Kingdom Plantae (Introduction) Thallophyta

Objectives

After going through this lesson, the learners will be able to understand the following:

- Classification of plant kingdom.
- General Features, Habitat, lifestyle and classification of thallophyta.
- General characteristics, habitat, reproduction and economic importance of Chlorophyta, Phaeophyta and Rhodophyta.
- Ecological role of algae

Content Outline

- Introduction to plant kingdom
- Introduction to the world of algae
- Green Algae (Chlorophyta)
- Red Algae(Rhodophyta)
- Brown Algae(Phaeophyta)
- Economic importance of Algae
- Ecological importance of Algae

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, Plantae and Animalia. In this chapter, we will deal with detailed study of 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 as the science of classification keeps on evolving. It was in the 1700 century when Linnaeus initiated the first formal system of classifying living organisms; however, this system was entirely based on morphological characteristics, thus the organisms with most common looking character were kept in one group. However, with development of advanced DNA Molecular technology there has been a radical shift with the study of gene sequences revealing a great deal of information about evolutionary relationships of organisms. With the use of current technology, classification of many species, primitive and modern, continues to evolve as scientists find new information or interpret facts in new ways. In this lesson we will

learn about some general characteristics of plants, their classification followed by detailed study on classification, characteristics, life-cycle, ecological role and economic importance of Algae.

The green plants provide us with food, shelter, and medicines and represent one of evolution's great success stories. The kingdom of plants shows enormous morphological diversity, along with ecological dominance. The new DNA technology opened up new horizons for our quest to find solutions to questions pertaining to evolutionary origin of multicellularity, diversification of life-history strategies, the conquest of land, the nature of the relationship between ontogeny and phylogeny, and modes of evolution at the molecular level. The answers to the above question revolutionized our understanding about the kingdom of plants. 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. Numbers 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, behavior and chemotaxonomy that uses the chemical constituents of the plant to resolve confusions, are also used by taxonomists these days.

General Characters of plants: The members of kingdom plantae are found in a wide range of terrestrial and aquatic habitats, the are mostly autotrophic with some parasitic heterotrophic forms. They are eukaryotic and generally multicellular with being some unicellular forms such as *Chlorella, Chlamydomonas*. Plants usually contain chlorophyll a, b and carotenoids, as they do photosynthesis they store reserve food material in form of starch, another characteristic of plants is that they do not voluntarily move, though they may grow branches in a particular direction.

Based on the system of classification proposed by A.W.EICHLER (1875 -78), the plant kingdom is divided into two subkingdoms. They are: (a) Cryptogamae. (b) Phanerogamae.

CRYPTOGAMAE (cryptogams) - The cryptogams are flowerless (non-flowering) and seedless, spore bearing plants. This sub-kingdom is subdivided into three divisions:

(a) Thallophyta (b) Bryophyta (c) Pteridophyta

PHANEROGAMAE - Phanerogams are flower bearing, seed producing tracheophytes which are divided into –
(a) Gymnospermae and (b) Angiospermae

However, with recent advancements in the field of molecular biology most biologists now group algae under the kingdom Protista along with protozoa and slime moulds. Protists are usually defined as eukaryotic organisms which Since at present biologists have not been able to completely agree on how to classify protists.

Introduction to the World of Algae

Algae are chlorophyll-bearing, simple, thalloid, autotrophic and largely aquatic (both freshwater and marine) organisms. The term algae was coined by Carolus Linnaeus which means sea weeds.

Habitat - Algae are found in a variety of habitats such as fresh water, sea water, brackish water, and wastewater. They even are found over snow, moistrocks, tree trunks, hot springs etc. Some of them also occur in association with fungi (lichen) and animals (e.g., on sloth bear). Also a unicellular green algal species *Dunaliella salina* is found in very salty, or hypersaline, environments such as the Dead Sea. Out of all these, aquatic forms are most common.

Characteristics - The plant body of algae is called thallus. The thalli of algae show a great variation of forms. The body of multicellular organisms ranges from simple floating colonial aggregates of cells like *Volvox* to the filamentous forms like *Ulothrix* and *Spirogyra*. Some other form sheets of cells, a few of the marine forms such as kelps, form massive plant bodies. Some of these algae are much complex and their thallium attaining a length of 60 meters and even more, some of these algae are also of terrestrial form with distinct features to adapt under inadequate availability of water.
The foliaceous and filamentous forms are attached to the substratum by means of hold fast, some of the forms of algae have leaf like lamina, and a stem like stipe and basal hold fast. The vascular tissues are completely absent. The algal thalli are flexible and are generally coated by a layer of mucilage which protects them from desiccation. The specific groups of

algae have a wide variety of pigment combinations that helps to separate one group from another the red, brown and green coloured algae.

Reproduction - Like in other plants they also show reproductive cycles very similar to that of land plants, photosynthetic pigments,cell wall and specialized tissues. The body of many of these algae is differentiated into specialized tissue like the hold fast, stipe, and flattened leaf like blades. The algae reproduce by vegetative, asexual and sexual methods. Vegetative reproduction is by fragmentation. Each fragment develops into a thallus. Asexual reproduction is by the production of different types of spores, the most common being the zoospores. They are flagellated (motile) and on germination gives rise to new plants. Sexual reproduction takes place through fusion of two gametes. These gametes can be flagellated and similar in size (as in Chlamydomonas) or non-flagellated (non-motile) but similar in size (as in *Spirogyra*). Such reproduction is called isogamous. Fusion of two gametes dissimilar in size, as in some species of Chlamydomonas is termed as anisogamous. Fusion between one large, non-motile (static) female gamete and a smaller, motile male gamete is termed oogamous, e.g*., Volvox, Fucus*.

Classification - Dr. F.E Fritsch, known as father of algae, classified algae into various classes depending upon the phylogeny, affinities and inter relationship. However, according to Whittaker's system of classification, algae are mainly of three types: Green, Brown and Red. The three phyla of Algae are largely multicellular and are commonly known as **Chlorophyta** or the green algae, **Rhodophyta** or the red algae, **Phaeophyta** or the brown algae.

Chlorophyta

The members of chlorophyceae are commonly called green algae. The plant body may be unicellular, colonial or filamentous. About 90% of species grow in freshwater and 10% are marine forms. There are about 7000 species of green algae. The freshwater species is ubiquitous in distribution inhabiting most lakes, ponds, pools etc. The marine species occur in tropical seas. Some are sub aerial and are found as sheets on damp soil like Egs.*Ulothrix* and *Vaucheria*. Some green algae are also epiphytic like the species of *Protococcus*, species of *Cladophora* are epizoic growing on animal bodies, whereas some unicellular forms are epiphytic, *Cephaleuros* is parasitic and cause rust diseases of tea leaves, whereas *Chlorella* has thermophilic species that can even be found in hot springs, and *Chlamydomonasnivalis* is found over the snow. They are usually grass green due to the dominance of pigments

chlorophyll a, chlorophyll b and β-carotene. The chlorophylls of green algae can absorb blue and red light, like that of terrestrial plants; the β-carotene mostly prevents cell damage from bright light. The pigments are localized in definite chloroplasts. The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon-shaped in different species. Most of the members have one or more storage bodies called pyrenoids located in the chloroplasts. Pyrenoids contain protein besides starch. Some algae may store food in the form of oil droplets. Green algae usually have a rigid cell wall made of an inner layer of cellulose and an outer layer of pectose. Vegetative reproduction usually takes place by fragmentation or by formation of different types of spores. Asexual reproduction is by flagellated zoospores produced in zoosporangia. The sexual reproduction shows considerable variation in the type and formation of sex cells and it may be isogamous, anisogamous or oogamous. Some commonly found green algae are: ***Chlamydomonas, Volvox, Ulothrix, Spirogyra*** and ***Chara***.
It is believed that land plants have arisen from green algae as it shares many of the characteristics with modern land plants like presence of chlorophyll in chloroplast in stacked grana structure, starch as the principle storage carbohydrate, cellulosic cell wall and many other biochemical features. As algae rarely forms fossils there is no direct evidence to link mosses and green algae but still most scientists have consensus on the belief green algae were ancestors of modern land plants.

Unicellular Green Algae - *Chlamydomonas* is a unicellular green alga that grows well in ponds, ditches and wet soil. It is a small unicellular alga with an egg shaped structure it also has a pair of flagella, its chloroplast is cup shaped it lacks a large vacuole instead has two small contractile vacuoles.

Colonial Green Algae - Several other forms of green algae live as multicellular colonies like *Spirogyra* – A filamentous green alga it is also commonly called as the pond scum it reproduces by vegetative and sexual methods. Similarly, *Volvox* colonies are more amplified in the sense that it consists of 500 to as many as 50,000 cells arranged to form hollow spheres.

Multicellular Green Algae - A marine algae *Ulva* is a multicellular green alga it appears bright green in color and is very commonly near rocky sea shores. It is truly a multicellular algae as it is differentiated into specialized tissue like the hold fast which helps it to attach

itself to the rocks. Like *Ulva* there are many other multicellular green algae found in both fresh water as well as marine water.

Rhodophyceae

The members of Rhodophyceae are commonly called red algae where 'Rhodon' means rose and 'Phyta' means plants. They are red because of the predominance of the red pigment phycobilins, it contains chlorophyll - a, chlorophyll - d, α and β Carotene, Xanthophylls along with reddish accessory pigments called phycobilins (r-Phycoerythrin & r-Phycocyanin) in their body. The main food product is stored in the form of 'Floridean Starch'. Many species of red algae are multicellular and species have complex life cycles. The thallus ranges from simple unicellular to complex multiaxial forms. Some species also form coral by depositing calcium carbonate on their walls. Red algae lack centrioles and flagella.

The red algae is able to live at greater depths due to efficiency in harvesting light energy. Majority of the red algae are marine with greater concentrations found in the warmer areas. They occur in both well-lighted regions close to the surface of water and also at great depths in oceans where relatively little light penetrates. The major reason why red algae are able to live at deep sea is because the phycobilin pigments are good at absorbing blue and green light. Rhodophyta are cosmopolitan, found from the arctic to the tropics. Although they grow in both marine and freshwater, 98% of the 6,500 species of red algae are marine. Most of these species occur in the tropical and subtropical region, with many being found in temperate regions.

In tropical regions they are mostly found in the subtidal zone, growing as epiphytes on seagrasses, within the crevices of rock and coral reefs, or may also be found over dead coral or sand. In some tropical waters, red algae can be found as deep as 200 meters. In temperate regions they mostly are found in the inter–tidal region.

The red algae usually reproduce vegetative by fragmentation. They reproduce asexually by non-motile spores and sexually by non-motile gametes. Sexual reproduction is oogamous and accompanied by complex post fertilization developments. The common members are: *Polysiphonia, Porphyra,Gracilaria and Gelidium.* The reproductive cycle of red algae may be triggered by factors such as day length.

Phaeophyta - They are also called Brown Algae or the Dusky Plants

The members of phaeophyta or brown algae are found primarily in marine habitats. They are multi celled protists. They show great variation in size and form though they appear

plant-like however it does not form an evidence of shared ancestry. They range from simple branched, filamentous forms (Ectocarpus) to profusely branched forms as represented by kelps, which may reach a height of 100 metres. They possess chlorophyll a, c, carotenoids and xanthophylls. They vary in colour from olive green to various shades of brown depending upon the amount of the xanthophyll pigment & fucoxanthin present in them. Food is stored as complex carbohydrates, which may be in the form of laminarin or mannitol. The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous coating of algin. The protoplast contains, in addition to plastids, a centrally located vacuole and nucleus. The plant body is usually attached to the substratum by a holdfast, and has a stalk, the stipe and leaf-like photosynthetic organ – the frond. Vegetative reproduction takes place by fragmentation. Asexual reproduction in most brown algae is by biflagellate zoospores that are pear-shaped and have two unequal laterally attached flagella. Sexual reproduction may be isogamous, anisogamous or oogamous. Union of gametes may take place in water or within the oogonium (oogamous species). The gametes are pyriform (pear-shaped) and bear two laterally attached flagella. The common forms are *Ectocarpus, Dictyota, Laminaria, Sargassum* and *Fucus.*

Economic Importance of Algae

a) **Economic importance of Green Algae –** Many species of green algae are a source of food in many parts of the world like *Ulva, Chlorella, Caulerpa, Enteromorpha*etc they have high amounts of protein and lipids along with several vitamins. An antibiotic Chlorellin is obtained from the Chlorella, it is also used in space research projects. Many species are also used in sewage treatment plants. Some of the unicellular algae like *Euglena, Chlorella, Volvox* etc. are eaten by fish and fish is eaten by man as food. This is how they are useful to man. The blue–green algae can fix atmospheric nitrogen. These algae are used to increase the soil–fertility and thus function as bio–fertilizers. It is estimated that in paddy fields about 625 kg of nitrogen can be fixed in a year by these algae in one kilometer square area. The addition of blue–green algae to barren fields increases the nitrogen and humus content of the soil. Because of increase in humus content, the water holding capacity of soil is improved. The net result is that there is better growth of crops.

b) **Economic Importance of Red Algae** – Many species of red algae including *Poryphyra, Chondrus, Rhodymenia* are edible and are eaten widely in several parts of

the world. Many Phycocolloids like Agar-Agar, Carrageenan and Funori are extracted from red algae for commercial purposes. *Gelidium*, a red alga, is a source of 'agar–agar', which is available in the market as flakes from which a gel is obtained on boiling. This agar–agar is a good culture medium for growing microbes for study and research. Agar–agar is also used in many ways, as food in soups, in polish as paints and also as a medicine. Bromine along with several medicines can also be extracted from some of the red algae species. Today, various species of red algae provide not only food but also produce extracts such as agar, carrageenans (sulfated polysaccharides that are extracted from red seaweeds), and alginates. These extracts are used in numerous food, pharmaceutical, cosmetic, and industrial applications.

c) **Economic importance of Brown Algae -** Kelps are brown algae from the sea. Kelp is an excellent source of minerals from the sea, including iodine, which is essential for proper thyroid function. Cultural studies relating to the result of diet including kelp have indicated a link to a lower breast cancer rate, and a healthier hormonal balance. Some Kelps are rich in potassium and other minerals, and are used as fertilizers along coastal areas. It is used in the making of ice cream and certain medicines. Many species of brown algae, for example *Laminaria, Alaria, Macrocystis, Sargassum, are* used as food in several countries. Food obtained from *Laminaria saccharina* is known as 'Kombu'. Many phycocolloids are commercially obtained from kelps, in India *Sargassum* is used in obtaining Alginic acid. Besides this brown algae is used in extraction of Iodine and Potash and some other extracts with medicinal properties like that of being a sort of an antibiotic and a blood anticoagulant.

Ecological Role of Algae

Microscopic Algae plays a very important role in supplying oxygen to the earth's atmosphere. Algae is also a part of the food chain in aquatic ecosystems. At least a half of the total carbon dioxide fixation on earth is carried out by algae through photosynthesis. In lakes and ponds excessive accumulation of nutrients lead to eutrophication. Freshwater algae can also cause several problems when they grow. Algal blooms can cause foul tastes in water stored in reservoirs that are used to provide drinking water to nearby communities.

Summary

To summarize the five kingdom theory was proposed by Robert Whittaker which includes kingdom Plantae including several organisms with a unique set of features specifically attributed to plants. The Kingdom plantae have further been classified into Thallophyta (Algae), Bryophyta (Moss), Pteridophyta (Fern), Gymnosperm & Angiosperm (Flowering Plants). In this module we learned about the Thallophyta, the most primitive form of non-vascular plants and its subdivision that includes a) Chlorophyta – The green algae that includes more than 7000 species with great diversity in terms of shape and size. b) Phaeophyta – The brown algae that include about 2000 marine species. They are brown in colour due to the presence of the fucoxanthin pigment. c) Rhodophyta or the red algae having about 5200 species with characteristic r-phycoerythrin pigment that imparts red colour. Most of these different forms of algae have economic importance. Algae are useful to man in a variety of ways. At least a half of the total carbon dioxide fixation on earth is carried out by algae through photosynthesis. Being photosynthetic they increase the level of dissolved oxygen in their immediate environment. They are of paramount importance as primary producers of energy-rich compounds which form the basis of the food cycles of all aquatic animals. Many species of Porphyra, Laminaria and Sargassum are among the 70 species of marine algae used as food. Certain marine brown and red algae produce large amounts of hydrocolloids (water holding substances), e.g., algin (brown algae) and carrageenan (red algae) which are used commercially. Agar, one of the commercial products obtained from Gelidium and Gracilaria, are used to grow microbes and in preparations of ice-creams and jellies. Chlorella, a unicellular alga, rich in proteins, is used as a food supplement even by space travelers. Nowadays, biodiesel can also be obtained from a wide variety of algae.