PROKARYOTIC ALGAE

DIVISION CYANOPHYTA
(Blue-green Algae)

- These are a small group of primitive algae characterized by presence of a blue-green pigment, **PHYCOCYANIN**, in addition to chlorophyll (together giving a blue-green colour)

CYANOPHYTA Cont'd

- Some species are truly unicellular, while in others, the daughter cells after divisions adhere together to form a chain of cells (filament) or a flat or spherical colony
- A great majority of them are freshwater dwellers and are often found in almost every stagnant pool, wet ground or in the form of road slime after rains

CYANOPHYTA Cont'd

- The cell structure is a primitive type
- There is no definite nucleus or any plastid, and the protoplast is differentiated into:

✓ a peripheral coloured zone – the **CHROMOPLASM**, and

✓ an inner colourless portion – the **CENTRAL BODY**

CYANOPHYTA Cont'd

- The cell wall is made of **cellulose** and **pectic** compounds
- Carbohydrate occurs in the form of **glycogen**, starch being altogether absent
- A **gelatinous sheath** is a common feature in most of them
- Some filamentous forms, particularly *Oscillatoria*, exhibit a slow, spontaneous movement

CYANOPHYTA Cont'd

- Blue-green algae never reproduce sexually, nor do they bear any kind of ciliated body
- The common types of vegetative reproduction are:

✓cell division in unicellular forms

✓breaking up of the colony in colonial forms

CYANOPHYTA Cont'd

- ✓ fragmentation of the filament into short pieces called **HORMOGONIA** in filamentous forms
- In some filamentous forms (except *Oscillatoria*), a vegetative cell may act as a resting spore called **AKINETE**
- One or more enlarged vegetative cells with transparent contents and thickened walls may be present in such forms

CYANOPHYTA Cont'd

- ✓These are called **HETEROCYSTS**
- **AKINETES** are thick-walled cells formed after a period of active growth that survive in a dormant state when conditions are unfavorable for further growth
- They may be produced singly or in a chain

CYANOPHYTA Cont'd

- They are larger than vegetative cells and have thick walls and granular cytoplasm with an abundance of **cyanophycin granules**
- The cell wall is indistinct from that of the mother cell
- They may remain inactive for many years

- At germination the protoplast is released by rupture of the wall or through a pore before growth commences

CYANOPHYTA Cont'd

- **HETEROCYSTS** are specialized cells for nitrogen fixation
- In the process, N_2 from the air is converted to ammonium
- When dissolved nitrogen compounds are low in the surrounding water, some vegetative cells differentiate into heterocysts

CYANOPHYTA Cont'd

- During differentiation additional walls are added to the wall and pores through the wall connect heterocysts to other vegetative cells
- Heterocysts are usually larger than vegetative cells, have light yellow-green colour from loss of their (phyco)biliproteins, and lack storage granules

SOME MEMBERS OF THE CYANOPHYTA

- *Gloeocapsa*
- *Oscillatoria*
- *Nostoc*
- *Anabaena*
- *Rivularia*
- *Lyngbya*

MEMBERS OF THE CYANOPHYTA Cont'd

- ***Gloeocapsa*:** Always unicellular, but often, 2 to 4, or sometimes several daughter cells are held together in a colony by a mucilagenous sheath
- ***Oscillatoria*:** Consists of a slender, unbranched, cylindrical filament
- Each filament is made up of numerous short cells.

MEMBERS OF THE CYANOPHYTA Cont'd

- All the cells are alike except the end cell.
- This is usually convex and the filament is not differentiated into base and apex.
- When a sheath is present as in *Lyngbya*, the term **TRICHOME** refers to the series of cells, while the **filament** includes the sheath and cells.

MEMBERS OF THE CYANOPHYTA Cont'd

- ***Lyngbya*:** Is similar to *Oscillatoria*, but its filaments have a firm mucilaginous sheath that normally extends beyond the terminal cell
- ***Nostoc* and *Anabaena*:** Both are characterized by unbranched filamentous forms made of beaded cells and the presence of heterocysts

MEMBERS OF THE CYANOPHYTA Cont'd

- They differ in the following respects:

✓ *Nostoc* filaments are twisted and flexuous, forming a tangled mass and have a thick (but not very firm) sheath

✓ *Anabaena* filaments are straight or slightly curved, more rigid, often free and with a thin sheath

Nostoc and *Anabaena* Cont'd

- ✓ *Nostoc* filaments often lie embedded in more or less firm gelatinous matrix, while *Anabaena* filaments are often free or sometimes in a thin gelatin
- ✓ In *Nostoc* the heterocysts are intercalary as well as apical, while in *Anabaena* they are intercalary
- ✓ Akinetes are more frequent and much more elongated in *Anabaena* than in *Nostoc*

Nostoc and *Anabaena* Cont'd

- ✓ *Nostoc* is equally terrestrial and aquatic, while *Anabaena* is mostly aquatic
- Some species of *Nostoc* are symbiotic and live within the tissues of land plants (e.g. in the thallus of *Anthoceros* spp.),or are the algal partner in some lichens.

EUKARYOTIC ALGAE

DIVISION CHLOROPHYTA (Green algae)

- They are characterized by the presence of **chlorophyll** located in definite **plastids** (**chloroplasts**)
- They are mostly freshwater algae, but some species are terrestrial
- They exhibit a variety of forms:

✓ **Unicellular** or **colonial** - being motile or non-motile

CHLOROPHYTA Cont'd

- **Multicellular** - being thalloid or filamentous
- **Coenocytic** (colony of constant size)
- The protoplast is well organized, having a definite nucleus (usually one in each cell or several in **a coenocyte**), and one or more distinct chloroplasts

CHLOROPHYTA Cont'd

- The chloroplasts contain one or more **pyrenoids** (rounded protein bodies surrounded by a starchy envelope)
- The cell wall is made of cellulose and often has a layer of **pectose** around it
- The gelatinous sheath may or may not be present

CHLOROPHYTA Cont'd

- Most unicellular and colonial forms are provided with whip-like structures called **FLAGELLA/CILIA** – often 2, sometimes 4 or many – for motility of cells or colonies
- The flagella/cilia are of uniform length and always formed at the anterior end of the cell

CHLOROPHYTA Cont'd

- In higher forms of Chlorophyta the flagella/cilia are restricted to the reproductive bodies – **zoospores** and **zoogametes**
- Primitive forms have two or more **contractile vacuole**s and a small **eyespot**

REPRODUCTION

- Vegetative reproduction takes place by cell division or fragmentation
- Asexual reproduction takes place by spores of various types:

✓A motile, ciliate spore (zoospore)

REPRODUCTION Cont'd

- ✓A non-motile, non-ciliate spore with a distinct wall of its own but produces within a mother cell (**APLANOSPORE**)
- A vegetative cell acting as a spore, having no wall of its own – the wall of the mother cell acting as the wall of the spore **(AKINETE)**

REPRODUCTION Cont'd

- Sexual reproduction takes place **by isogamy**, **anisogamy** or **oogamy** depending on the species
- Whatever the mode of sexual reproduction, some species are:

REPRODUCTION Cont'd

- ✓ **HOMOTHALLIC** (i.e. the pairing gametes come from the same parent), while others are
- ✓ **HETEROTHALLIC** (i.e. the pairing gametes come from two separate parents

REPRODUCTION Cont'd

- In many green algae, it has been observed that a gamete grows **PARTHENOGENECALLY** (i.e. without fusion with another gamete) into a new plant
- The gamete thus behaves as a spore and is called a **PARTHENOSPORE** or **AZYGOSPORE**

REPRODUCTION Cont'd

- Sometimes, as in *Spirogyra*, the gamete has no cilia/flagella and is called **APLANOGAMETE**

ORIGIN AND EVOLUTION OF SEXUALITY IN THE CHLOROPHYTA

- The vegetative method of reproduction is the most primitive method of multiplication of individual plants
- Asexual reproduction by zoospores appeared later in the lower Chlorophyta possibly as a means of rapid multiplication

ORIGIN AND EVOLUTION OF SEXUALITY Cont'd

- Sexual reproduction appeared later and still continued right up to the highest division of the plant kingdom

✓ evidently to achieve ***something*** that was not possible by the other methods

SEXUALITY IN THE CHLOROPHYTA Cont'd

- This ***something*** is protection,

✓for the thick walled zygote – the result of the sexual act – is better equipped to withstand environmental conditions before it starts a new life

SEXUALITY IN THE CHLOROPHYTA Cont'd

- Sexual reproduction has other advantages too:

✓When conditions are favourable for vegetative activity, neither spores nor gametes are produced

✓When conditions are less favourable, sexual cells or spores are produced

SEXUALITY IN THE CHLOROPHYTA Cont'd

- ✓As the plant approaches the end of its life or when conditions are very unfavourable, sexual cells or gametes are produced
- The mode of reproduction is thus, greatly influenced by the changing environment and age of the plant

SEXUALITY IN THE CHLOROPHYTA Cont'd

- The origin of sexuality in the Chlorophyta appeared as a modification of the older asexual method
- And is directly correlated with the origin of sexual cells or gametes from asexual cells or spores (zoospores)

SEXUALITY IN THE CHLOROPHYTA Cont'd

- Because of their small size (owing to repeated divisions)

✓The gametes have lost the power of functioning individually

- They have thus, developed some kind of mutual attraction and freely come together in pairs and fuse
- This is the earliest indication of sexuality

SEXUALITY IN THE CHLOROPHYTA Cont'd

- It may then be rightly said that gametes are derived from spores (zoospores)
- It is also seen that spores and gametes are similar in several members of the Chlorophyta

✓ eg. in *Chlamydomonas*, *Ulothrix*, and *Oedogonium*, except that the gametes are smaller and more numerous

SEXUALITY IN THE CHLOROPHYTA Cont'd

- Once sexuality appeared, it established itself and its evolution through isogamy to anisogamy to oogamy, based on the differentiation of sexual cells and sexual organs, proceeds towards a high degree of complexity, possibly towards a state of perfection through successive stages

SEXUALITY IN THE CHLOROPHYTA Cont'd

- In the simple and primitive forms of Chlorophyta, there is fusion of two gametes (zoogametes) similar in shape and size
- This is called **ISOGAMY** as found in *Chlamydomonas*, *Ulothrix*, etc.
- The next stage in the evolution of sexuality is **ANISOGAMY**, as found in *Pandorina*, certain species of *Chlamydomonas*, etc.

SEXUALITY IN THE CHLOROPHYTA Cont'd

- Here, a slight difference is noticed in the size of the gametes or in their behaviour: the first indication of differentiation into male and female
- A complete differentiation of gametes and gametangia into male and female is found in the advanced forms of the Chlorophyta

SEXUALITY IN THE CHLOROPHYTA Cont'd

- The union of such differentiated gametes is called **OOGAMY**, as found in *Oedogonium*, *Vaucheria*, etc.
- In all the Chlorophyta, however, the gametangia are single-celled

EXAMPLES OF MEMBERS OF THE CHLOROPHYTA

- *Chlamydomonas*
- *Pandorina*
- *Eudorina*
- *Ulothrix*
- *Chaetophora*
- *Protococcus*
- *Zygnema*
- *Oedogonium*
- *Vaucheria*
- *Caulerpa*
- *Chara*
- *Spirogyra*

DIVISION EUGLENOPHYTA (Euglenoids)

- *Euglena* is a most simple, unicellular organism
- The evolution of the higher forms of plants possibly started from it
- It grows in large numbers in polluted water containing organic substances and colours it green

EUGLENOPHYTA Cont'd

- It is a single-celled, naked, free-swimming organism
- It has a single flagellum, i.e. a long, slender, whip-like projection, which vibrates and helps the plant to swim
- It can also crawl by changing its shape

EUGLENOPHYTA Cont'd

- The protoplast contains a central nucleus, several green plastids, a contractile vacuole and an eyespot near the blunt end

DIVISION PHAEOPHYTA
(Brown Algae)

- These are a group of seaweeds with a variety of peculiar forms and sizes
- They are widely distributed between tidal levels along sea coasts predominantly of temperate seas
- They are attached to rocks or some other substrata

PHAEOPHYTA Cont'd

- In colder seas they seldom go beyond a depth of 20m
- While in warmer seas, a few species may grow up to a maximum depth of 90m
- Some also grow as epiphytes or endophytes on/in other algae
- A few are free-floating
- Their colour ranges from brown to olive-green

PHAEOPHYTA Cont'd

- ✓ Due to the presence in the chloroplast of a brown pigment **FUCOXANTHIN**, which masks the chlorophyll
- There are **no pyrenoids**
- The reserve food may be
- ✓ A kind of sugar (and not starch)
- ✓ Or, more commonly, a complex carbohydrate called **LAMINARIN**

PHAEOPHYTA Cont'd

- Some like *Ectocarpus* are short filaments
- While others, like *Fucus* and *Sargassum*, are usually a few cm to 1m in length
- Others are massive seaweeds, called **GIANT KELPS** (*Laminaria*: 2-9m, *Necrocystis*: 45m, and *Macrocystis*: 60-90m)

PHAEOPHYTA Cont'd

- They grow at or below the low tide level, extending far into the sea to a depth of about 90m
- Small kelps are only about a meter long
- Unicellular brown algae are not known to exist

PHAEOPHYTA Cont'd

- The body of the kelp is differentiated into

✓A basal root-like, branched **HOLDFAST**

✓A long or short 'stem' called **STIPE**

✓And one or more leaf-like blades called **FRONDS**, which have air bladders to facilitate floating

PHAEOPHYTA Cont'd

- Some species have fronds of massive size
- The Phyaeophyta (except *Fucus* and *Sargassum*) show a regular alternation of generation

PHAEOPHYTA Cont'd

- With different degrees of development of the sporophyte and the gametophyte
- The sporophyte and the gametophyte can be

✓ Similar (**ISOMORPHIC**, as in *Ectocarpus*)

✓Or dissimilar **(HETEROMORPHIC**, as in *Laminaria*) in external appearance

PHAEOPHYTA Cont'd

- And their motile cells (zoospores and gametes or sperms) are

✓Laterally biciliate

✓The two cilia being of unequal lengths

✓ In contrast with the apically ciliate cells of most algae

REPRODUCTION

- Motile reproductive bodies (zoospores and gametes or sperms) are universally present throughout the Phaeophyta
- Several species reproduce vegetatively by fragmentation of the thallus

REPRODUCTION Cont'd

- Most of them reproduce asexually, through zoospores or aplanospores (except *Fucus* and *Sargassum*) and sexually by isogamy, anisogamy or oogamy
- The zygote germinates without any period of rest.

EXAMPLES

- *Ectocarpus*, *Laminaria*, *Fucus*, *Sargassum*

DIVISION RHODOPHYTA (Red Algae)

- The Rhodophyta form a big group of highly specialized marine algae
- They are very widely distributed in both temperate and tropical seas, particularly in the latter

RHODOPHYTA Cont'd

- Many species are found between the high tide level and the low tide level along coasts; a good number of species grow at depths of 60-90m, a few at much greater depths, up to 180m
- They are mostly attached to rocks

RHODOPHYTA Cont'd

- There are, however, some epiphytic and parasitic varieties which grow on other algae
- Although mostly marine, about 50 species have been found to occur in fresh water
- Red algae are characteristically red or purplish in colour due to the presence of a red pigment called **PHYCOERYTHRIN** which often masks the presence of chlorophyll

RHODOPHYTA Cont'd

- Many red algae contain a small amount PHYCOCYANIN, the blue pigment of the Cyanophyta
- Fresh water species are often green in colour
- Red algae have a variety of forms – filamentous, ribbon-shaped, distinctly leaf-like and marked with veins, etc

RHODOPHYTA Cont'd

- They are mostly a few to about 25cm in length, while a few are as long as 1 to 1.3m
- Deep-water ones are much longer
- Gelatinous material is abundant in the red algae, either occurring within the thallus or forming a sheath in the filamentous forms

RHODOPHYTA Cont'd

- Some red algae are heavily incrusted with lime
- The cells may be uninucleate or multinucleate with one or more plastids, which may be or without pyrenoids

RHODOPHYTA Cont'd

- A sugar or, more commonly, a special kind of starch called **FLORIDEAN STARCH** accumulates in the cells as a result of photosynthesis
- There is a total absence of motile ciliate cells; zoospores are altogether absent and gametes are never ciliate

RHODOPHYTA Cont'd

- Members of the Rhodophyta are either haploid or they show a regular alternation of similar haploid and diploid stages, as in *Polysiphonia*

EXAMPLES

- *Polysiphonia*, *Batrachospermum*

DIVISION BACILLARIOPHYTA (DIATOMS)

- These are commonly called DIATOMS and consist of mostly one-celled algae
- They are of infinite variety of forms and often of exquisite beauty
- The single cells may occasionally form filaments and colonies

BACILLARIOPHYTA Cont'd

- They are universally distributed in fresh water, as well as in salt water and also in wet ground

BACILLARIOPHYTA Cont'd

- In some parts of the ocean they occur in vast assemblage as floating **PLANKTON**
- They often occur in huge numbers in a small space
- Most diatoms are free-floating, but some are attached by a gelatinous stalk

BACILLARIOPHYTA Cont'd

- The cells of diatoms have walls composed of silica
- Each cell wall is in two overlapping halves which are arranged exactly like the two halves of a Petri dish

BACILLARIOPHYTA Cont'd

- The half which overlaps the other, like the lid of a Petri dish, is the **EPITHECA**
- The other half is the **HYPOTHECA**
- Fossil diatoms have formed huge deposits of **SILICEOUS** or **DIATOMACEOUS EARTH**, often of considerable depth, in various parts of the world