CYANOPHYCEAE

It is a primitive group of algae, consists of 150 genera and about 2,500 species. In India, the division is represented by 98 genera and about 833 species. Members of the class Myxophyceae (Cyanophyceae) are commonly known as blue green algae. The name blue green algae is given because of the presence of a dominant pigment c-phycocyanin, the blue green pigment.

In addition, other pigments like chlorophyll a (green), c-phycoerythrin (red), β-carotene and different xanthophylls are also present. The members of this class are the simplest living autotrophic prokaryotes.

They have the following important characteristics:
a. Nucleus is of prokaryotic nature i.e., devoid of nuclear membrane and nucleolus,

b. Absence of well-organised cell organelles, and

c. Pigments are distributed throughout the chromoplasm (the outer part of protoplasm).

Depending on the above prokaryotic characteristics many microbiologists consider the members of Cyanophyceae as bacteria. Based on prokaryotic cell structure like bacteria, Christensen (1962) placed both Cyanophyta and bacteria under a common phylum Prokaryota. Cyanophyta or blue green algae have also been named as cyanobacteria.

Important Characteristics of Cyanophyceae:

The important characteristics of the division are as follows:
1. The individual cells are prokaryotic in nature. The nucleus is incipient type and they lack membrane bound organelles.

2. Both vegetative and reproductive cells are non-flagellate.

3. Cell wall is made up of microfibrils and is differentiated into four (4) layers. The cell wall composed of mucopeptide, along with carbohydrates, amino acids and fatty acids.

4. Locomotion is generally absent, but when occurs, it is of gliding or jerky type.

5. The principal pigments are chlorophylls a (green), c-phycocyanin (blue) and c-phyco- erythrin (red). In addition, other pigments like β-carotene and different xanthophylls like myxoxanthin and myxoxanthophyll are also present.

6. Membrane bound chromatophore are absent. Pigments are found embedded in thylakoids.

7. The reserve foods are cyanophycean starch and cyanophycean granules (protein).

8. Many filamentous members possess specialized cells of disputed function (supposed to be the centre of N_2 fixation) known as heterocysts.
9. Reproduction takes place by vegetative and asexual methods. Vegetative reproduction takes place by cell division, fragmentation etc. Asexual reproduction takes place by endospores, exospores, akinetes, nannospores etc.

10. Sexual reproduction is completely absent. Genetic recombination is reported in 2 cases.

Occurrence of Cyanophyceae:
Members of Cyanophyceae are available in different habitats. Most of the species are fresh water (e.g., Oscillatoria, Rivularia), a few are marine (e.g., Trichodesmium, Darmocarpa), and some species of Oscillatoria and Nostoc are grown on terrestrial habitat.

Species of some members like Anabaena grow as endophytes in thallus of Anthoceros (Bryophyta) and in leaves of Azolla (Pteridophyta) and Nostoc in the root of Cycas (Gymnosperm).

Species of Nostoc, Scytonema, Gloeocapsa, and Chroococcus grow symbiotically with different fungi and form lichen. Some members like Nostoc, Anabaena etc. can fix atmospheric nitrogen and increase soil fertility.

Thallus Organisation in Cyanophyceae:
Plants of this group show much variation in their thallus organisation.

The thallus may be of unicellular or colonial forms:
1. Unicellular Form:
In unicellular form, the cells may be oval or spherical. Common members are Gloeocapsa (Fig. 3.23A), Chroococcus and Synechococcus.

2. Colonial Form:
In most of the members the cells after division remain attached by their cell wall or remain together in a common gelatinous matrix, called a colony.

The colonies may be of two types:
a. Non- filamentous, and

b. Filamentous.

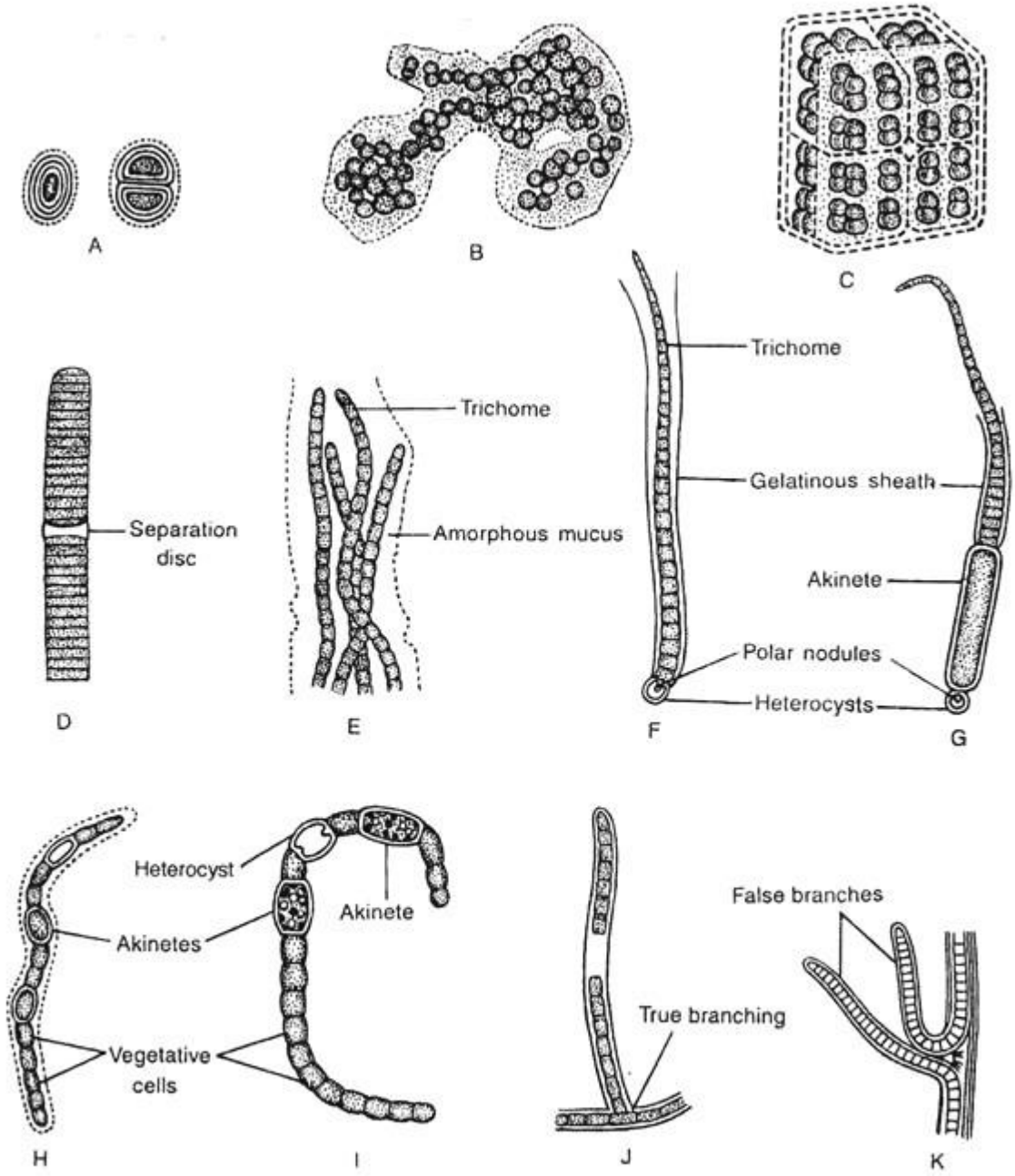

Fig. 3.23 : A few members of Cyanophyceae showing thallus organization : A. *Gloeocapsa* sp., B. *Microcystis* sp., C. *Eucapsis alpina*; D. *Oscillatoria* sp., E. *Microcoleus* sp., F. *Rivularia poliotis*, G. *Gloeotrichia pisum*, H. *Nostoc* sp., I. *Anabaena* sp., J. *Mastigocladus limilosus*, and K. *Scytonema* sp.

a. Non-Filamentous Type:

The cells of this type divide either alternately or in three planes, thereby they form spherical (Gomphosphaera, Coelosphaerum), cubical (Eucapsis alpine, Fig. 3.23C), squarish (Merismopedia) or irregular (Microcystis, Fig. 3.23B) colony.

b. Filamentous Type:

By the repeated cell division in one plane, single row of cells are formed, known as trichome. e.g., Oscillatoria (Fig. 3.23D), Spirulina, Arthosporia etc. The trichome when covered by mucilaginous sheath is called a filament. The filament may contain single trichome (Oscillatoria, Lyngbya) or several trichomes (Hydrocoleus, Microcoleus, Fig. 3.23E).

The trichomes may be unbranched (Oscillatoria, Lyngbya), branched (Mastigocladus limilosus, Fig. 3.23J) and falsely branched (Scytonema, Fig. 3.23K and Tolypothrix).

Reproduction in Cyanophyceae:

The blue green algae (Cyanophyceae) reproduce by both vegetative and asexual means. Sexual reproduction is absent.

The vegetative reproduction performs through fission (Synechococcus), fragmentation (Oscillatoria, Cylindrospermum muscicola), hormogonia formation (Oscillatoria, Nostoc), hormospores (Westiella lanosa), planococci and Palmelloid stage.

During asexual reproduction various types of asexual spores are formed. These are akinetes (Anabaena sphaerica, Gloeotrichia natans, Calothrix fusca), endospores (Dermocarpa), exospores (Chamaesiphon) and nannocyte (Microcystis) (Fig. 3.27).

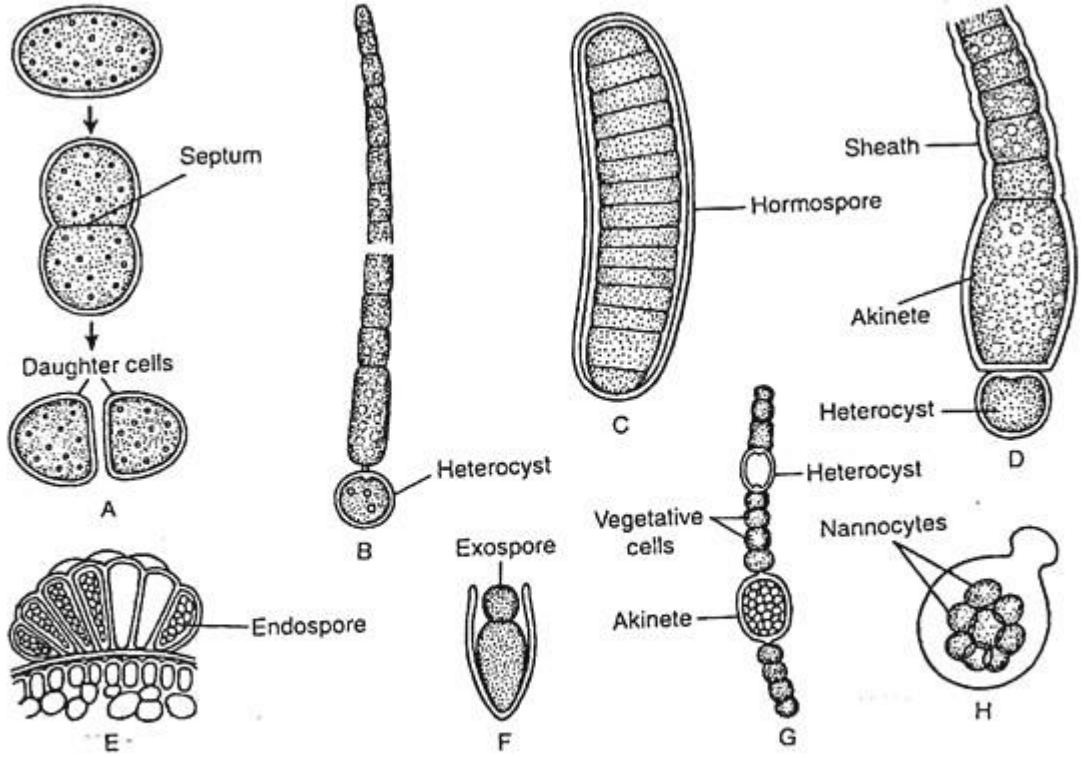

Fig. 3.27 : Vegetative and asexual reproduction in Cyanophyceae : A. Cell division (*Synechococcus* sp.), B. Fragmentation of filament (*Cylindrospermum muscicola*), C. Hormospore (*Vestiella lanosa*), D. Akinete (*Gloeotrichia natans*). E Endospore (*Dermocarpa prasina*), F. Exospore (*Chamaesiphon incrustans*), G. Akinete (*Anabaena* sp.) and H. Nannocytes (*Aphanothece*)

Gaidukov phenomenon or complementary chromatic adaptation:
The efficiency to change the pigment composition, to absorb maximum light for photosynthesis, with the variation of the incident light is called complementary chromatic adaptation.

Many members of Cyanophyceae have the capacity to change their colour in relation to the wave length of incident light. Due to variation of the wavelength of incident light they can change their pigment composition.

It may appear blue green in yellow light, green in red light and reddish in green light. Gaidukov (1903) first invented the phenomenon and according to his name it is also known as Gaidukov phenomenon.

Origin of Cyanophyceae:
This group is considered to be the most primitive because of the presence of some important features.

These are:
a. Presence of unorganised nucleus,

b. Absence of chromatophores,

c. Absence of flagella, and

d. Lack of sexual reproduction.

They are found in all habitats where life is possible and distributed throughout the world. Fossil records indicate that they have originated in early Pre-Cambrian period. But their ancestry is not known. Absence of flagella and the prokaryotic nature of cells lead to believe that possibly they have originated from unicellular aflagellate cells.

Presence of most of the members in terrestrial habitat leads to believe by most of the investigators that the Cyanophyceae have originated from terrestrial members.

Affinities of Cyanophyceae:
The members of Cyanophyceae show some relationship with both bacteria and Rhodophyceae.

Similarities of Cyanophyceae with Bacteria:
1. Cell structure is prokaryotic in both the group, having unorganised nucleus and devoid of membrane bound organelle.

2. The capsule of bacteria (if present) and mucilaginous sheath of blue green algal cells are made up of fine fibrils.

3. Cell wall composed of mucopeptide (murein).

4. Oscillatoria (blue green alga) shows similarity with Beggiatoa (sulphur bacterium), both in shape and movement.

5. Both are sensitive to antibiotics.

6. Both the groups show similarity in many metabolic processes like nitrogen and sulphur metabolism.

7. Absence of sexual reproduction.

8. Genetic recombination has been reported in Anacystis nidulans, a member of Cyanophyceae, showing similarity with bacteria.

Similarities of Cyanophyceae with Rhodophyceae (Red Algae):

1. Both the groups resemble in the absence of motile cells.

2. The Cyanophycean pigments, c-phycocyanin (blue) and c-phycoerythrin (red) are chemically similar to the Rhodophycean pigment r-phycocyanin and r-phycoerythrin.

3. Stignema and some other members of Cyanophyceae have pit connections, and show relationship by having similar structures as found in the members of Rhodophyceae.

Economic Importance of Cyanophyceae:

The Cyanophycean members show both beneficial and harmful activities.

Beneficial Activities:

1. Nostoc commune is boiled and used as soup in China.

2. Few species of Nostoc, Anabaena, Scytonema form a thick substratum over the soil resulting a reclamation of land.

3. About twenty two (22) filamentous members of Cyanophyceae like Nostoc, Anabaena, Aulosira, Anabinopsis, Calothrix, Scytonema etc. can fix atmospheric nitrogen and form nitrogenous compounds. These compounds are further absorbed by the plant for their metabolic activity and increase yield.

All the above members have heterocyst. But certain non-heterocystous members like Plectonema boryanum are able to fix atmospheric nitrogen in anaerobic condition.

Harmful Activities:

1. Some members of Cyanophyceae cause damage of building plasters, stones etc. It can be avoided by spraying $CuSO_4$ and sodium arcenate.

2. Some members like Microcystis, Anabaena, form water blooms and can grow well in O_2 deficient water. Continuous respiration by submerged plants and animals during night time (when photosynthesis does not take place) causes the depletion of O_2 to almost zero level. At that condition mortality of both animals and other submerged plants takes place due to suffocation.
3. Blue green algae contaminate the water of reservoirs. They develop a foul odour in water and make it unhygienic for human being and cause several diseases.

Different diseases like gastric troubles may appear by drinking the water contaminated with Microcystis and Anabaena.

CHLOROPHYCEAE (GREEN ALGAE)

Chlorophyceae (chloros, green; phyceae, algal organisation) is commonly known as green algae'. Fritsch (1935) considered to include the green algae under the class Chlorophyceae, which have been raised to the rank of division Chlorophyta by Smith (1938), Tippo (1942) and Bold (1950).

Later Prescott (1969) and Round (1973) considered it to the rank of phylum Chlorophyta. Papenfuss (1946) included the suffix 'phyco' to the divisions of algae and named chlorophyta as Chlorophycophyta. Later Bold and Wynne (1978) also followed the same suggestion. Considering more appropriate, the classification of Fritsch (1935) is followed in this book.

This class consists of 425 genera and about 6,500 species but, later Prescott (1969) reported that the number of species may be as many as 20,000; with more being discovered continuously. The name green alga is given because of the presence of dominant pigments like Chlorophylls a and b over the carotenoids and xanthophylls. They are all eukaryotes.

Occurrence of Chlorophyceae (Green Algae):

The members of Chlorophyceae generally grow in fresh water (about 90%) and the rest in saline water, terrestrial habitat etc. The fresh water members such as Volvox, Oedogonium, Spirogyra etc. grow in ponds, pools and lakes.

Members of conjugales (e.g., Spirogyra, Zygnema etc.) and Oedogoniales (e.g., Oedogonium etc.) are strictly fresh water, but the members of Ulvaceae and Siphonales are predominantly marine. Some members of Volvocales, Chaetophorales and Cladophorales grow both in fresh and saline water.

Some species of Ulothrix and Vaucheria are subaerial and grow on damp soil. Some members may be terrestrial and grow as epiphytes on tree trunk, leaves etc. (e.g., Trentepohlia); as epizoic i.e., (growing on animal bodies (species of Characium and Cladophora); as

endophytes (e.g., Chlorella), as parasites (e.g., Cephaleuros, Rhodochytrium and Phyllosiphon) and also cause diseases.

They can also grow in further different habitats like hot springs (Chlorella), snow (Chlamydomonas yellowstonensis), saline water (C. ehrenbergi) and some remain as partners in lichen associations.

Important Characteristics of Chlorophyceae (Green Algae):

1. Members of Chlorophyceae grow mostly in fresh water, a few in brackish and saline water and a few are terrestrial.

2. They show wide range of variations in their thallus structures like unicellular motile (Chlamydomonas) and non-motile (Chlorella), coenobium (Volvox), palmelloid (Tetraspora), dendroid (Ecballocystis), filamentous branched (Cladophora) and unbranched (Spirogyra), heterotrichous (Coleochaete), siphonaceous (Vaucheria) and parenchymatous (Ulva).

3. Flagella are 1-many, equal in size and inserted either apically or sub-apically. The flagella show typical 9+2 arrangement when viewed under E.M.

4. The cells are eukaryotic in nature. Usually there is only one nucleus in each cell, but in Siphonales and Cladophorales many nuclei are present in their coenocytic body. Normally the number of nucleolus is one per nucleus, but several nucleoli are present in the members of Conjugales.

5. The cell wall is mainly made up of cellulose, which comprised of hydroxyproline glycosides or xylans and mannans. In Chara the cell wall is encrusted with calcium and magnesium carbonate.

6. Inner to the cell wall, semipermeable cell membrane is present which encircles the protoplast. The cytoplasm contains many small vacuoles which pushes the nucleus with cytoplasm towards the periphery and called primordial utricle.

7. The flagellate cells have eye-spot or stigma in the anterior portion, which remain inserted at one side of the chloroplast.

8. The pigments are located in the chloroplast. Chkiroplast generally contains pyrenoid(s).

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7. The flagellate cells have eye-spot or stigma in the anterior portion, which remain inserted at one side of the chloroplast.

8. The pigments are located in the chloroplast. Chkiroplast generally contains pyrenoid(s).

9. The main pigment is chlorophylls a and b; those dominate over α- and β-carotenes and xanthophylls.

10. Phycobilins are absent.

11. The reserve food is starch, composed of amylose and amylopectin.

12. They reproduce by all the three means i.e., vegetative (cell division and fragmentation), asexual (zoospore, aplanospore, akinete etc.) and sexual (isogamy to oogamy). The sexual reproduction is absent in some members of Chlorococcales

13. The zygote or oospore is the only diploid structure in their life cycle.

Thallus Organisation of Chlorophyceae (Green Algae):

The class Chlorophyceae shows a range of variation in the structure of plant body (thallus). It ranges from unicellular e.g., Chlamydomonas, Chlorella, Sphaerella etc. to multicellular structure. The multicellular forms may be of different types. They may have a number of cells arranged in colonies of definite shape, the coenobium.

The number of cells in a coenobium may be definite and motile as in Volvox, Pandorina, Pleodorina etc. or the number may be indefinite, arranged in net-like masses and are non-motile as in Hydrodictyon. The multicells may aggregate and form a non-motile palmelloid structure, where the cells remain embedded in an amorphous or gelatinous matrix as found in Tetraspora and Palmodictyon.

In multicellular forms the cells may be arranged in a single row to form the filament. The filament may be branched (e.g., Pithophora, Cladophora etc.) or unbranched (e.g., Oedogonium, Spirogyra, Ulothrixetc.). The multicells may aggregate and form an expanded sheet-like structure as found in Coleochaete.

It shows heterotrichous habit where the erect system is well-developed. In some members the plant body is like cylindrical tube i.e., coenocy- tic as in Vaucheria. In some algae like Ulva, the plant body is leaf-like. The highly organised plant body in Chlorophyceae is found in Chara, where the plant is very much complicated in structure with well protected sex organs.

Classification of Chlorophyceae (Green Algae):

1. Order. Volvocales:

The order Volvocales includes 60 genera and about 500 species.

Important characteristics:

i. They are commonly found in fresh water. Some are grown in brackish water, marine water and also on soil.

ii. The plant body is unicellular or multicellular and the multicellular ones are colonial in habit.

iii. Both unicellular and colonial members are motile, either throughout or some part of their life cycles.

iv. They reproduce both asexually and sexually. Asexual reproduction takes place by zoospores, aplanospores, hypnospores etc. and sexual reproduction by iso-, aniso-, and oogamy.

Classification:

Fritsch (1935) divided the order Volvocales into 3 suborders and 7 families.

The outline of classification is given below:

Order. Volvocales:

I. Sub order. Chlamydomonadineae

Family. i. Chlamydomonadaceae

ii. Sphaerellaceae

iii. Polyblepharidaceae

iv. Phacotaceae

II. Sub order. Tetrasporineae
Family. i. Tetrasporaceae

ii. Palmellaceae

III. Sub order. Chlorodendrineae
Family. i. Chlorodendraceae

Family. Chlamydomonadaceae
Important characteristics:
i. Plant body is unicellular, uninucleate with definite cell wall.

ii. Cells have 2-4 flagella which a.re equal in length.

iii. Chloroplast is generally cup-shaped, but it may be H-shaped, reticulate, stellate etc.

iv. Asexual reproduction takes place mainly by zoospores.

v. Sexual reproduction takes place by all the three means iso-, aniso-, and oogamy.

2. Order. Ulotrichales
Important characteristics:
The order Ulotricales includes 80 genera and about 430 species. Most of them are fresh water, while a few are marine (e.g., Ulva).

The important characteristics of the order are:
i. They are commonly found in fresh water (e.g., Ulothrix) or on soil, but a few are marine (e.g., Ulva, Enteromorpha).

ii. Plant body is commonly an unbranched filament; but in Ulvaceae it is parenchymatous or foliaceous.

iii. Cells are uninucleate and contain chloroplast of different types like C-shaped, parietal, axial etc.

iv. Each chloroplast contains one or more pyrenoids.

v. Asexual reproduction takes place by means of bi- or quadriflagellate zoospores, aplanospore and akinetes.

vi. Sexual reproduction takes place by gametic union and may be iso-, aniso-, or oogamous type.

Classification:
Fritsch (1935) divided the order Ulotrichales into 3 suborders and 6 families.

The outline of classification is given below:
Order. Ulotrichales
I. Sub order. Ulotrichineae
Family. i. Ulotrichaceae

ii. Microsporaceae

iii. Cylindrocapsaceae

iv. Ulvaceae

II. Sub order. Prasiolineae
Family. i. Prasiolaceae

III. Sub order. Sphaeropleineae
Family. i. Sphaeropleaceae

Family. Ulotrichaceae

Important characteristics:
i. The plant body is an unbranched filament.

ii. Cells of the filament are uninucleate.

iii. Cells have single girdle-shaped, parietal chloroplasts.

iv. Sexual reproduction is isogamous and takes place by the union of biflagellated gametes.

3. Order. Chaetophorales:

Chaetophorales are the plants with hair or setae.

The important characteristics of the order are given below:
i. Members are generally found in fresh water.

ii. Plant body is filamentous and shows prominent heterotrichous habit; however, in Coleochaete, the prostrate system is well-developed and in Microthamnion the erect system is well-developed.

iii. Some members have setae (Coleochaete) or hairs (Stigeoclonium) of different types. The hairs may be in the form of single elongated cell or rows of fine and elongated cells.

iv. The cells contain a parietal chloroplast with many pyrenoids.

v. Erect system bears reproductive structures.

vi. Vegetative reproduction takes place by fragmentation.

vii. Asexual reproduction takes place by bi- or quadriflagellate zoospores, aplanospores or akinetes.

viii. Sexual reproduction is commonly isogamous (Fritschiella, Stigeoclonium), anisogamy (Aphanochaete) and oogamy (Coleochaete) are found occasionally.

Fritsch (1935) classified the order into 5 families.

These are:
Chaetophoraceae, Trentepohliaceae, Coleochaetaceae, Chaetosphaeridiaceae and Pleurococcaceae.

Family. Coleochaetaceae:
Important characteristics:
i. Plant bodies possess a typical heterotrichous habit. Generally the projecting system is dominant and looks like disc.

ii. Cells are uninucleate with single lamellate parietal chloroplast with one or two pyrenoids.

iii. All or some cells bear a single long sheathed bristle or seta.

iv. The sheath is present in the form of a basal cylinder of mucilage.

v. The growth is always through the apical region.

vi. Asexual reproduction takes place by means of biflagellate zoospores.

vii. Sexual reproduction is oogamous.

4. Order. Oedogoniales

Important characteristics:

i. Most of the members grow in fresh water. The order is represented by only three genera, Oedogomium, Oedocladium and Bulbochaete.

ii. They are filamentous and the filaments may be branched (Oedocladium and Bulbochaete) or unbranched (Oedogomium).

iii. The plant body is differentiated into apical and basal region.

iv. It consists of cylindrical cells and the cells are longer than breadth.

v. Cells are uninucleate and have reticulate chloroplast with pyrenoids.

vi. Cell division is elaborate and a cap is formed at the upper end of the daughter cell.

vii. Asexual reproduction takes place by pyri- form, multinucleate and multiflagellate zoospores. Flagella are arranged in a ring around the beak-like anterior end.

viii. Sexual reproduction is advanced oogamous type.

ix. Both androspores and antherozoides are multiflagellate.

x. Male gametes are similar to zoospore but smaller in size.

xi. Heterothallic or dioecious species are of two types: macrandrous (where male and female filaments are of normal size) and nannandrous type (where male is very small i.e., dwarf male or nannandrium and the female one is of normal size).

Classification:
According to Fritsch (1935) the order Oedogoniales contains only one family Oedogoniaceae. The family has only three genera: Oedogomium, Oedocladium and Bulbochaete.

5. Order. Siphonales:

Important characteristics:
i. Most of the members of Siphonales are marine. A few members are freshwater. Some members grow as epiphytes or endophytes.

ii. Thalloid plant body is variously branched, aseptate and multinucleate i.e., coenocytic.

iii. Plant body may be simple vesicular type (Protosiphon) to much branched filamentous type.

iv. Numerous small and discoid chromato- phores are arranged peripherally inside the thallus.

v. Nuclei are present towards the inner layer.

vi. The characteristic pigments of this order are siphonin and siphonoxanthin.

vii. Presence of siphon-like central vacuole throughout the plant body, which remains filled with sap. Cytoplasm is present between the outer wall and vacuole. The order is named “Siphonales” because of the presence of siphon-like vacuole.

viii. The plant reproduces by all the three means vegetative, asexual and sexual. Vegetative reproduction takes place by fragmentation, asexual reproduction by multiflagellate zoospore, aplanospore or hypnospore and sexual reproduction by oogamy. Rarely they perform iso- and anisogamy.

Classification:
Fritsch (1935) divided the order Siphonales into 9 families.

These are:
i. Protosiphonaceae,

ii. Caulerpaceae,

iii. Dasycladaceae,

iv. Derbesiaceae,

v. Codiaceae,

vi. Valoniaceae,

vii. Chaetosiphonaceae,

viii. Phyllosiphonaceae, and

ix. Vaucheriaceae.

This classification is also followed by M. O. P. lyenger (1951)

6. Order. Charales

Important characteristics:
i. Members of this order are distributed throughout the world.

ii. Commonly they are found in fresh water with muddy or sandy bottom and also in water flowing over limestone.

iii. Plants are macroscopic, much branched, and erect and commonly up to 30 cm in length.

iv. The plants are differentiated into nodes and internodes. Some of the nodes bear branches of unlimited growth, those are again divided into nodes and internodes. Each node of the main axis and branch of unlimited growth bear a number of branches of limited growth.

v. Cells are very long, uninucleate and contain many discoid chloroplasts.

vi. Most of the species show cortication in the internodes. The cortex consists of vertically elongated row of cells.

vii. Sexual reproduction is highly advanced, oogamous type.

viii. The male and female reproductive bodies are globule and nucule, respectively. Globule develops many antherozoids and nucule contains only one egg.

ix. Zygote is produced after sexual reproduction. It shows very much elaborate post- fertilization changes. During germination, zygote undergoes meiosis and gradually it forms the plant body.

Classification:
Fritsch (1935) placed the order Charales under the class Chlorophyceae includes only one family the Characeae having 2 sub families: 1. Nitelleae and 2. Chareae.

Bold and Wynne (1978) placed the order Charales alone under the only class Charophyceae, under the division Charophyta. The order Charales includes only one family Characeae.

Divn. Charophyta: Class. Charophyceae.

H. C. Bold and M. J. Wynne (1978) in their classification took out Chara along with some other genera like Tolypella, Nitella, Nitellopsis, Protochara, Lamprothamnium and Lychnotham- nus from Chlorophyceae and placed them in a separate Division Charophyta. The Charophyta consists of single class Charophyceae; order Charales and family Characeae.

Important characteristics of Characeae:
i. The division Charophyta includes the members of green algae, commonly known as stoneworts.

ii. Plant body shows much elaboration of vegetative structures encrusted with calcium carbonate.

iii. Plant body is erect and consists of elongated, jointed, commonly green main axis bearing branches, differentiated into nodes and internodes.

iv. Each node bears a whorl of lateral branchlets.

v. Asexual reproduction is absent.

vi. Sexual reproduction is of oogamous type.

vii. Antheridia (globule) and oogonia (nucule) show more complexity and elaboration than other Chlorophycean members.

viii. Motile cells are asymmetrical and two flagella are attached in lateral position of an antherozoid.

ix. Sex organs are so large that they can be visible with naked eye.

x. Zygote on germination forms proto- nema (Chara, Nitella) from which vegetative plants are developed.