places where vascular plants cannot grow.
- Bryophytes are often the first plants to invade an area after a fire, grow at elevations varying from sea level to 5,500 meters. There are no marine bryophytes.
- Their life cycle is dominated by free living, photosynthetic haploid gamete-producing plant – the gametophyte; which regularly alternates with a diploid, spore-bearing plant – the sporophyte.
- Bryophytes require free water to carry out sexual reproduction. Asexual spores are absent in bryophytes.
- Members reproduce asexually by fragmentation of gametophyte or by special bodies known as gemmae (singular, gemma).
- Their gametangia – antheridia and archegonia) are surrounded with sterile cells.

There are three major classes of bryophytes, namely;

1. Hepaticae (liverworts)
2. Anthocerotae (hornworts)
3. Musci (mosses)

Class Hepaticae

These are the most primitive bryophytes and consist of simple, flat, ribbon-like, green thallus. There are about 8,500 species of liverworts and they range in size from 0.5mm in diameter to thallus more than 20 cm wide. All liverworts have a prominent gametophyte which sometimes has a waxy cuticle. They also bear thick-walled spores. These water-proofing features are important adaptations to live on land in moist environments, but a few liverworts are adapted to dryer environments. Members of the class hepaticae have the following distinguishing features;

- unicellular rhizoids
- Their gametophytes are leafy and often lobed and bilaterally symmetrical. They lack mid rib.
- The entire thallus is photosynthetic, and the lower side modified for storage in a few species.
- Their sporangia are often unstalked.
- They shed spores from sporangia for a relatively short time.

Liverworts reproduce asexually by death of old parts of the plant or by fragmentation. They also bear ovoid, star-shaped or lens-shaped pieces of haploid tissues called gemmae.

A dominant haploid gametophyte has two shapes; leafy and thallose (a plant body undifferentiated into root, stem and leaves). The diploid sporophyte of liverworts lack stomata. The capsule and its stalk are attached to the gametophyte by a knob-like foot. The sporophyte of some thallose liverworts is spherical, unstalked and held within the gametophyte until they shed their haploid spores. Many liverworts are unisexual ie. Male and female reproductive parts are produced on separate gametophytes eg *Marchantia*; while others are bisexual e.g. *Riccia*.

Class Anthocerotae

Members of this class have the simplest gametophyte of bryophytes. They are about 100 species in six genera; the most familiar of which is *Anthoceros*, a temperate genus. Hornworts have several features that distinguish them from other bryophytes:

❖ The sporophyte is shaped like a tapering horn, hence the common name hornwort.
❖ Each photosynthetic cell contains one to only a few chloroplasts; and each chloroplast is associated with a starch-storing body called pyrenoid as in the cells of green algae and vascular plants.
❖ Archegonia and antheridia are enclosed snugly in the sporophyte thallus and are in contact with the surrounding vegetative (non reproductive) cells of the thallus.
❖ The flat dark green gametophytes are structurally simpler than those of the other bryophytes. They are flattened and may superficially resemble those of thallose liverworts. Hornwort gametophytes are either annual or perennial and are anchored to the substratum by rhizoids.
❖ Sex organs form on the upper surface of thallus. One or more antheridia resembling those of liverworts form in roofed chambers in the upper portion of the thallus and the archegonia form in rows beneath the surface.
❖ Asexual reproduction is by fragmentation.

The diploid sporophyte of hornworts differs remarkably from those of other bryophytes. They are long, green spindles (1-4cm long), with tapering tips. They are semi independent, photosynthetic and can live for several months on the gametophyte while spores are released over time.

Class Musci

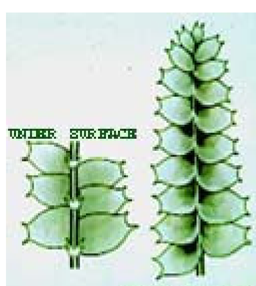
Mosses are remarkably successful land plants that thrive alongside more successful conspicuous vascular plants. The approximately 12,000 species of mosses make up the largest and most familiar group of bryophytes. Moss morphology is diverse and the gametophytes of nearly all species have two growth stages.

✓ Creeping, filamentous stage – the protonema- from which develops;
✓ The moss plant with an upright or horizontal stem bearing small, spirally arranged green leaves.
✓ Rhizoids are found at the base of the stem

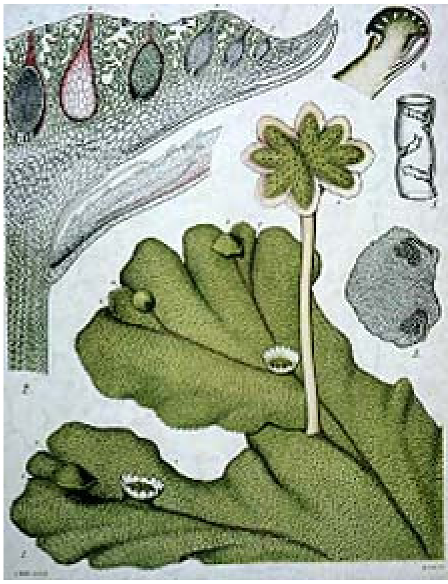
- ✓ The mature sporophyte is brown, yellowish or reddish and has three parts; a foot, a seta (stalk) and a capsule covered by a calyptra.
- ✓ The foot which penetrates the base of the venter (the swollen base of the archegonium containing an egg) and grows into the gametophyte, absorbs water, minerals and nutrients from the gametophyte.
- ✓ The wiry seta elongates and raises the capsule as much as 15 cm above the gametophyte. As this occurs, the protective covering or calyptra is around the capsule. Specialized sporangium cells (sporogeneous tissues) of the capsule undergo meiosis forming as many as 50 million haploid spores per capsule.
- ✓ Spores that land on suitable environment germinate, forming protonemata and thus complete the life cycle.
- ✓ Mosses include, *Sphagnum, Funaria, Polytrichium, Bryum, Mnium, Dicranoweisia* etc

ECONOMIC IMPORTANCE OF BRYOPHYTES

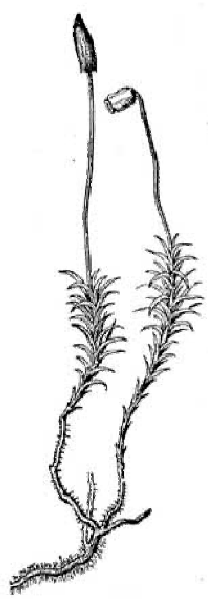
- ❖ Bryophytes have very limited economic importance. They are generally not edible.
- ❖ They are used as furniture stuffing, soil conditioners, for fuel, as absorbent in oil spills and for cushioning.
- ❖ Florists use peat moss as a damp cushion when shipping plants. *Sphagnum* serves as disinfectant for some Aboriginal people and for wound dressing.
- ❖ North American Indians used *Mnium* and *Bryum* to treat burns. *Dicranoweisia* has been used to water proof roofs in Europe.
- ❖ Bryophyes reduce erosion, condition soil and are often among the first organisms to invade disturbed areas.
- ❖ Many of them grow on specific habitats and are sensitive to pollution.
- ❖ Examples of leafy liverworts



- ❖
- ❖ The leafy liverwort *Bazzania* *Lophocolea*




- Kny's Wall Chart Showing Male Gametophyte of *Marchantia* a thallose liverwort



Moss -
radially symmetrical
rhizoids multicellular
leaves with or without a midrib

PTERIDOPHYTES (Seedless vascular plants)

The seedless vascular plants are primarily ferns, but they also include whisk ferns (which are not true ferns), club mosses and horsetails. Features of the seedless vascular plants that enable them to thrive on land include;

- a resistant cuticle
- complex stomata
- vascular tissues
- absorptive root hairs
- desiccation - resistant spores.

Typical of pteridophytes is that they have xylem and phloem tissues for transport of mineral nutrients, water and food but do not produce seeds. There are four distinguishable groups of living pteridophytes that show significant variation among their branching patterns, leaf morphology, vascular organization and underground absorptive organs. The type and arrangement of sporangia on the sporophyte can also be used as distinguishing features among the groups. Gametophytes of the groups vary in their origin by different types of spores and their mechanism of obtaining nutrients. No single characteristic defines each group; rather classification is based on a set of features summarized below.

Division Psilotophyta (whisk ferns)

- This is the most primitive of all vascular plants.
- This is because they have no leaves and root. Instead of root hairs they have rhizomes with absorptive rhizoids.
- There are two genera in the division; *Psilotum* and *Tmesipteris*.

Division Lycopodiophyta

- Members of this group are also known as club mosses.
- They are also known as Lycopods and most of the species are included in 2 genera, club mosses (*Lycopodium*, about 400 species) and the spike mosses (*Selaginella*, about 700 species), both of which get their common names from their club or spike shaped strobilli.
- Most species are terrestrial, but many are epiphytic (growing on other plants).
- The sporophytes of club mosses are differentiated into leaves (called microphyll), stem and roots.
- The roots branch from perennial rhizomes that sometimes grow outwards from a central point to form ‘fairy rings’.
- The Lycopodiophyta also include the quillworts (*Isoetes*) so named because of their narrow quill-like leaves.

- Most of the leaves of quillworts are fertile and do not aggregate into strobilli. Some leaves produce sporangia that abort before maturity.

Division Equisetophyta

- These are also known as horsetails and represented by one living genus *Equisetum*, with about 15 species. They have branched stems, although some may be unbranched.
- *Equisetum* species are also called scouring rushes because their epidermal tissues contain abrasive particles of silica.
- They have true leaves and the stems are the dominant photosynthetic organs of the plant body. The most conspicuous feature of the stem is the presence of small leaves arranged in whorls.
- The branching pattern of *Equisetum* stem is unique among vascular plants. Their lateral branches sprout from between the leaf bases instead of growing from the leaf axils.
- The gametophyte of Equisetum is a photosynthetic, pin-cushion shaped plant that can grow up to 1 cm in diameter.
- The sexuality of *Equisetum* gametophytes is not well understood because it is variable and appears to be related to environmental conditions.

Division Polypodiophyta (ferns)

Fern include approximately 12,000 living species, making them the largest seedless vascular plants. Ferns are primarily tropical plants, but species inhabit temperate regions and even deserts.

The most conspicuous parts of the fern are the compound leaves called fronds. A pinna is the leaflet of a frond. New leaves grow a fleshy rhizome. The leaves exhibit what is called circinate venation as they grow faster at their lower surface than the upper surface giving them initial curled shape. The curled young leaves are known as fiddleheads. New fiddle heads arise close to the growing tips of the rhizome at the beginning of each season. Near the tip of each leaf, certain cells revert to meristems and grow into new root, leaves and rhizomes. Fern leaves are usually fertile but do not form strobilli. The fronds characteristically have dark, spot like structures, often on their lower surfaces, each of which is a collection of sporangia. Together sporangia are called a sorus (plural, sori). The sori of some species are covered by an outgrowth from the leaf surface called an indusium, while the sori of other species either are not covered or are not covered or are enfolded by the edge of the leaf. Some ferns can produce millions of spores because the number of sporangia per sorus, large number of spores per sporangia and the enormous number of sori per leaf.

The flinging spore dispersal action of ferns is as a result of the behavior of an incomplete ring of cells called annulus that circles the sporangium. In most ferns, haploid (n) spores germinate into green, heart-shaped prothallus gametophytes anchored to the soil by rhizoids. The haploid gametophytes are usually bisexual with the sex organs on the lower surface. Archegonia are sunken in the gametophyte with their neck sticking out slightly. Antheridia protrude from the surface near the tip and are intermingled with rhizoids. The sperms swim into the neck of the archegonium to reach the egg. Once fertilization occurs, the diploid zygote germinates into a young sporophyte that quickly becomes independent of the gametophyte. The short lived gametophyte dies.

ECONOMIC IMPORTANCE OF PTERIDOPHYTES

- The seedless vascular plants have their greatest economic impact in fossil fuel deposits. Their spores are easy to identify and are associated with oil deposits.
- Many ferns are often found in greenhouses or are grown as houseplants and ground covers.
- *Azolla* is substituted as a rotated crop in rice paddies.
- As an aquatic plant, it harbors a cyanobacterium *Anabaena azollae* that fixes nitrogen from air thereby acting as a fertilizer to replenish nitrate in the soil.
- Native Americans treated wounds and nose bleeds with spores from *Lycopodium clavatum* a club moss. It has blood coagulant and antibiotic properties.
- Resins from the rhizome of *Dryopteris marginalis* was once used to get rid of intestinal tapeworms.
- Many species of Lycopodium synthesize several alkaloids that are potent animal poisons. The dried and powdered leaves containing these chemicals are used as pesticides in parts of Eastern Europe.

GYMNOSPERMS

The term gymnosperm is derived from the Greek word *Gymnos* meaning “naked” and *sperma* meaning seed. Gymnosperms are plants whose pollens are carried by wind directly to ovules (unfertilized seeds) instead of to the stigma (as in flowering plants) and whose seeds are naked (not enclosed in fruits). Thus by definition, gymnosperms are all seed plants without fruits. All are trees and shrubs with varying forms. Many have needle or scale leaves and most of these forms are evergreen. Some have broad leaves, and in others the leaves are palm like. A number of gymnosperms are extinct but well known as fossil plants. Their fossils consisting of beautifully preserved stems, roots, leaves and even pollen grains, have been found encased in coal and rock mines. They have a distinct fern-like appearance and for years were regarded as ferns until seeds were found attached to their leaves and these are mainly found in the group pteridospermophyta.

They are characterized by secondary growth that usually forms woody trees or shrubs but species are vine-like. Most gymnosperms lack vessels in their xylem, in this regard they are like most ferns and their relations.

In the life cycle of gymnosperms, the alternation between the sporophytic and gametophytic phases is similar to that of other plants. The male gametophyte produces the sperm cells while the female gametophyte produces the egg cells; thus the gametophyte is unisexual. Examples of gymnosperms include, the maiden hair tree (G*inkgo*), cycads, junipers, pines, redwoods and members of the Gnetophyta (*Ephedra, Gnetum*).

Most gymnosperms produce seeds in a complex reproductive structure consisting of several scales grouped together at the end of a stem and commonly called cones or strobili. There are two types of strobili – the male cone (microstrobilus) in which pollen grains (male gametophyte) are produced and female cone (megastrobilus), in which ovule (female gametophyte) is produced. Sexual reproduction requires the transfer of gametes from a male cone to a female cone.

There are considerably fewer species of gymnosperms than there are angiosperms. Most classifications of gymnosperms include about 65 genera, 720 species in 4 divisions namely;

(i) Cycadophyta (cycads)
(ii) Pinophyta (conifers)
(iii) Ginkgophyta (maiden hair tree)
(iv) Gnetophyta (gnetophyta)

Division Cycadophyta

There are about 10 genera and 100 species of cycads, distributed in the tropical and subtropical regions of the world. Like *Ginkgo* all cycads are dioecious. Cycads have palm like leaves that bear no resemblance to the leaves of other living gymnosperms. Under favorable conditions, cycads usually produce one crown of leaves each year. In some, the roots grow at the surface of the soil and develop nodules containing nitrogen-fixing cyanobacteria. Cycads bear large cones with simple, shield-shaped modified leaves that may be covered with thick hairs. Cycads leaves are similar to those of *Ginkgo* than of any gymnosperm; they have a 3-layered integument, but the inner layer is softer instead of papery.

Also like *Ginkgo*, cycads have flagellated sperm cells. The sperm cells of cycads are the largest among plants (up to 400µm in diameter) and each sperm cell can have 10,000 to 70,000 spirally arranged flagella.

Division Pinophyta

The common name of this group, conifers, signifies plants that bear cones; even though other divisions of gymnosperms also include cone-bearing species. Members of the genus *Pinus*, considered a typical conifer are the most abundant in the Northern hemisphere.

Pines have short shoots, long shoots and two kinds of leaves. The more obvious type is the pine needle, which occur in groups called fascicles of 2 – 5 needles. A fascicle always forms a cylinder and is actually a short shoot that is surrounded at its base by small non photosynthetic, scale like leaves which usually fall off after one year of growth. Other conifers also have narrow leaves that often have a small point at the tip, but they do not occur in fascicles. These include yews, firs, larches, spruces. In contrast, leaves of others like cypresses and junipers are scale like at maturity. Most conifers are evergreen; however larches, the bald cypress and the dawn redwood are deciduous.

At the time of pollination, the seed cones of conifers are small, and the ovule-bearing scales are slightly separated from one another enabling the pollen grains to reach the pollination droplet. The micropyl closes after pollen grains are drawn into the ovule. Meiosis begins in the megasporangium about a month later. The development of the female gametophyte from the functional megaspore is very slow. In pines, the pollen tube transports sperm cells to the female gametophyte. The seed cone becomes larger and woodier but remains closed while the embryos develop. The time between pollination and seed maturation in pines is usually about 18 months.

When mature, the cones of most pines are dry, the scales are woody and they open releasing winged seeds. Some cones require fire to cause them to open.

Division Ginkgophyta

Only one living representative, the maiden hair tree (*Ginkgo biloba*), remains in this very ancient division of plants. The trees are dioecious, having individual 'male' trees that produce pollen but no ovules and other 'female' trees that produce ovules and seeds but no pollen. Its venations are produced on two types of shoots, or stems. The relatively fast-growing long shoots produce leaves with a distinct apical notch (hence, *biloba*), while slow-growing short shoots produce leaves without a notch.

After wind carries pollen grains to ovule-bearing trees, the pollination droplet of the ovule withdraws with its load of pollen. Pollen tubes grow by digesting the tissue of the megasporangium. The flagellated sperm cells swim to fertilize the egg. *Ginkgo* seeds include a massive integument with an outer fleshy layer, a hard stony middle layer, and an inner dry papery layer. Mature seeds have the size and appearances of small plums, but these are not fruits because *Ginkgo* has no ovary surrounded its ovules.

Division Gnetophyta

The gnetophyta are the most unusual of all gymnosperms and include some of the most distinctive of all seed plants. They are tropical plants mostly occurring in Asia, Africa and South America. There are 3 clearly defined genera and 71 species. These genera are *Ephedra* (40 species), *Gnetum* (30 species) and *Welwitschia* (1 species). These genera also differ so markedly in their morphology and vegetative morphology and the division appears intermediate between gymnosperms and angiosperms.

Members of the *Ephedra* commonly called joint firs are either monoecious or dioecious, mainly low shrubs, found in dry and desert regions of the world. They have slender, green jointed branches, appear leafless but possess small scaly leaves that lose their photosynthetic capability as they mature. Therefore, most photosynthesis in *Ephedra* occurs in the green stems. Several species of joint fir yield ephedra, a medicinal herb that has been used in traditional Chinese medicine for thousands of years.

Members of the genus *Gnetum* inhabit tropical forests. They are dioecious, either as climbing vines or trees, and having broad, simple leaves similar to those of woody dicots.

Welwitschia mirabilis is the sole living representative of its genus. It is slow-growing and confined to the Namib and Mossamedes deserts of south western Africa. The woody stem which is concave and bark encrusted, may be as much as 1.5 meters in diameter and is connected to a large tap root. Mature plants have a pair of large strap-shaped leaves, which persist throughout the life of the plant. They split length wise, giving the appearance of more than two leaves per plant. Each leaf has a meristem at its base, which constantly replaces tissues that is lost at its drier, aging tip. *Welwitschia* is dioecious.

Gnetophyta are unique among gymnosperms because one of the sperm cells from a male gametophyte fertilizes an egg, while the second sperm cell fuses with another cell in the same female gametophyte. Thus gnetophyta undergo double fertilization, a process typical of angiosperms. Unlike double fertilization in angiosperms however, it is not followed by the formation of a triploid endosperm – the food reserve in seeds of flowering plants, instead the diploid cell from fertilization by the second sperm cell disintegrates.

ECONOMIC IMPORTANCE OF GYMNOSPERMS

The gymnosperms are second only to the angiosperms in their daily impact on human activities and welfare. Their greatest economic impact comes from our use of their wood for making paper and lumber. Other important gymnosperms include;

1. White spruce (*Picea glauca*) is the chief source of pulp wood for newsprint in temperate region.
2. Conifers produce 75% f the world's timber and much of the pulp used to make paper.
3. Douglas fir is the most desired timber tree and is heavily used in plywood and for large beams in construction.
4. Wood from the red spruce (*Picea rubens*) is specially used for musical instruments like violin and box guitars.
5. Some products from the bark of the gymnosperm pacific yew (*Taxus brevifolia*) have been found to shrink tumor caused by ovarian cancer. The drug Taxol, obtained from this plant has anticancer properties.
6. Wood products from conifers like turpentine and rosin (the liquid and waxy component of resin) have been used in many processes including varnishes, deodorants, lotions, drugs, water proofing, etc.

7. Gymnosperms also have an economic importance related to their value as part of national forests, parks and other recreational areas as well as their importance as symbols – Christmas trees. The tallest living plants are giant sequoias found in California in U.S.A are gymnosperms.

ANGIOSPERMS

The word angiosperm is derived from two greek words “angein” meaning “covered or vessel” and “sperma” meaning “seed”. Thus literally, angiosperm means plants producing covered seeds. The covering is the fruit (which is derived from the ovary). The angiosperms or flowering plants are the dominant plants of the world today. They are the most highly developed of all plants. They show a great variation from simple stem less, free floating duckweed (*Lemna*), through herbs, shrubs and trees. They occur in freshwater, in considerable numbers but few are found in marine environment. They form the major portion of vegetation of many areas; they are annuals, biennials and perennials. The outstanding features of the angiosperms are the flower and fruit. Their reproductive process occurs in the flower. In some plants however, the flower is not very conspicuous e.g. grass. They have true vessels and sieve tubes.

Gymnosperms vs. Angiosperms

Characteristic	Gymnosperms	Angiosperms
Growth Habit	Woody trees & shrubs	Woody or herbaceous
Xylem	Tracheids	Vessels and Tracheids
Reproductive structures	Cones (usually)	Flowers & fruits
Pollination	Wind	Animals, wind, water
Fertilization	Egg + Sperm = zygote	Egg + Sperm = zygote Polar nuclei + sperm = endosperm
Seeds	Exposed	Enclosed within fruit

Why are Angiosperms so successful?

1. Seed production in closed carpels with nutrient reserve.

2. Efficient water-conducting cells (*vessel elements* + tracheids).

3. Efficient carbohydrate-conducting cells (*sieve tube elements* + sieve cells).

4. Leaves -- broad, expanded blades for maximum photosynthesis; many are deciduous and can be shed during times of stress.

5. Modified stem and root storage organs.

6. Adaptation to animal pollination and seed dispersal mechanisms.

The gametophyte is reduced, retained in and dependent on the sporophyte. The further reduction in the gametophyte and its subsequent development is the main difference between gymnosperms and angiosperms. The male gametophyte is represented only by the pollen grain and the female gametophyte is reduced to an embryo sac which usually contains 8- nuclei.

All flowering plants produce seeds except some that have been modified by man so that they are now seedless. In angiosperms, seeds are borne within a closed structure, the ovary, which eventually becomes fruit. In gymnosperms, the seeds are not surrounded completely, but are borne on upper surface of a scale! The flower is a shoot bearing floral leaves. In a complete flower, the floral leaves are sepal (calyx), petal (corolla), stamens and carpels. Some flowers have only the essential reproductive structures, stamens and carpels. Other flowers are unisexual i.e. have either stamen or carpel not both. There are also other floral variations in angiosperms.

Comparative terminology of angiosperm reproductive parts with other division

Angiosperms	Other divisions
Stamen	Microsporophyll
Pollen sac	Microsporangium
Microspore	Microspore
Pollen grain	Germinating microspore or young gametophyte
Pollen tube	Mature male gametophyte
Carpel	Megasporophyll
Nucellus	Megasporangium
Megaspore	Megaspore
Embryo sac	Female gametophyte
Ovule	Ovule

Life cycle of Angiosperm

The dominant vegetative plant is the sporophyte which produces the flower, the organ of sexual reproduction.

Male gametophyte

The anther is the particular part of the stamen responsible for production of microspores which are products of meiosis. The microspore mother cell forms within the pollen sac. Each microspore contains one haploid nucleus, which divides into generative and tube nuclei. While this mitosis is taking place, a heavy sculptured wall forms around the microspore and a mature pollen grain results. The pollen is shed and carried in a number of means to a stigma and grows through the style, down to the ovule within the ovary. The tube nucleus, depending on the species may degenerate early or persist until later. The generative nucleus divides within the pollen tube into sperm cells. The pollen tube with sperm cells and tube nucleus constitute the mature male gametophyte.

Female gametophyte

An enlarged cell within the nucellus of a young ovule undergoes meiosis and forms 4 megaspore arranged in a row. While this process is taking place, integuments form about nucellar tissues, resulting in formation of a typical ovule. The 3 megaspores close to the micropyle generally disintegrate. The remaining megaspore undergoes 3 successive mitotic divisions resulting in 8 nuclei of the embryo sac or female gametophyte – one egg cell, two synergid cells, one endosperm mother cell with polar nuclei and three antipodal cells.

Fertilization and seed development

With the penetration of the pollen tube to the mature embryo sac, the stage is set for fertilization. In angiosperms, fertilization involves not only the union of the egg cell with the sperm cell but in addition, the union of a second sperm cell with the endosperm mother cell to form the primary endosperm cell. Since there are two nuclei in the endosperm mother cell, the nucleus of the primary endosperm cell will have three sets of chromosomes. The fusion of two sperm cells, one with egg cell, the second with the endosperm mother cell is known as double fertilization. The resulting zygote generally develops directly into a small pro embryo, from one end of which a typical embryo (seed) develops. The fate of the primary endosperm cell depends on the species. It forms the endosperm which plays some role in nourishing the developing embryo. In some genera, for example the grains, the endosperm enlarges and persists in the seed to form a main source of nourishment for the young seedling. A seed includes a dormant embryo and food a supply to enable the young seedling to establish itself. Food is generally stored either in cotyledons of the embryo or in endosperm. With the germination of seeds and the development of seedling into a flowering plant, the life cycle of an angiosperm is completed.

INTRODUCTION TO ETHNOBOTANY AND HERBAL MEDICINE

Ethnobotany is the study of the interaction between plants and people, with a particular emphasis on traditional tribal cultures; it is closely related to cultural anthropology, the study of human societies. An important branch of ethnobotany called economic botany focuses on the commercial use of plants, especially in industrialized societies.

MEDICINAL PLANTS

The importance of plant derived pharmaceuticals is undisputed. These plant derived drugs are more expensive than chemically synthesized drugs. There are many rich people in the world who can afford these plants derived drugs.

Balms

Balm, (*Melissa officinalis*, family Lamiaceae) common name for a fragrant, perennial herb, native to Europe and has been introduced worldwide. Balm has long been cultivated in gardens. The stems and leaves used in medicine as a gentle stimulant and tonic. The taste is somewhat astringent and the odor slightly aromatic. Balm like properties are common among the mints. The term balm is applied to several resins obtained from balsam fir trees.

Periwinkle Plant

Periwinkles make up the genus *Vinca,* of the family Apocynaceae. The lesser periwinkle is classified as *Vinca minor* and the greater periwinkle as *Vinca major.*