Plant Kingdom

1 INTRODUCTION

- Our understanding of the plant kingdom has changed overtime.
- Fungi and members of the Monera and Protista having cell walls have now been excluded from plantae. Cyanobacteria that are also referred to as blue green algae are not algae anymore.
- In plant kingdom, we describe algae, bryophytes, pteridophytes, gymnosperms and angiosperms.

2 CLASSIFICATION SYSTEMS

ARTIFICIAL

- Used only gross superficial morphological characters like habit, colour, number and shapes of leaves etc.
- Based mainly on vegetative characters or on the androecium structure (system given by Linnaeus).

LIMITATIONS

- Separated closely related species as they were based on a few characteristics.
- It gave equal weightage to vegetative and sexual characters. This is not acceptable because vegetative characters are more easily affected by environment.

NATURAL

- Based on natural affinities among organisms and consider both external and internal features, like
  - Ultrastructure
  - Anatomy
  - Embryology
  - Phytochemistry
- Such a classification for flowering plants was given by George Bentham and Joseph Dalton Hooker

PHYLOGENETIC

- Based on evolutionary relationship between the various organisms.
- This assumes that organisms belonging to the same taxa have a common ancestor.

3 BRANCHES OF TAXONOMY

NUMERICAL TAXONOMY

- Carried out using computers. Based on observable characteristics.
- Number and codes are assigned to all characters and then data are processed.
- Each character is given equal importance and at the same time hundreds of characters can be considered.

CYTOTAXONOMY

- Based on cytological information like chromosome number, structure and behaviour.

CHEMOTAXONOMY

- Uses chemical constituents of the plants to resolve confusions.

- (These become more important when there is no supporting fossil evidence)

4 ALGAE

- Algae are chlorophyll bearing, simple, thalloid, autotrophic and large aquatic (both fresh water and marine) organisms.
- They occur in variety of other habitats like moist stones, soil & wood.
- Some occur in association with fungi (lichen) & animals (e.g. on sloth bear).
- **Form and size** is highly variable, from colonial (*Volvox*) to filamentous (*Ulothrix* and *Spirogyra*) to massive plant bodies (**marine forms like Kelps**) to unicellular form (*Chlamydomonas*).
- Algae can reproduce by vegetative (**fragmentation**), asexual and sexual means.
- Asexual reproduction – by formation of different types of spores. Most common is zoospore.
- Sexual reproduction 1. ISOGAMOUS = Gametes are similar in size
  - (I) Flagellated gametes e.g. *Ulothrix*
  - (ii) Non -flagellated gametes e.g. *Spirogyra*
  2. ANISOGAMOUS = Gametes dissimilar in size e.g. *Eudorina*
  3. OOGAMOUS = Fusion between one large non-motile female gamete and a smaller male gamete. e.g. *Volvox, Fucus*

ECONOMIC IMPORTANCE

- At least a half of the total CO_2 fixation on earth is carried out by algae.
- Being photosynthetic they increase the level of dissolved oxygen in their immediate environment.
- They are primary producers of energy-rich compounds which form the basis of food cycles of all aquatic animals.
- Many species of *Porphyra*, *Laminaria* and *Sargassum* are among 70 species of marine algae used as food.
- HYDROCOLLOIDS like algin (brown algae) and carrageen (red algae) are used commercially.
- Agar obtained from *Gelidium* and *Gracilaria* are used to grow microbes and in preparations of ice-creams and jellies.
- *Chlorella* are rich in proteins and used as food supplement even by space travellers.

5 THE THREE MAIN CLASSES OF ALGAE

CHLOROPHYCEAE

- Usually grass-green due to dominance of Chl- a & b. Commonly called green algae.
- Pigments are localised in definite chloroplasts.
- Most members have one or more storage bodies in the chloroplasts called pyrenoids, which contain protein & starch.
- Have rigid cell-wall made of inner-cellulose and outer layer of pectose.
- Sexual reproduction may be isogamous, anisogamous or oogamous.
- Eg *Chlamydomonas, Volvox, Ulothrix, Spirogyra, Chara*. etc.

PHAEOPHYCEAE

- Found primarily in marine habitats.
- Commonly called brown algae.
- Possess chl- a, c; carotenoids and xanthophylls.
- Olive green to various shades of brown depending on amount of xanthophyll pigment fucoxanthin.
- Food storage as laminarin and mannitol
- Cellulosic cell wall covered by algin.
- Plant body usually has holdfast, stipe and frond.
- In most brown algae pear shaped biflagelled zoospores have two unequal laterally attached flagella.
- Sexual reproduction may be isogomous, anisogamous or oogamous.
- Gametes pyriform with two laterally attached flagella.
- *Eg. Ectocarpus*, *Dictyota, Laminaria, Sargassum, Fucus etc.*

RHODOPHYCEAE

- Red algae have predominance of red pigment r-phycoerythrin in their body.
- Possess chl-a and d.
- Majority are marine with greater concentrations found in warmer areas.
- Occur both in well-lighted regions close to water surface or at great depth in ocean where little light penetrates.
- Cell wall is made up of cellulose, pectin and polysulphated esters.
- Mostly multicellular with some having complex body organisation.
- Food stored as floridean starch, very similar to amylopectin and glycogen in structure.
- Asexual spores and gametes are non-motile
- Sexual reproduction is oogamous and accompanied by complex post fertilisation developments.
- Eg. *Polysiphonia, Porphyra, Gracilaria Gelidium* etc.

6 BRYOPHYTES (Mosses and Liverworts)

- Bryophytes commonly grow in moist shaded area in the hills.
- Called Amphibians of plant kingdom, because these plants can live in soil but are dependent on water for sexual reproduction.
- Rhizoids may be unicellular or multicellular.
- Main plant Body is haploid (gametophyte)
- Multicellular sex organ (♂ antheridium &♀ archegonium)
- Antherozoids are biflagellated.
- Some mosses provide food for herbaceous mammals, bird & other animals.
- Species of *Sphagnum* provide peat used as fuel and as packing material for trans-shipment of living material as they hold water.
- Mosses (along with Lichens) are of great ecological importance, they decompose rocks making substrate suitable for growth of higher plants. They play an important role in plant succession on bare rocks/soil.
- Mosses form dense mats on soil, reduce the impact of falling rain and prevent soil erosion.

BRYOPHYTES ARE DIVIDED INTO

LIVERWORTS

- Plant body thalloid.
- Thallus dorsi-ventral, appressed to the substrate.
- Leafy members have tiny leaf-like appendages in two rows on stem-like structures.
- Asexual reproduction is by fragmentation and gemmae.
- Gemmae are green, multicellular, asexual buds formed in gemma cups located on thalli.
- Sporophyte is differentiated into a foot, seta and capsule. After meiosis spores are produced in the capsule, which germinate to produce free-living gametophytes. Eg. *Marchantia.*

MOSSES

- Gametophytes consist of two stages
  1. Protonema; 2. Leafy-stage
- **Protonema stage:** develops directly from a spore. Protonema is creeping, green, branched and frequently filamentous stage.
- **Leafy stage:** develops from secondary protonema as a lateral bud. They consist of upright, slender axes bearning spirally arranged leaves, attached to the soil through multi-cellular branched rhizoids. It also bears sex-organs.
- **Vegetative reproduction:** by fragmentation and budding in secondary protonema.
- Sporophyte in mosses is more elaborate than in liverworts. They have more elaborate mechanism of spore dispersal.
- **Eg:** *Funaria, Polytrichum* and *Sphagnum*.

7 PTERIDOPHYTES (Horsetails and Ferns)

- Evolutionarily, they are the first terrestrial plants with vascular tissues.
- Found in cool, damp, shady places, though some flourish in sandy-soil.
- Main plant body is sporophyte (2n), with true root, stem and leaves.
- Leaves are small (microphylls) as in *Selaginalla* or large (macrophylls) as in ferns.
- Sporophytes bear sporangia subtended by sporophyll, which may be compact called strobili or cones, as in *Selaginella*, *Equisetum*.

$$\underset{(2n)}{\text{Sporangia}} \rightarrow \underset{(2n)}{\text{Sporemother Cell}} \xrightarrow{\text{Meiosis}} \underset{(n)}{\textbf{Spores}}$$

- Spores germinate to produce inconspicuous, small, multi-cellular, free-living, mostly photosynthetic thalloid gametophytes called prothallus.
- Gametophytes need cool, damp, shady places to grow. This specific requirement and need of water for fertilisation limit the spread of living pteridophytes and restricted to narrow geographical regions.
- Male and female sex organs are antheridia and archegonia.
- Majority are homosprous, but genera like *Selaginella* and *Salvinia* are heterosporous. In heterosporous species the female gametophytes are retained on the parent sporophyte. Zygote develops into young embryos within female gametophytes.
  This event is a precursor to seed habit, considered an important step in *Evolution.*
- Used for medicinal purposes and as soil binders, also grown as ornamentals.
- Pteridophytes are further classified into four classes:
  1. **Psilopsida** - *Psilotum*
  2. **Lycopsida** - *Selaginella*, *Lycopodium*
  3. **Sphenopsida** - *Equisetum*
  4. **Pteropsida** - *Dryopteris*, *Pteris*, *Adiantum*

8 GYMNOSPERMS (Gymnos = naked, sperma = seed)

- Plants in which ovules are not enclosed by ovary wall and remain exposed both before and after fertilisation. Seeds that develop post-fertilisation are naked.
- Gymnosperms include medium-sized or tall trees and shrubs.
- The giant redwood tree *Sequoia* is one of the tallest tree species.
- **Roots:** generally tap roots, having fungal association as mycorrhiza *(Pinus)* or coralloid root with N_2-fixing cyanobacteria as in *Cycas*.
- **Stem:** Branched (*Pinus*; *Cedrus*), Unbranched (*Cycas*)
- **Long and Dwarf shoot:** in *Pinus* and *Ginkgo*.
- **Leaf:** Simple *(Pinus)*; pinnate compound (*Cycas*).
- Leaves are well-adapted to withstand extreme temperature, humidity and wind. In the conifers, needle-like leaves reduce surface area. Thick cutile and sunken stomata help to reduce water loss.
- Gymnosperms are heterosporous
- Sporophylls → Microsporophylls → Male cone/strobili/lax
  Sporophylls → Megasporophylls → Female cone/strobili
- Male and female sporangia borne on microsporophylls and megasporphylls respectively.
- Sporangia → Microsporangia (2n) → Pollen grain (n)
  Sporangia → Megasporangia/Ovule (2n) $\xrightarrow[\text{of MMC}]{\text{Meiosis}}$ 4 Megaspores
  ↓
  one develops into **Female gametophyte/Endosperm** (n)
- *Pinus* is monoecious, i.e., male and female cone or strobili are borne on same tree; *Cycas is dioecious, i.e.,* male cone and megasporophylls are borne on different trees. (Female cone is absent in *Cycas*).
- Male gametophyte, *i.e.,* pollen grains are highly reduced and confined to limited number of cells.
- Female gametophytes bear two or more archegonia or female sex organs. The multicellular female gametophyte is retained within megasporangium.
- Male and female gametophytes do not have an independent free living existence.
- Pollen grains are carried by air currents and come in contact with opening of ovules.
- Fertilisation is by pollen-tube formation which carries male gametes. Zygote forms embryo and ovules form naked seeds.

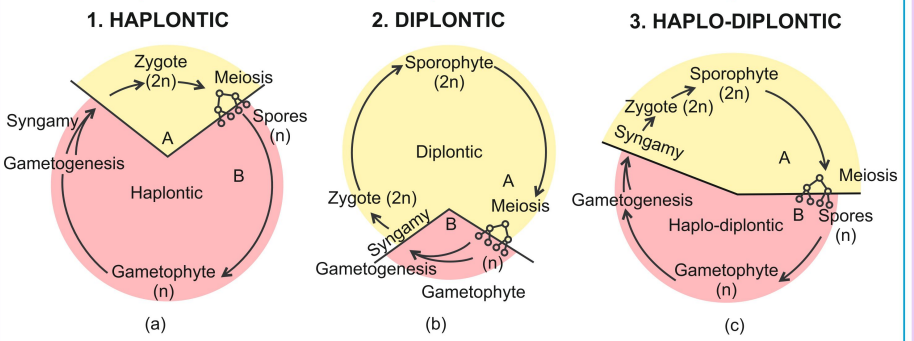
9 ANGIOSPERMS

- In angiosperms or the flowering plants, pollen grains and ovules develop in specialised structures called flowers. Seeds are enclosed in fruits.
- Angiosperms are an exceptionally large group of plants occurring in wide range of habitats.
- Smallest angiosperm is *Wolffia*.
- They are divided into two classes: Dicots having seeds with two cotyledons, reticulate venation in leaf and tetra or pentamerous flowers and Monocots having single cotyledon seed, parallel venation in leaves and trimerous flowers.
- Pollination is by wind or various other agencies.
- Double-fertilisation is unique to the angiosperms. Syngamy produces zygote and triple-fusion produces triploid primary endosperm nucleus (PEN).
- Zygote develops in embryo (with one or two cotyledons) and PEN develops into endosperm (3n) which provides nourishment to the developing embryo. The ovules develop into seeds and the ovaries develop into fruits.

10 PLANT LIFE-CYCLES AND ALTERNATION OF GENERATIONS

- In plants both haploid and diploid cells can divide by mitosis, which leads to the formation of haploid and diploid plant bodies.
- The haploid plant body produces gametes by mitosis, so called gametophytes.
- After fertilisation zygote also divides by mitosis to produce diploid sporophyte plant body.
- Haploid spores are produced by the sporophyte by meiosis which divide to form haploid body again, thus there is alternation of generation between haploid gametophyte and spore producing sporophyte during sexual reproduction in plants.

THE DIFFERENT LIFE-CYCLE PATTERNS



1. **HAPLONTIC:** Sporophytic generation represented only by single-cell zygote. There are no free living sporophytes. Meiosis in zygote produces haploid spores, which divide mitotically to form dominant, photosynthetic free-living gametophyte.
   E.g., Many algae such as *Volvox, Spirogyra* and some species of *Chlamydomonas.*
2. **DIPLONTIC:** Sporophyte dominant, free-living and photosynthetic. The gametophytic phase is represented by single to few-celled gametophyte.
   E.g., All seed bearing plants, *i.e.,* gymnosperms and angiosperms and alga like *Fucus* sp.
3. **HAPLO-DIPLONTIC:**
   (a) Gametophyte dominant, independent, photosynthetic which alternates with totally or partially dependent sporophyte *e.g.,* All bryophytes.
   (b) Sporophyte dominant, independent, photosynthetic, vascular which alternates with saprophytic/autotropic independent but short-lived gametophyte.
   e.g., All pteridophytes
   - Some alga like *Ectocarpus, Polysiphonia,* Kelps are also haplodiplontic.