3 Plant Kingdom

INTRODUCTION

In the previous chapter, we looked at the broad classification of living organisms under the system proposed by Whittaker (1969) wherein he suggested the Five Kingdom classification viz. Monera, Protista, Fungi, Animalia and Plantae. In this chapter, we will deal in detail with further classification within Kingdom Plantae popularly known as the 'plant kingdom'.

We must stress here that our understanding of the plant kingdom has changed over time. Fungi, and members of the Monera and Protista having cell walls have now been excluded from Plantae though earlier classifications put them in the same kingdom. So, the cyanobacteria that are also referred to as blue green algae are not 'algae' any more. In this chapter, we will describe Plantae under Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.

Let us also look at classification within angiosperms to understand some of the concerns that influenced the classification systems. The earliest systems of classification used only gross superficial morphological characters such as habit, colour, number and shape of leaves, etc. They were based mainly on vegetative characters or on the androecium structure (system given by Linnaeus). Such systems were **artificial;** they separated the closely related species since they were based on a few characteristics. Also, the artificial systems gave equal weightage to vegetative and sexual characteristics; this is not acceptable since we know that often the vegetative characters are more easily affected by environment. As against this, **natural classification systems** developed, which were based on natural affinities among the organisms and consider, not only the external features, but also internal features, like ultrastructure, anatomy, embryology and phytochemistry. Such a classification for flowering plants was given by George Bentham and Joseph Dalton Hooker.

At present **phylogenetic classification systems** based on evolutionary relationships between the various organisms are acceptable. This assumes that organisms belonging to the same taxa have a common ancestor. We now use information from many other sources too to help resolve difficulties in classification. These become more important when there is no supporting fossil evidence. **Numerical Taxonomy** which is now easily carried out using computers is based on all observable characteristics. Number and codes are assigned to all the characters and the data are then processed. In this way each character is

given equal importance and at the same time hundreds of characters can be considered. **Cytotaxonomy** that is based on cytological information like chromosome number, structure, behaviour and **chemotaxonomy** that uses the chemical constituents of the plant to resolve confusions, are also used by taxonomists these days.

ALGAE (= sea weed)

- It involves those organisms that have thallus like plant body, chlorophyll, accessory spores for asexual multiplication nonjacketed gametangia, absence of embryo stage.
- Study of Algae is called **Phycology or Algology**. **F. E. Fristch** is known as **'Father of phycology'**. He classified Algae in to 11 classes on the basis of their pigments, storage products, type of flagella, nucleus reproduction etc.

Characters of Algae :

(i) They are usually found in water (either marine or fresh water).

(ii) Its plant body is covered by mucilage that provides protection from water currents and epiphytic growth.

(iii) Plant body is thallus that can be unicellular, filamentous, colonial and composed of true parenchyma. Mechanical tissue is absent.

(iv) Cell wall consists of **cellulose.** Nutrition is autotrophic, **chlorophyll a and β carotene are universal pigments.**

(v) Reserve food is mainly **starch.**

(vi) Vegetative and asexual reproduction are quite common. One celled mitospores perform asexual reproduction.

(vii) Sexual reproduction comprises **isogamy (Ex: Chlamydomonas debaryanum, Ulothrix), anisogamy (Ex: Chlamydomonas braunii) and oogamy (Ex: Chlamydomonas coccifera)** in different forms.

(viii) Sex organs are nonjacketed gametangia that may be unicellular or multicellular.

(ix) Embryo stage is absent. Mainly **zygotic meiosis** takes place except brown algae (sporic meiosis).

(x) Life cycle is mostly **haplontic type (Diplontic type in brown Algae).**

- **Whittaker** classified three types of Algae in plant kingdom – **Red algae, brown algae and green algae.**

(I) Class – Rhodophyceae (Red Algae) :

General characters :

(i) These are mainly found in **marine water** except few species **Ex: Batrachospermum – Fresh water algae**. Red algae are usually autotrophic but Harveyella is colourless and parasite on other red algae.

(ii) Its thallus shows variations in different members – **unicellular**

Ex: Porphyridium, ribbon like Ex:Chondrus, parenchymatous sheet

Ex: Porphyra, multiaxial poysiphonous filaments

Ex: Polysiphonia, uniaxial monosiphonous branched filaments

Ex: Batrachospermum, graceful lace like Ex: Gelidium.

(iii) Flagellated cells are completely absent in life cycle.

(iv) Cell wall is mucilaginous and contains **cellulose, pectin and abundant sulphated phycocolloids (like agar, carrageenin, funori)**. In some red algae it has deposition of **calcium carbonate** and appear coral like and called **coralline Ex: Corallina**.

(v) Photosynthetic pigments involve **chlorophyll a, α– carotenes and phycobilins**. **Chlorophyll d** has been reported in some cases. Phycobilins are of two types

(a) red coloured r-phycoerythrin – It is responsible for red colour of red algae.

(b) Blue coloured r-phycocyanin and allophycocyanin.

(vi) Reserve food is floridean starch. It is highly branched as cyanophycian starch. Thus floridean starch and cyanophycian starch both are similar as **glycogen** in structure.

(vii) Reproduction :

(a) Vegetative reproduction – By fragmentation and regeneration of hold fast.

(b) Asexual reproduction – By many types of spores like monospores, carpospores, tetraspores.

(c) Sexual reproduction – It is most advanced type. Male sex organ is called spermatangium that forms nonmotile spermatia. Female sex organ is a flask shaped carpogonium that contains basal swollen carpogyne & upper long neck like trichogyne which receives spermatia from water.

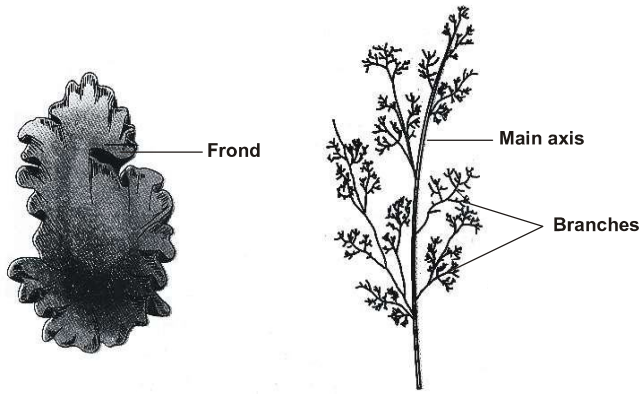


Fig: Porphyra (a) & Polysiphonia (b)

Economic importance :

(i) Food :

Some red algae are edible **Ex: Laver (Porphyra), Dulse (Rhodymenia), Irish moss (Chondrus)**.

(ii) Phycocolloids :

(a) Agar-agar is obtained from **Gelidium, Gracilaria** etc (these algae are called agarophytes). It is used to solidify culture medium. It is also used as laxative stabilizer or thickener in preparing jams, jellies, creams, pudding, baby food, ice cream, bakery products.

(b) Carrageenin is obtained from **cell wall of chondrus crispus and Gigartina**. It is used in confectionary, bakery, jelly, creams, as clearing agent in liquors (Beer) and leather finishing, as emulsifier in chocolates, icecreams, sauces, toothpastes paints and costmetics.

(c) Funori is obtained from **Gloiopeltis**. It is a glue used as adhesive and in sizing textiles, papers etc.

(II) Class – Phaeophyceae (Brown Algae) :

General characters :

(i) They are mostly marine lithophytes.

(ii) Unicellular, unbranched, filamentous and colonial forms are absent.

(iii) The body is composed of **heterotrichous branched filamentous structure** in lower forms **Ex: Ectocarpus** and **parenchymatous structures** in higher forms **Ex: Laminaria, Sargassum, Fucus**.

(iv) Some **brown algae are giant** (large sized) that are called **kelps or sea weeds Ex: Macrocystis – length is 30–60 m, Nereocystis–length is 20–30 m, Laminaria–Length is 2–12 m.**

(v) Plant body is differentiated into **hold fast (for fixation), stipe and lamina (for photosynthesis)**. Sargassum (gulf weed) is free floating and has air filled floats called vesicles that provide buoyancy. **North Atlantic sea** is called **sargasso sea** due to abundant occurrence of free floating **Sargassum fluitans**.

(vi) Conducting tubes or **trumpet hyphae** are found in larger brown algae or kelps.

(vii) Cell wall contains **cellulose** and **nonsulphated phycocolloids like fucin, fucoidin and algin**.

(viii) Main pigments are **chlorphyll a, c, β carotene. Brown pigment fucoxanthin provides brown colour to the brown algae**.

(ix) Reserve food is laminarin, mannitol and oil.

(x) Flagella two, unequal heterokont. Pyrenoids are naked.

(xi) They reproduce asexually by biflagellated zoospores. Sexual reproduction varies from isogamy to oogamy. **Zygotic meiosis absent** but **sporic meiosis occurs**.

(xii) Alternation of generation is **isomorphic (Ex: Ectocarpus, Dictyota) or heteromorphic (Ex: Laminaria).**

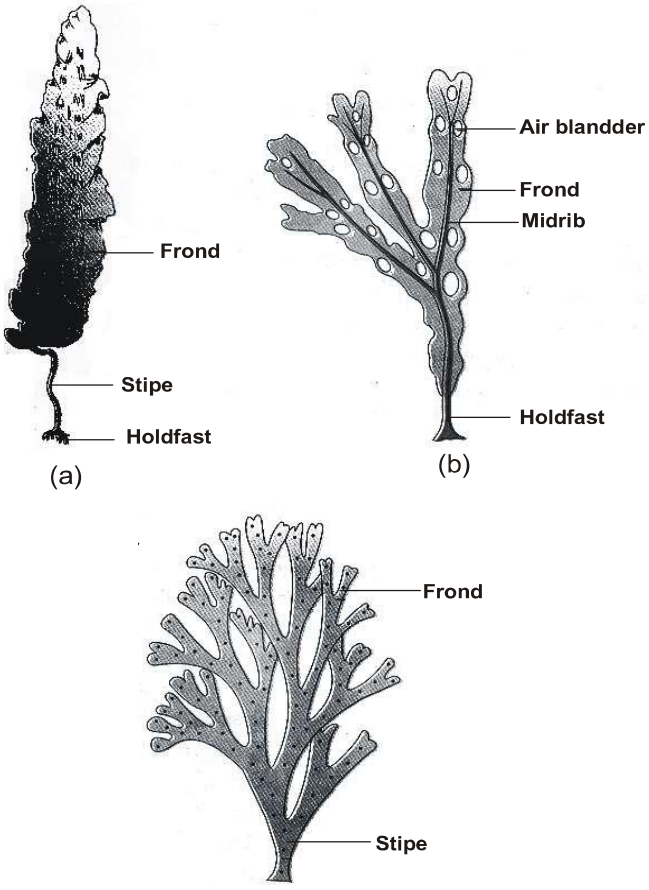


Fig: Laminaria (a), Fucus (b), Dictyota (TB)

Economic importance :

(i) **Algin :** It is **nonsulphated phycocolloid** and obtained from **Laminaria, macrocystis, Fucus, sargassum**. It is used in flame proof plastics, security glass, gauze and surgical threads, shaving creams, tooth paste, cosmetic creams, shampoos, sauces, sizing textiles, etc.

(ii) **Mannitol :** It is used as food and added to inks, plastic, paints and varnishes. **It is half as sweet as sugar and is a good substitute of sugar for diabetic patients**.

(iii) **Iodine :** It is extracted from **Laminaria and Fucus**.

(iv) **Food :** Some brown algae are used as food in some countries. **Kombu** is rich in carbohydrate and formed by **Laminaria**. **Alaria** yields a product called **sarumen** in japan.

(v) **Potash :** It is extracted from **Macrocystis and Nereocystis** and used as fertilizer in germany.

(III) Class Chlorophyceae (Green Algae) :

(i) Most of species are found in fresh water. Some species are marine **Ex: Caulerpa, Acetabularia, Codium**.

(ii) Thallus may be in various forms

(a) Unicellular motile Ex: Chlamydomonas.

(b) Cocooid or nonmotile Ex: Chlorella.

(c) Filamentous Ex: Ulothrix, Spirogyra.

(d) Colonial :

Motile colony Ex: Volvox

(iii) They bear **chl a, b, carotenes(α β and γ type), xanthophyll like lutein**.

(iv) **2, apical and isokont flagella** are present.

(v) **Chloroplast** are **agranal (grana is absent)**. **Starch** is reserve food material and stored as sheets in pyrenoids, present in the chloroplast.

(vi) **Cell wall** consists of **cellulose** and also have pectin & xylan.

(vii) Vegetative reproduction takes place through fragmentation, stolons and tubers.

(viii) Asexual reproduction occurs by mitospores and meiospores.

(ix) **Sexual reproduction** takes place through **isogamy, anisogamy and oogamy**.

(x) In green algae, three types of life cycle occur.

(a) Haplontic (b) Diplontic

(c) Diplohaplontic

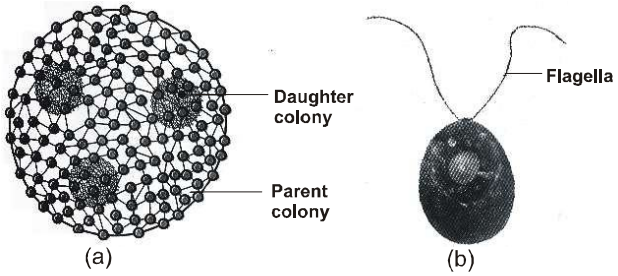


Fig : Volvox (a), Chlamydomonas (b) (TB)

(a) Haplontic : The dominant phase is haploid. The diploid phase is represented only by **zygote or zygospore**. Meiosis takes place during germination of zygote or zygospore **(zygotic meiosis) Ex: Ulothrix, Chlamydomonas, Spirogyra**.

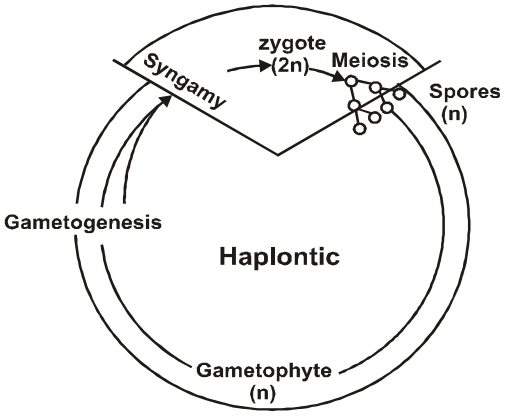


Fig :-Life cycle pattern :Haplontic
(TB)

(b) Diplontic : The dominant phase of Algae is diploid. It forms haploid gametes by meiosis. The gametes fuse to form zygote that regenerates the diploid phase. **Ex: Caulerpa**.

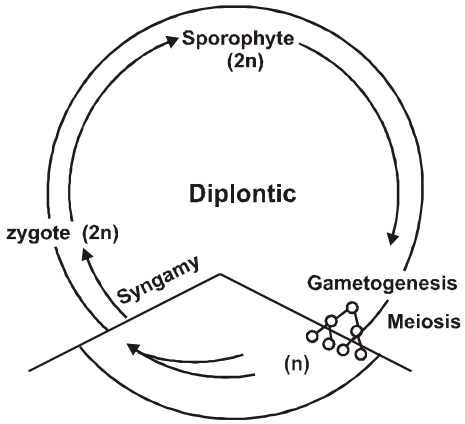


Fig :-Life cycle pattern :Diplontic
(TB)

(c) Haplodiplontic : In this type of life cycle, well developed multicellular haploid and diploid phases occur which are respectively called **gametophyte and sporophyte**. The haploid gametophyte forms haploid gametes and after fusion of gametes diploid zygote is formed that gives rise to diploid sporophyte. The latter forms haploid spores by meiosis **(Sporic meiosis)**. Meiospores form new gametophytes after germination. **Ex: Ulva, Cladophora**.

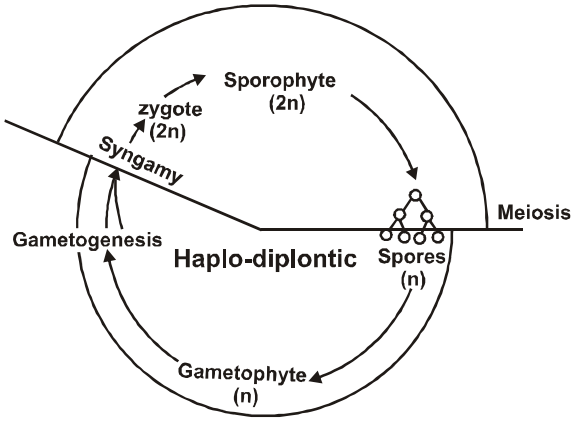


Fig :-Life cycle pattern :Haplo-diplontic
(TB)

Economic importance :

(i) Food : Chlorella pyrenoidosa (called space alga) is used by **exobiologists** for food, O_2, disposal of CO_2 in prolonged space flight. Chlorella has proteins (upto 50%), fats (20%), carboydrates (20%), vit A, B_1, B_2 B_{12}, C and E. It is used as **SCP (single cell protein)** and its nutritional value is equal to soybean and spinach. Ulva (see lettuce) and codium are used as salad.

(ii) Sewage oxidation : Chlamydomonas, Scenedesmus and Chlorella are found in sewage oxidation tanks where they produce O_2. The latter helps aerobic bacteria to decompose sewage.

(iii) Antibiotic : Chlorellin is extracted from **Chlorella**. It is effective against bacteria.

(iv) Larvicidal property : Chara show larvicidal property. They kill mosquito larvae.

o **Land plants have been evolved from chara like green algae.**

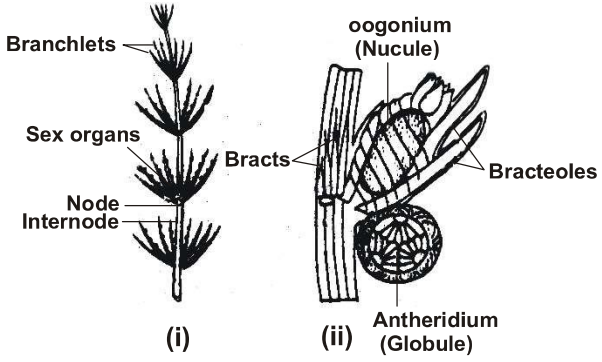


Fig:- Chara (i) Thallus (ii) Sex organs
(TB)

Comparision of characters of chlorophyceae, phaeophyceae & Rhodophyceae							
S. No.	Class	Colour of thallus	Pigments	Flagella	Reserve food	Pyrenoids	Sexual reproduction
1	Chlorophyceae Ex:- Spirogyra, chlamydomonas, Ulothrix, Oedogonium, Ulva, Acetabularia etc.	Grass green	Chlorophyll a,b, Beta-carotene, lutein,	2, apical and isokont	Starch	Present	Iso-, aniso- and oogamous
2	Phaeophyceae Ex:- Sargassum Laminaria, Fucus, Macrocystis, etc.	Brown	Chl a,c, Beta-carotene, fucoxanthin, violozanthin,	2, unequal and heterokont	Mannitol, Laminarin	Naked pyrenoid	Iso-,aniso- and oogamous
3	Rhodophyceae Ex:-Polysiphonia, Batrachospermum, Gelidium, Gracillaria, etc.	Red	Chl a, d, Beta-carotene, lutein, r-phycoerythrin, r-phycocyanin,	absent	Floridean starch	Present in primitive members only	Oogamous

CHLAMYDOMONAS

- It is unicellular, eukaryotic, microscopic (10–30μm), pyriform, biflagellate green alga.
- It is found in both stationary fresh water and marine habitats (rich in ammonia salts).

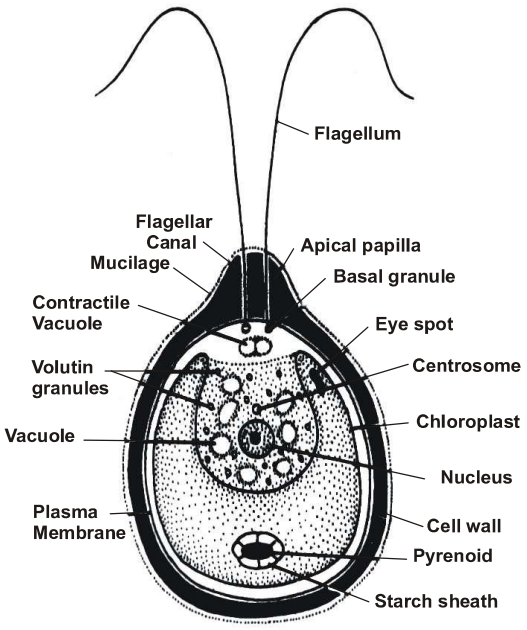


Fig:- Chlamydomonas: Ultrastructure

Volvox : Commonly called **Rolling ball alga**

Bryophytes (Bryon = moss; phyton = Plant) :

Introduction :

- These are **first land inhabiting or terrestrial plants**. Bryophytes are non vascular, autotrophic, seedless, nonflowering plants. These are known as **amphibians of plant kingdom**.
- The term **Bryophytes** coined by **Robert Braun (1864)**. He included algae, fungi, lichen and moss in it.
- On the basis of evolution, **It is placed between thallophyta and pteridophyta**.
- **Study of Bryophytes is called Bryology. Hedwing is known as Father of Bryology while S.R. kashyap is known as the Father of Indian Bryology**.
- These are the most primitive plants of the **kingdom embryophyta**.

General characters :

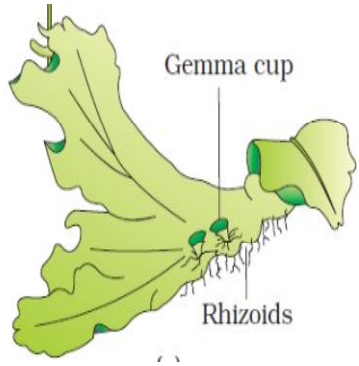
(i) These are found in moist, shady and cool places. They form green carpets or mats on damp soil, rocks, walls tree trunks.

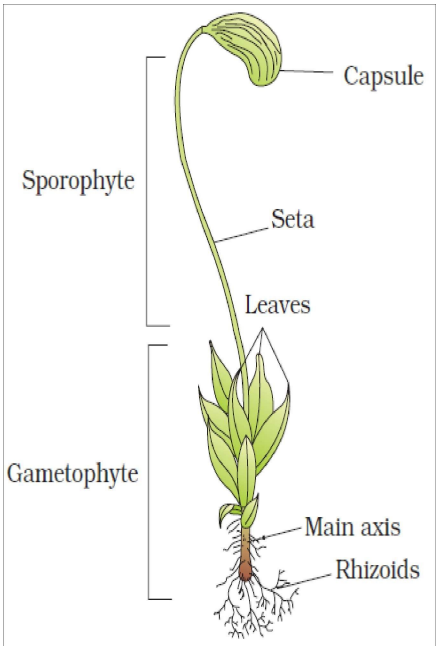
(ii) Some Bryophytes are **aquatic** like **Riccia flutians, Riccia abuensis, Ricciocarpus natans, Riella, some sp. of Sphagnum, Fontinalis** etc. In india, they are abundantly found in Himalyan region. Hence **western himalaya is known as gold mine of bryophytes**.

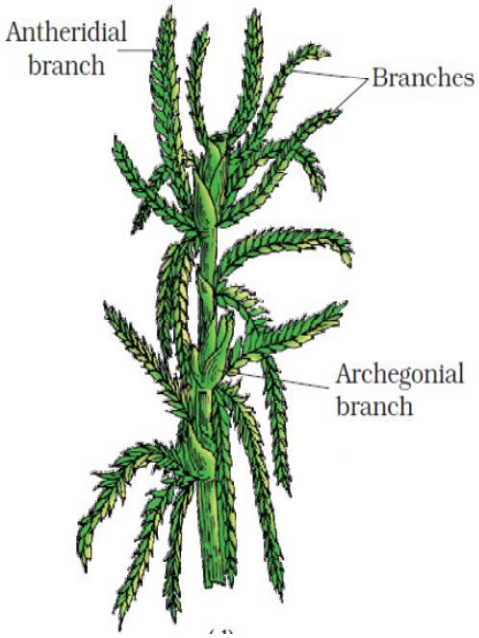
(iii) The **main plant body** is **haploid independent thalloid or foliose gametophyte** which does not differentiate into true roots, stem & leaves but foliose plants bear root like nonvascular rhizoids, leaf like phylloid and stem like cauloid **Ex : Funaria, Sphagnum**.

(iv) Thallus is multicellular, **dichotomously branched,** thick having **unicellular or multicellular rhizoids** for **fixation**.

(v) **Cell wall in liverworts** is composed of **cellulose and pectose** whereas in **mosses** it is of **hemicellulose and pentosan**. **Reserve food** is **starch**.







(vi) **Vascular tissues (xylem and phloem) are absent** in both gametophytic and sporophytic phases. The **conduction** takes place through **specialized parenchyma**.

(vii) Vegetative reproduction takes place through fragmentation, buds, gemmae, tubers, protonema, adventitious branches etc.

(viii) Asexual reproduction absent.

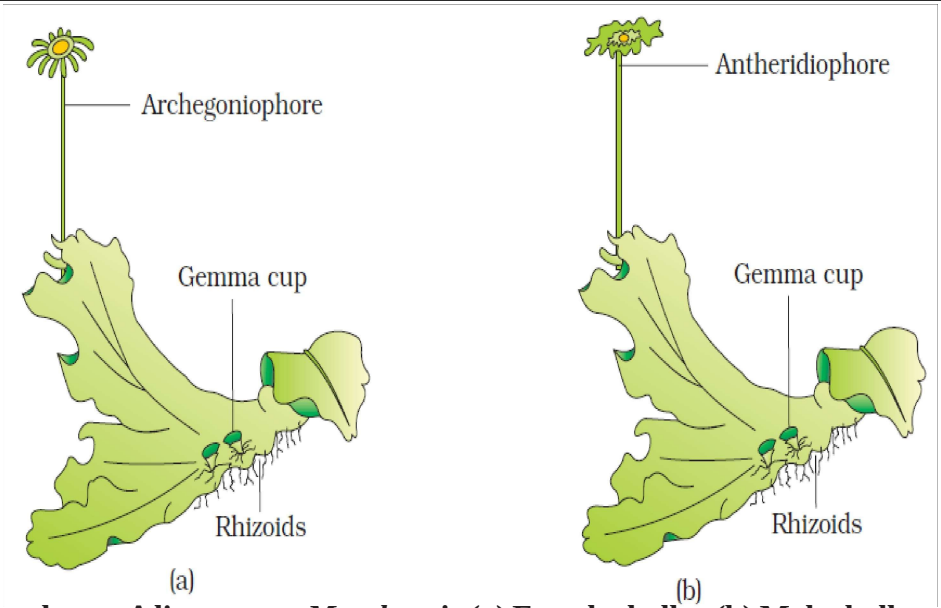
(ix) **Sexual reproduction** is **oogamous type**. Sex organs are multicellular and surrounded by **single layered sterile jacket**.

(x) **Male sex organ** is called **antheridium** which is globular and forms **biflagellated antherozoids or sperms (motile male gamete)**. **Flask shaped female sex organ** is called **archegonium** that consists of **a swollen venter** and **a tubular neck**.

(xi) **Water is essential for fertilization**. **Archegonia** secretes **mucilage** rich in **potassium salts / proteins / sucrose** for attracting antherozoids in water.

(xii) Fertilization is internal and takes place by **zoodiogamy**. Diploid zygote forms in the venter by the fusion of one antherozoid with egg cell.

(xiii) After fertilization zygote immediately divides and form multicellular embryo. The Development of embryo is **exoscopic (The apex of embryo develops from outer cell)**.



Bryophytes: A liverwort – *Marchantia* (a) Female thallus (b) Male thallus

(xiv) Embryo gives rise to multicellular sporogonium or sporophyte. The latter differentiates into either capsule only or foot, seta and capsule. Sporophyte is completely (Ex: Riccia) or partially (Ex: Funaria) parasite on gametophyte.

(xv) Spore mother cells or sporocytes of capsule of sporophyte undergo **sporic meiosis** and form haploid **meiospores** which are alike or **homosporous**.

(xvi) On germination, **spore** forms **new gametophytic plant** either **directly (Ex: liverworts and hornworts)** or by juvenile filamentous **protonema stage (Ex: moss)**.

(xvii) Life cycle is diplohaplontic and **alternation of generation** is **heteromorphic**.

Classification of Bryophyta :

- Bryophytes are Classified into three classes.
  (i) Hepaticopsida – (Ex: Liverworts)
  (ii) Anthocerotopsida – (Ex: Hornworts)
  (ii) Bryopsida – (Ex: Mosses)

Comparsion of Hepaticopsida, Anthoceratopsida and Bryopsida.

S. No.	Hepaticopsida	Anthoceratopsida	Bryopsida
1	Plant body is Thalloid/ Foliose.	Plant body is Thalloid.	Plant body is leafy, erect.
2	Rhizoids are Unicellular	Rhizoids are Unicellular	Rhizoids are multicellular
3	Scales present.	Scales absent.	Scales absent.
4	Columella Absent in capsule.	Columella present in capsule.	Columella present in capsule.
5	Elaters present, they help in dispersal of spores as well as dehiscence of capsule.	Pseudoelators present, function of former is similar as elaters.	Elaters absent but peristome teeth are present that help in dispersal of spores.
6	Sporogonium is completely parasite on gametophyte	Sporogonium is partially parasite on gametophyte.	Sporogonium is partially parasite on gametophyte.
7	Ex:- Riccia, Marchantia Pellia, Porella.	Ex:- Anthoceros, Notothallus.	Ex:- Funaria, Sphagnum, Polytrichum.

Marchantia :

1. It is a thalloid liverwort, grow prostrately on the surface and show dichotomous branching.
2. The thallus have dorsal groove on the upper surface and **rhizoids and scales** on lower (ventral) surface.
3. Rhizoids are unicellular.
4. Vegetative reproduction occur by progressive death, regeneration, adventitious, branches and gemmae.
5. **Gemmae** are formed inside small **gemma cups** developing middorsally on vegetative thalli. **gemma cups** have eight shaped (8) gemmae and mucilagenous hairs.
6. Each gemma is an elliptical and biconvex structure, having unicellular stalk and two lateral notches. On germination one daughter thallus is produced from each notch. Thus **each gemma produce two daugther thalli**.

Sexual reproduction :

7. Marchantia is dioecious. Sex organs are borne on **disc-shaped receptacles** borne at the tips of vertical gametophores. Male receptacle on **antheridiophore** and femate receptacle on **archegoniophore**.
8. Male receptacle is 8 lobed and slightly concave on upper side.
9. Archegonia are shortly stalked, having **6 vertical rows of neck cells, enclosing 4-6 neck canal cells**. Venter has only one venter canal cell and egg cell or oosphere.

Economic importance :

(i) **Mosses** grow in tufts over the soil surface and bind soil particles thus they prevent **soil erosion**.

(ii) Both **mosses and lichens produce soil** cover over the barren rocks during succession.

(iii) Sphagnum grows in acidic bogs where it helps in formation of peat hence called peat moss.

(iv) **Peat** is used as fuel as well in making alcohol, ammonium sulphate, tar, tanning material and paraffin and dye.

(v) **Sphagnum** has **good water holding capacity** therefore it is widely used for **packing** of young seedlings, flowers, vegetables, fruits, corrosive materials, glasses etc during transportation.

(vi) Dry clean, disinfected sphagnum is used as a replacement of absorptive cotton for wound dressing.

(vii) **Sphagnol,** an **antibiotic** that is derived from distillation of peat tar which is effective against **skin diseases**.

(viii) **Polytrichum** has ability to dissolve stones in kidney and gall bladder.

Point of Remember

1. **Largest bryophyte is Dawsonia (moss - 70 cm) and smallest bryophyte is zoopsis argentea (liver wort)**
2. **Terrestrial Amphibians :** Bryophytes are considered as terrestrial Ampibians because they require external water on the soil surface for following reasons.

   (i) Dehisence of archegonia and antheridia.

   (ii) Swimming of male gametes to archegonia.

   (iii) Supply of water to all parts by capillarity in the absence of vascular tissues.

   (iv) Protection from transpiration.

PTERIDOPHYTES

(Pteris = feather, phyton = plant) :

- These are most primitive, seedless, spore producing land plants which are popularly knownas **botanical snakes (because, reptiles are first land animals)** or **vascular cryptogams (vascular tissues xylem and phloem present)**.
- The term **pteridophyta** coined by **Haeckel (1866)**. The study of pteridophytes is called pteridology**. F.O. Bowers** is called **'Father of pteridology'** while **S.S. Bir** is known as **'Father of Indian Pteridology'**.

General characters :

(i) Most of the plants are terrestrial and grow well in damp and shady places. Some pteridophytes are found in **xerophytic** conditions **Ex: Selaginella lepidophylla, S. rupestis, Equisetum arvense**. Some are **epiphytic Ex: Lycopodium phlegmaria, Pleopeltis, Ophioglossum**. Some are **aquatic Ex: Marsilea, Azolla, Salvinia, Isoetes**.

(ii) Most of the pteridophytes are herbaceous except **tree ferns like Cyathaea, Alsophila**.

(iii) The main plant body is sporophyte that is differentiated into root, stem and leaves.

(iv) Primary root is short lived. Later on the former is replaced by adventitious roots developed by stem.

(v) Stems may be underground or aerial. The branching of stem may be **dichotomous Ex: Marsilea, Lygodium** or **monopodial Ex: Lycopodium, Selaginella**.

(vi) All the vegetative parts bear vascular tissues that form different types of steles. Vessels are usually absent in xylem similarly companion cells, sieve tubes and fibres are absent in Phloem but sieve cells are present. Secondary growth is absent except in Isoetes.

(vii) **Leaves** are of two types **microphyllous and megaphyllous**. In microphyllous types, Leaves are small and unveined while stem is comparatively longer and leaf traces do not leave leaf gaps in the stele **Ex: Lycopodium, Selaginella, Equisetum** while in megaphyllous types stems are short and leaves are large (called frond) with branched venation. Leaf gaps are found in stele **Ex: ferns (Pteridium, Dryopteris, Pteris)**.

(viii) **Meiospores** are formed by **sporic meiosis** in **sporangia** during asexual reproduction. The former are either same type **(homosporous Ex: ferns like pteridium, Adiantum, Pteris) or different types (heterosporous Ex: Selaginella, Marsilea, Salvinia, Azolla)**.

(ix) Sporangia are borne on abaxial side of fertile leaves. Sporangia bearing leaves are called **sporophylls Ex: Ferns,** in other pteridophytes sporangia are developed **in the axil of leaves on stem Ex: Selaginella**, or on **sporangiophores Ex: Equisetum or in sporocarp.**

(x) Sporangia are developed singly or in groups. The latter is called **sori** which is protected by **true or false indusium** or both. True inducium arise from placenta e.g. Dryopteris and false inducium formed by curling of leaf margin e.g. Pteris and Adiantum. In Pteridium both true and false inducium are found.

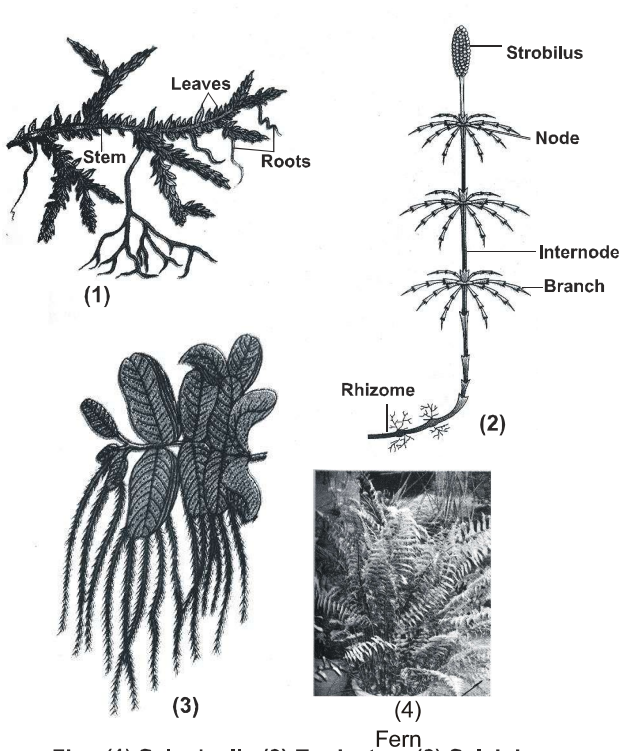


Fig : (1) Selaginella (2) Equisetum (3) Salvinia (4) Fern (TB)

(xi) In **heterosporous pteridophyta**, sporangia are of two types-**microsporangia** and **megasporangia** that form **microspores** and **megaspores** respectively by **sporic meiosis**.

(xii) Gametophyte is small/reduced, independent, nonvascular.

(xiii) Sex organs are multicellular, jacketed and developed on gametophyte. Male sex organs are Antheridia that are reduced and sessile. Antheridium forms **motile sperms (usually multiflagellated but biflagellated in Selaginella)**. Female sex organs are archegonia embedded in gametophyte. Archegonium consists of neck and swollen venter. Neck is composed of four vertical rows of cells and it has 1–4 Neck canal cells while venter is non motile having a venter canal cell and an egg cell or oosphere.

(xiv) Sexual reproduction is **oogamous type**. Water is required for movement of sperms from antheridia to archegonia (chemotactic movement due to **malic acid rich mucilage** secreted by archegonia) during fertilization.

(xv) After fertilization, deploid zygote is formed that is first cell of sporophytic generation.

(xvi) The development of embryo is **holoblastic or meroblastic, exoscopic/endoscopic/lateral. Life cycle is diplohaplontic** and distinct **heteromorphic alternation of generations** occurs.

Point of Remember

1. **Sori :** Sporangia are borne in groups called sori that are of three types.
2. **Azolla :** It is **smallest pteridophyta**. It is **aquatic fern** that is used as **biofertilizer** due to presence of **ntirogen fixing cyanobacteria- Anabaena in its leaves**.
3. **Aquatic ferns–Ex: Marsilea, Salvinia, Azolla.**
4. **Seed habit in pteridophytes :** Seed habit is seen is some pteridophytes like **Selaginella**.

Economic importance :

(i) Food : Sporocarps of marsilea (a water fern) contains starch and are used as food article by certain tribes.

(ii) Medicines : An antihelminthic drug is obtained from rhizomes of Dryopteris. Homeopathic medicine is obtained from Lycopodium.

(iii) Selaginella is helpful in soil conservation.

(iv) Ornamentals : Ferns are grown as ornmental plants.

Classification of Pteridophytes :

- Pteridophytes are classified in to 4 classes.
  (i) Psilopsida **(ii) Lycopsida**
  (iii) Sphenopsida **(iv) Pteropsida**

S.No.	Common name	Botanical name
1	Walking fern, Maiden hair fern.	Adiantum caudatum
2	Club moss, trailing evergreen	Lycopodium
3	Horse tail, Scouring rushes	Equisetum

Differences between Bryophytes and pteridophytes

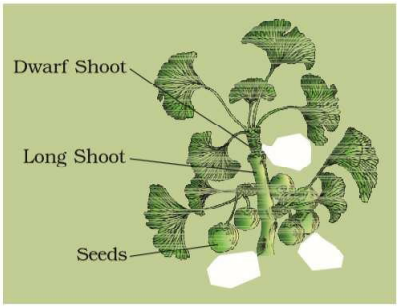
S. No.	Bryophytes	Pteridophytes
1	Plant body is gametophyte.	Plant body is sporophyte.
2	Plant body is thalloid that does not differentiate into roots, stem and leaves.	Plant body is differentiated into roots, stem and leaves.
3	Vascular tissue is absent.	Vascular tissue is present.
4	Sporophyte is parasite over gametophyte.	Total independent sporophyte.
5	Antherozoids are biflagellate.	Antherozoids are multiflagellate.
6	Gametophyte is well developed.	Gametophyte is reduced, independent and short lived.

GYMNOSPERMS
(gymnos–naked, sperm–seed)

- These are **perennial woody plants or ancient seed bearing phanerogamic sporophytic plants without flowers, ovary and fruits**. They are popularly called **naked seeded vascular plants**.
- It is the smallest group of plant kingdom and involves only 70 **living genera** and 900 species. In india, its 16 genera and 54 species have been reported. These are found in cold temperate climates but cycads occur in warmer areas.
- The term **Gymnosperm** coined by **Theophrastus (300 BC)** in his book **'Enquiry into plants'**.
- **The study** of **Gymnosperm** is called **Gymnospermology**.

(a)

(b)



(c)

Fig: Cycas (a), Pinus(b), Ginkgo(c)

(TB)

General characters :

(i) The main plant body is diploid sporophyte which is differentiated into true roots, stem and leaves.

(ii) Root is tap root. In some members, roots are symbiotically associated with blue green algae **Ex: coralloid roots in Cycas or with fungus Ex: mycorrhizal roots of Pinus.**

(iii) **Stem** bears **eustelic condition**. **Vessels are absent in xylem of gymnosperms except gnetales** Sieve tubes and companion cells absent in phloem. But the latter has sieve cells and albuminous cells. Secondary growth occurs in stem and root.

(iv) **Wood of gymnosperms** is **homoxylous, noporous and soft**. Wood is of two types.

(v) Mostly unisexual monosporangiate cones are found instead of flowers. All gymnosperms are **heterosporous**.

(vi) Two types of sporophylls are found– **micropsorphylls and megasporophylls**. Both types of sporophylls form cones or strobili (the male cone and female cone). In case of Cycas megasporophylls do not form cone.

(vii) Microsporophyll (stamen) has microsporangia or pollensacs **(900–1000 microsporangia in sori of Cycas and two microsporangia in Pinus sps.)** while megasporophylls (carpel) has megasporangia or ovules.

(viii) The distinction into anther and filament is absent in Microsporophyll. Similarly Megasporophylls are not organised and rolled into carpels. Stigma and ovary are absent.

(ix) **Ovules lie exposed on megasporophyll**. **Ovule is orthotropous, sessile, unitegtmic. Single integument is usually divisible into 3 layers.**

(x) Megaspores are formed by sporic meiosis in ovule. The former forms **haploid female gametophyte (called endosperm) before fertilization**.

(xi) In microsporangia, microspores (pollen grains or androspore) are formed by sporic meiosis. On germination, microspore forms male gametophyte.

(xii) Pollination is **anemophilous (Wind pollination) and direct (Pollen grains reach directly into ovule)**. Pollen grain is released in 3 celled stage in Cycas and 4 celled in Pinus

(xiii) Male gametophyte has two male gametes. Female gametophyte contains archegonia **Neck canal cells are absent in archegonia**.

(xiv) Water is not required for transport of male gametes. **Actually malegametes are carried by pollen tube (that is called siphonogamy)**. One male gamete fuses with egg cell to form zygote.

(xv) Fertilization, ovule is converted into seed.

(xvi) Seeds are naked (they do not enclose in ovary), endospermic and having three generations. **Polyembryony** is common in gymnosperms.

Economic Importance :

(i) The wood of conifers like **Pinus roxburghii (chir pine), Cedrus deodara (deodar, strongest of all soft wood), Sequoia (red wood tree) is used in making light furniture, plywood, packing cases, railway sleepers, drawing board, pencils,match boxes and sticks**.

(ii) Paper is composed of wood of **Pinus, Picea (spruce), Gnetum, Larix (Larck), Abies (fir)**.

(iii) **Sago** a kind of **starch** is obtained from **cortex and pith of stem and seeds of Cycas**. The **Roasted seeds of Pinus gerardiana (Chilgoza)** are used as dry fruit. Seeds of Ginkgo biloba are eaten in china and japan.

(iv) **Ephedrine** is obtained from **stem branches of Ephedra** and used to cure **cough, cold, bronchitis, asthma and fever**.

(v) Many Gymnosperms are grown in the gardens as ornamental plants **Ex: Cycas**

Differences between Pteridophytes and Gymnosperm

S.No.	Pteridopohytes	Gymnosperms
1	These are found in moist and shady places.	They are xerophytic.
2	Secondary growth is absent.	Secondary growth is quite common.
3	Ovules absent.	Ovules present.
4	Pollen tube is not formed.	Pollen tube is formed.
5	Neck canal cell is found in the archegonium.	It is absent in archegonium.
6	Seed formation does not take place.	Seed formation takes place.

Point of Remember

1. Ephedra foliata is naturally occurring gymnosperm in Rajasthan.
2. Double Fertilization is usually absent in Gymnosperms but found in Ephedra.
3. Ephedra has largest pollen chamber & longest neck of archegonium (32 celled in 8 tiers).
4. Ginkgo bears root nodules formed by a Nitrogen fixing nonleguminous actinomycete bacte ria-Frankia.
5. Gnetum : Gnetum show many similarities with angiosperms like reticulate veinnation in their leaves, presence of vessels in xylem absence of archegonia and presence of two cotyledons. But stile it is gymonosperm because ovules are naked.

ANGIOSPERMS
(angeion = vessel, sperma = Seed)

- Angiosperms are most advanced plants, that have flowers, covered ovules, seeds. It involves 12500 genera and 2.70 lakh species (2.20 lac are dicots and 50000 are monocots).
- They are most dominant and highest evolved plants on this earth. **Tertiary period of coenozoic era** is called **Age of angiosperms**.
- Angiosperms have been reported in every habitat. All types of catagories of plants involve in angiosperms–annuals/biennials/perennials; autotrophs/Parasites/epiphytes/insectivorous/ Saprophytes.

General characters :

(i) The main plant body is sporophyte that is differentiated into roots, stem and leaves.

(ii) The characteristic features is **presence of vessels in xylem** and **presence of companion cells in phloem**.

(iii) Wood is hard, porous, monoxylic. Secondary growth is found in dicots.

(iv) Antheridia and archegonia are absent. Presence of flowers is most important feature. Sex organs enclosed in the flower.

(v) Flower consists of 4 whorls – **Calyx, Corolla, Androecium, Gynoecium. Androecium (stamen)** is **microsporophyll** and **Gynoaecium (carpel)** is **megasporophyll**.

(vi) Megasporophyll or carpel contains ovary, style and stigma.

(vii) Ovules are enclosed within ovary. **Pollen grains** are shed at **2-3 celled stage** and fall on stigma.

(viii) Double fertilization (syngamy and triple fusion) is characteristic feature that is found in angiosperms only.

(ix) Endosperm is triploid (3n) and formed after double fertilization.

(x) Ovules & ovary are converted into **seeds and fruits** respectively after fertilization.

(xi) Seed has two generations–a parent sporophyte and future sporophyte but gametophytic generation is absent in seeds.

(xii) Seed bears 1–2 cotyledons.

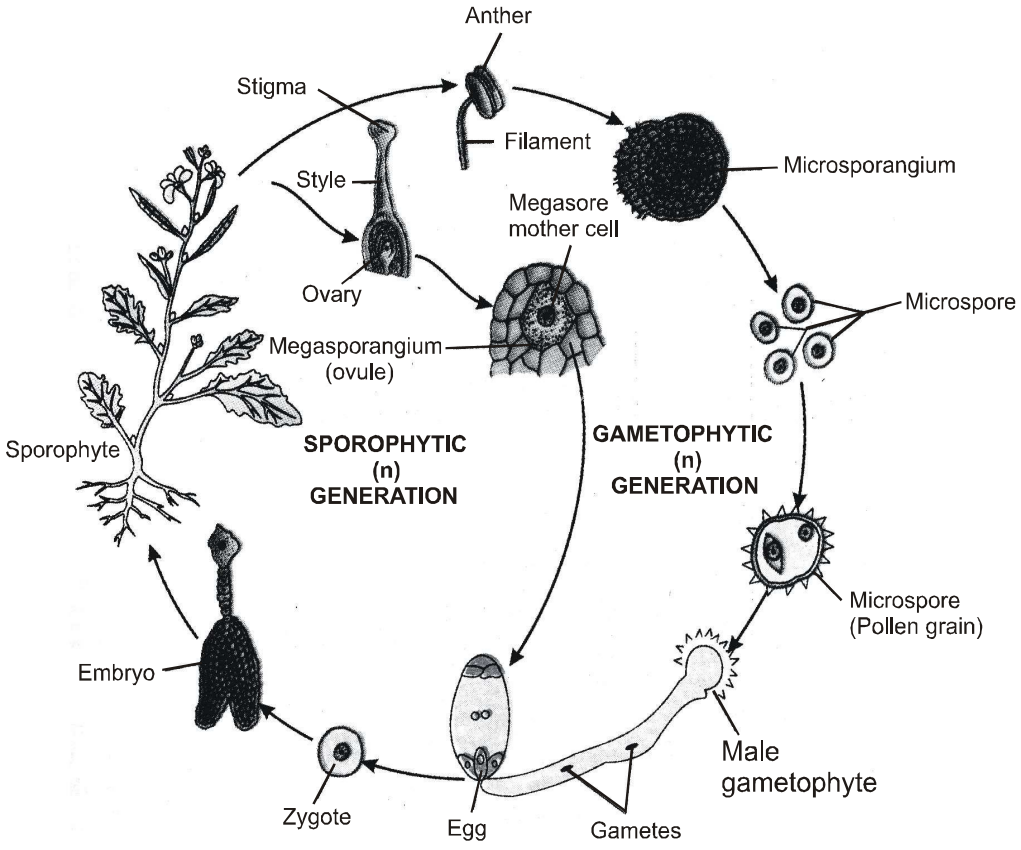


Fig: Life of cycle of an angiospermic plant

(TB)

Differences Between Gymnosperms and Angiosperms		
S.No.	**Gymnosperms**	**Angiosperms**
1	Flowers and fruits are absent.	Flowers and fruits are found.
2	Seeds are naked & exposed directly on the surface of megasporophylls.	Seeds lie inside ovary/fruit.
3	Seeds are sessile & unitegmic.	Seed is borne on a stalk (funiculus) & uni / bitegmic.
4	Archegonia present.	Archegonia absent.
5	Double fertilization is absent.	Double fertilization is present.
6	Endosperm is haploid (n) and formed before fertilization.	Endosperm is triploid (3n) and formed after double fertilization.
7	Seed bears three generations (parent-sporophyte, gametophyte and future sporophyte).	Seed bears two generations (parent- sporophyte and future sporophyte).
8	Pollination is direct and by wind only.	Pollination is indirect and by many agencies.
9	Vessels in xylem, sieve tubes and companion cells in phloem are absent.	Vessels in xylem, sieve tubes and companion cells in phloem are present.

Point of Remember

1. Smallest angiospermic plant is Wolffia microscopica (1 mm) while largest angiospermic plant is Eucalyptus regnans (114 mt or 375 feet– tallest angiospermic tree).
2. Zostera arina : Thalassia are marine angiosperms.

Differences between Dicots and Monocots		
S. No	**Dicots**	**Monocots**
1	Number of Cotyledons is 2 in the embryo of seed.	Number of Cotyledons is 1 in the embryo of seed.
2	Flower is mostly pentamerous	Flower is mostly trimerous.
3	Tap root system is present.	Adventitious root system is common.
4	Leaves are dorsiventral , bifacial & bear reticulate venation.	Leaves are isobilateral, unifacial and have parallel venation.
5	Vascular bundles of stem are arranged in a ring & they are conjoint, collateral, open (cambium present).	Vascular bundles of stem are scattered in the ground tissue & they are conjoint, collateral, closed (cambium absent).
6	Secondary growth is common in stem and roots.	Secondary growth is usually absent.