Myxophyceae

(Blue-green Algae)

8.1 NOMENCLATURE

The class Myxophyceae (Gr. *myxa*, slime; *phyton*, a plant) or Cyanophyceae (Gr. *kyanas*, a dark blue substance; *phyton*, a plant) is commonly called blue-green algae because of the presence of a principal bluish green pigment (c-phycocyanin) along with chlorophyll-a, β-carotene, and some quantity of Myxoxanthin, Myxoxanthophyll as well as small quantity of carotene, flavacin and c-phycoerythrin (Chapman, 1962). Though Fritsch (1945) has used the name Myxophyceae (Cyanophyceae), he mentioned that this class is also named Schizophyceae or Phycochromophyceae. Many of the earlier workers (Desikachary, 1959; Prescott, 1969; Morris, 1973; Round, 1973; Kumar and Singh, 1982, etc.) have included blue-green algae under division Cyanophyta but Chapman (1962) placed them under Myxophycophyta. The new name Cyanochloronta has been used by Bold (1973), and Bold and Wynne (1978).

Genera and Species:

According to Desikachary (1959), out of a total of 160 genera and 1500 species of blue-green algae reported from the world, 85 genera and 750 species have been reported from India so far, and thus the Indian flora is nearly 50% of the genera as well as species. Montagne (1849) reported the first blue-green alga (*Calothrix indica*) from India[1].

8.2 ARE MYXOPHYCEAE ALGAE?

Two important characteristics of blue-green algae, i.e. absence of a definite nucleus with typical chromosomes, and the distribution of the pigments in a very primitive chromatophore structure, are still compelling botanists to think seriously whether they really belong to algae. According to Fott (1959), blue-green algae are more close to bacteria (Schizomycophyta), and he put both of them together under Prokaryonta and all the remaining algae under Eukaryonta (having typical nuclei). Christensen (1962) used the words 'Prokaryota' and 'Eukaryota' instead of Prokaryonta and Eukaryonta. According to Round (1973), the practice of placing blue-green algae with bacteria continued "for over a hundred years." Because of the biochemistry and cellular organization, blue-green algae are still considered bacteria by Stanier et al. (1971).

[1]Notable contributors on the Indian blue-green algae are Y. Bhardwaja, K. Biswas, J.C. Banerji, T.V. Desikachary, S.L. Ghose, E.A. Gonzalves, M.O.P. Iyengar, C.B. Rao, R.N Singh and G.S. Venkataraman (For their detailed Bibliography see *Cyanophyta* by T.V. Desikachary, pp. 653-660). Recently, Prasad and Mehrotra (1979) reported 39 blue-green algae, new to Uttar Pradesh.

But according to Pringsheim (1949), there exists very little relationship between bacteria and blue-green algae because bacteria move with the help of simplified flagella, whereas blue-green algae move by gliding movements. Round (1973) has treated Cyanophyta with algae but he reported:

It is perhaps best to think of both groups as primitive, being divergent in certain features (e.g. motility, fermentative activity) and convergent in others (e.g. nitrogen fixation, pigmentation), but having more mutual affinities than the other algal groups.

Most of the algologists (Fritsch, 1945; Desikachary, 1959; Prescott, 1969; Morris, 1973; Round, 1973) also believe that they belong to algae.

Blue-green algae have been proposed to be named "Cyanobacteria" (Lang, 1983, *Personal Communication*) by some bacteriologists under the rules of International Code of Nomenclature of Bacteria (1978). A critical analysis of this proposal has recently been made by Kondratena (1981). He has also discussed in detail the problem of the position of blue-green algae in the system of living organisms.

The author, however, feels that though there exists a close similarity between blue-green algae and bacteria because of the presence of prokaryotic nucleus, absence of plastids and some biochemical aspects, they are nearer to algae because of the presence of chlorophyll-a and liberation of free oxygen, similar of other algal groups. Because of the mixed nature of the members of this class of algae, however, the name "Myxophyceae" is more appropriate.

8.3 SIMILARITIES OF MYXOPHYCEAE AND BACTERIA

Myxophyceae resemble bacteria in the following points:

1. Absence of a definite and well-organized nucleus
2. Absence of well-organized plastids
3. Absence of sexual reproduction
4. Presence of diaminopimilic acid in the cell wall
5. Presence of sheath
6. Ability to fix atmospheric nitrogen by certain members of both the groups
7. Absence of flagellated phase in the life-cycle
8. Easy growth in sulphurated atmosphere
9. Occurrence of transformation and transduction phenomena (only in these groups)

8.4 DISTINGUISHING FEATURES

Morris (1973) has mentioned the following five main points of blue-green algae:

1. Procaryotic (lacking membrane bound genetic, photosynthetic and respiratory organelles) cellular structure
2. Complete absence of flagella
3. Movement of the plants by the characteristic gliding motion
4. Pigments include their characteristic bilo-proteins along with myxoxanthin and myxoxanthophyll
5. Cyanophycin, a proteinaceous[2] material, is included in the storage products.

[2] Biswas (1961) detected the following amino acids from *Nostoc muscorum*: aspartic acid, glutamic acid, cystine, serine, glycine, threonine, lysine, α-alanine, tyrosine, arginine, valine, methionine, leucine, phenylalanine and proline.

Some of the other characteristic points of this class are mentioned below:

6. Besides a blue pigment (*c*-phycocyanin[3]), a red pigment (*c*-phycoerythrin) is also present.
7. Besides cyanophycin, the main food storage compound is myxophycean starch.
8. The protoplast of the cell is divisible into a peripheral, pigmented region called chromoplasm and central colourless region called centroplasm (Fischer, 1897).
9. According to Schmid (1918), mitochondria are absent.
10. According to Desikachary (1959), the "products of photosynthesis are sugars and glycogen." These are present in chromoplasm region. Fats and metachromatin are also considered as reserve food material by some workers.
11. Many species of *Nostoc*, *Anabaena*, *Cylindrospermum*, *Anabaenopsis*, *Mastigocladus*, *Calothrix* and *Tolypothrix* are capable to fix the atmospheric nitrogen (Allen, 1952; Fogg and Wolfe, 1954; Desikachary, 1959).
12. Gupta (1953) has reported the presence of enzymes such as invertase, lipase, catalase, etc.
13. Gas vacuoles have been reported in many species of *Nostoc*, *Anabaena* (Plate 4G), *Phormidium*, *Calothrix*, *Glaeotrichia*, *Microcystis*, etc. They are mostly found in planktonic species. According to Geitler (1936) they are mostly located in the inner part of chromoplasm. According to Fischer (1905) the gas vacuoles are gas-filled cavities which serve the function of floatation. According to Pringsheim (1966) the pseudovacuoles in *Oscillatoria agardhii* were not simply gas bubbles "but cell organelles of definite shape. They were elongated and multiplied by fission."
14. According to Castle (1926) and Lund (1942, 1950) various types of movements are shown by both the types of members, i.e. trichomatous (*Oscillatoria* ,*Spirulina*, *Anabaena*, *Cylindrospermum*) as well as coccoid (*Synechococcus*, *Holopedia*, *Chroococcus*) forms. Various theories[4] have been put forward to explain the cause of the movements.
15. Mucilage is secreted by all members of blue-green algae (Plates 4G-H, and 5I). Some members of Chroococcales are surrounded by their individual mucilaginous sheath, whereas others are surrounded by a common mucilaginous envelope. A firm sheath is present in many filamentous members. According to Desikachary (1959) "the exact method of secretion of mucilage is not known." According to him, the mucilaginous envelope may be yellowish, brownish, reddish violet or bluish.
16. Heterocysts are the thick-walled cells (Plate 5 I) of unusual structure found in the members of Nostocaceae, Scytonemataceae, Stigonemataceae and Rivulariaceae (Lazaroff, 1973). Because of their homogeneous and pale-yellowish contents and owing to their thick walls,

[3] *c*-Phycocyanin stands for cyanochlorontan phycocyanin (*r* stands for rhodophycophytan).

[4] See Desikachary (1959) and Fogg et al. (1973) for detailed discussion of various theories of movements in Myxophyceae.

they can be easily distinguished from the rest of the cells of the filaments. The heterocysts have conspicuous pores on both the ends. They are either intercalary or terminal.

17. Branching is observed in many members of Myxophyceae (*Scytonema*, *Mastigocladus*, *Brachytrichia*, *Hapalosiphon*, etc.). According to Bornet and Flahault (1886) the branching is of two types: true branching and false branching.

True branching is again of three types, i.e. lateral branching (*Hapalosiphon*, Fig. 8.1 A-D), dichotomous branching (Fig. 8.1E-G, *Colteronema*) and reverse V-shaped (Fig 8.1H-K, *Mastigocladus*). False branching is shown (Fig. 8.1L-N) by the members of Scytonemataceae and Stigonemataceae (Fremy, 1930), and in some members of Stigonemataceae true branching is also present (Borzi, 1917 and Fremy, 1930).

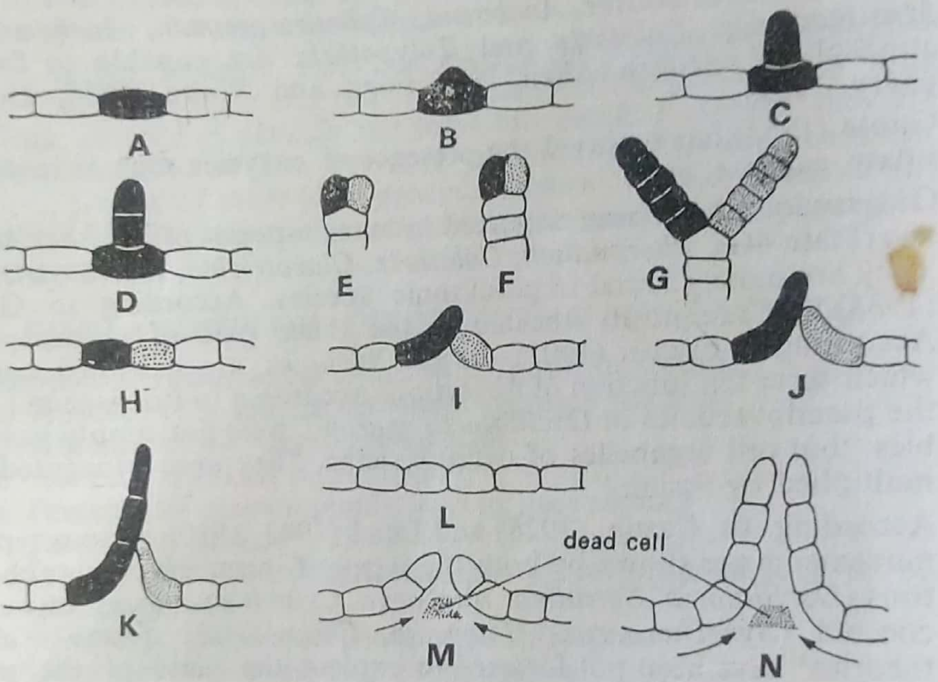

Fig. 8.1 **A-N. Branching in blue greens. A-D, True lateral branching; E-G, Dichotomous branching; H-K, Reverse V-shaped branching; L-N, False branching (after Fremy)**

18. According to Fritsch (1942), the plant body in Stigonemataceae and Pleurocapsaceae show heterotrichous habit, i.e. thallus is divisible into prostrate and erect portions.

19. Members of Myxophyceae reproduce only by vegetative means. Sexual reproduction is absent. Various means of vegetative reproduction are the formation of hormogones, pseudohormogonia, endospores, exospores, nannocytes, akinetes and planococci.

(a) Hormogones are the "small pieces of trichome with one to many uniform cells" (Desikachary, 1959). They remain surrounded with the help of a delicate mucilaginous sheath (Fig. 8.2A). According to Lazaroff (1973) the hormogones are capable of motility and hence called motile trichomes, e.g. *Calothrix*, *Oscillatoria*, *Cylindrospermum*, etc. The hormogones are the only means of propagation in Hormogoniales.

(b) Pseudohormogonia are the non-motile filaments, similar in structure to hormogonia. These are also called hormocysts or hormospores, and are commonly found in majority of Scytonemataceae and some Stigonemataceae (Fig. 8.2 B). Desikachary (1948) called them pseudohormogonia.

(c) Endospores are spherical, thin walled, small spores formed endogenously within a cell. They are formed by quick successive divisions, commonly in Dermocarpaceae (*Dermocarpa*, Fig 8.2C). According to Lazaroff (1973) such spores cannot survive in adverse conditions.

(d) Some spores, resembling endospores, have been described as Pseudohormocysts in *Westiellopsis* (Janet, 1941).

(e) Exospores are the spores which are abstricted serially from the open ends of sporangia (*Chamaesiphon*, Fig. 8.2D).

(f) Nannocytes are actually the naked protoplasts formed by repeated and successive divisions. No well-marked cell enlargement is noted in such cases. Because of their naked nature they are called nannocytes, e.g. *Gloeocapsa, Aphanothece* (Fig. 8.2 E), etc.

(g) Planococci are single-celled hormogones according to Desikachary (1959). A type of slow creeping movement is shown by planococci, e.g. *Desmosiphon*.

(h) Akinetes are enlarged and often elongated cells present in heterocystous species of Nostocaceae, Scytonemataceae, Stigonemataceae and Rivulariaceae (Lazaroff, 1973). These are also called 'resting spores', 'gonidia' or 'deverzellen' by different workers. They remain surrounded by a firm cell membrane and a thick sheath, and can survive in very adverse condition (Fig. 8.2F).

20. In Rivulariaceae (Borzi, 1882; Lazaroff; 1973) some colourless cells are found at the tips of the filaments. These are called hair-cells.

21. In Hormogoniales some concave cells or separation discs are present, which help in the release of hormogonia from the parent filament. Borzi (1878) and Brand (1903) have used the term necridia for such cells.

22. Sexual reproduction is completely absent in Myxophyceae. Borzi (1895) alone claimed the occurrence of sexual reproduction in Cyanophyta. But his results were not supported by any workers and were later on virtually disclaimed by himself (Borzi, 1914). Other reports (Kumar, 1962) also suggest some type of genetic recombination in two Myxophycean genera.

9

Chlorophyceae

(Green Algae)

9.1 NOMENCLATURE

Fritsch (1935) has adopted the name 'Chlorophyceae' (*chloros*, green; *phyceae*, algal organization) which literally means the 'green algae'. Smith (1955) and many other workers have raised it to the rank of a division with the name 'Chlorophyta', which literally means "green plants", whereas Prescott (1969) and Round (1973) have raised it to the rank of a phylum, Chlorophyta. The suggestion of Papenfuss (1946) to include the word 'phyco' in the algal divisions has given it the name 'Chlorophycophyta', which literally means "green algal plants." The same suggestion has been followed by Bold and Wynne (1978). The author is, however, of the opinion that the word 'Chlorophyceae', used by Fritsch (1935) for the 'green algae', is more appropriate because it provides a direct and clear idea of these plants as well as "it has the advantage of maintaining a uniform terminology for the classes of the algae", as described by Fritsch.

Genera and Species: Regarding the number of species, the Chlorophyceae is a very large group of green algal plants with no definite number, because regularly many new genera and species are added to the list in different parts of the world, and the old estimate thus becomes obsolete. However, Alexopoulos and Bold (1967) have mentioned that green algae include "approximately 425 genera and 6500 species." Prescott (1969) also reported that Chlorophyta "is composed of an unknown number of species, perhaps as many as 20 000, with more being discovered and named continually. There are, for example, 11 000 species of desmids alone (a group of Conjugales)."

9.2 DISTINGUISHING CHARACTERS

Though Chlorophyceae is a very large and diversified class, with its members differing greatly in their vegetative structure, distribution and methods of reproduction, the following characters may be treated as their main distinguishing features:

1. Members of Chlorophyceae enjoy a wide range of habitat. They occur in freshwater, brackish water, salty water and also in terrestrial habitat. Siphonales and Ulvales are almost completely marine whereas Oedogoniales and Conjugales are confined mainly to freshwater. Volvocales, Cladophorales and Chaetophorales occur in sea as well as freshwater.
2. Chief pigments are chlorophyll-a, chlorophyll-b, α and β-carotenes and xanthophylls like lutein and astaxanthin. Violaxanthin, neoxanthin

and zeaxanthin are present in a small quantity. In Siphonales, siphonein and siphonoxanthin are present.

3. According to Gibbs (1970) and Dodge (1973), the plastid organization is 2-5 thylakoids per stack.
4. Phycobilins are absent.
5. Starch (specially amylose and amylopectin) is the chief reserve food. However, in some members the oil is the main stored food.
6. The flagella are 1, 2-8 or many in number. They are of equal size and apically or sub-apically inserted.
7. The cell wall is made up of cellulose, which is β-1, 4 glucopyranoside. In some genera it is made up either of hydroxyproline glycosides or xylans and mannans. Cell wall is calcified in some, and made up of silica or proteins in others.
8. Pyrenoids are usually present in the chloroplasts.
9. The main sterol is sitosterol, although fucosterol, chondrillosterol and ergosterol are also present in small quantity.

Xanthophyceae[1–3]

(Yellow-green Algae)

10.1 PHYCOLOGICAL POSITION

The group "Xanthophyceae" has been the subject of repeated and continuous taxonomic rearrangements. It was distinguished as a 'class' by Luther (1899), and the same was also followed by workers such as Allorge (1930), Fritsch (1935) and others. Pascher (1931) preferred to call it as Class 'Heterokontae' of 'division' Chrysophyta, whereas Smith (1955) treated 'Xanthophyceae' as one of three classes of division Chrysophyta. Prescott (1969) treated Xanthophyceae as a 'sub-phylum' of phylum Chrysophyta, whereas Round (1973) raised it up to the rank of a 'phylum' under the name Xanthophyta (Heterokontae). Chapman and Chapman (1973) treated Xanthophyceae as one of the two classes of division Xanthophyta (the other class being Eustigmatophyceae), whereas Bold and Wynne (1978) treated Xanthophyceae as one of the six[4] classes of division Chrysophycophyta.

10.2 GENERAL CHARACTERS

1. Most of the Xanthophyceae are freshwater members found in free-floating conditions. Some are found attached on the walls or tree trunks and others are soil inhabitants. A few representatives (*Halosphaera*) are also marine. According to Chapman and Chapman (1973) Xanthophyceae are represented by about 450 species.

2. Plants show a definite range in their thallus structure, and thus exhibit a well-marked parallelism with Chlorophyceae. Like Chlorophyceae the Xanthophyceae also include motile, palmelloid, filamentous and even siphonous forms. However, highly elaborate pseudoparenchymatous and parenchymatous forms are not found in Xanthophyceae.

Some examples are mentioned below:

Unicellular motile forms: e.g. *Chloramoeba*, *Heterochloris*, *Phacomonas*, *Chloromeson*, etc.

Palmelloid forms: e.g *Chlorosaccus*, *Chlorogloea*, *Pelagocystis*, *Botryococcus*, etc.

Dendroid forms: e.g *Mischococcus*

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[1]Luther (1899) established and named it "Heterokontae".

[2]Allorge (1930) proposed the name "Xanthophyceae".

[3]Fritsch (1935) also adopted the name 'Xanthophyceae' proposed by Allorge because it "has the great advantage of affording a designation uniform with that of other classes of Algae."

[4]Other 5 classes of Chrysophycophyta are Chrysophyceae, Prymnesiophyceae, Eustigmatophyceae, Bacillariophyceae and Chloromonadophyceae.

Rhizopodial forms: e.g. *Stipitococcus*
Coccoid forms: e.g. *Chlorobotrys*
Epiphytic forms: e.g. *Ophiocytium, Characiopsis, Chlorothecium*, etc.
Filamentous forms: e.g. *Tribonema* and *Heterococcus*
Siphonous forms: e.g. *Botrydium* (Fig. 10.1B).

3. The cell wall in most of the non-flagellated forms is made up of two equal or unequal halves, which generally overlap each other. According to Fritsch (1935) the cell wall is generally "rich in pectic compounds", but Chapman and Chapman (1973) have mentioned that cell wall contains cellulose. Cellulosic cell wall has also been reported in *Tribonema* by Cleare and Percival (1973).

4. Flagella are present in motile forms. They are generally two in number and unequal in size. Both the flagella are anteriorly attached. One flagellum is pleuronematic (bearing hair-like appendages) and the other is acronematic (without appendages) type.[5] Because of the heterodynamic nature and unequal length of the flagella the class Xanthophyceae was originally named Heterokontae by Luther (1899).

5. Because of the presence of excess of yellow xanthophylls in the chromatophores, the Xanthophyceae are commonly called "yellow-green algae."

6. Chief pigments consist of chlorophyll-a, chlorophyll-e, β-carotene and xanthophylls. Guillard and Lorenzen (1972) also reported the presence of chlorophyll-c. Prescott (1969) has mentioned that α-carotene and ε-carotene have also been reported in some members of Xanthophyceae. According to Whittle and Casselton (1975) chief xanthophyll is diadinoxanthin. Some other xanthophylls reported by different workers are lutein, violaxanthin, neoxanthin, flavacin and flavoxanthin (Prescott, 1969). Chlorophyll-b is absent. Of all these pigments β-carotene is present in fairly high concentrations.

7. Chief food reserves of Xanthophyceae are oil, lipid and leucosin (=chrysolaminarin, Dodge, 1973). The principal sterol is the ergosterol.

8. Starch is absent, and the pyrenoids are either totally absent or rarely seen (Fritsch, 1935).

9. Chromatophores are discoid in shape.

10. Plants reproduce vegetatively or asexually. In a few genera sexual reproduction has also been reported.

11. Asexual reproduction is brought about by cell division, motile zoospores, non-motile aplanospores or akinetes (Chapman and Chapman, 1973).

12. Internal cysts or statospores are also produced in some genera of Xanthophyceae. Each statospore germinates into 2-4 amoeboid bodies or motile zoospores.

13. Sexual reproduction, though rare, is generally of isogamous type. It is commonly seen in siphonaceous genera. Some genera show anisogamy and even oogamy.

14. According to Fritsch (1935) all Xanthophyceae "are probably haploid."

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[5]Chapman and Chapman (1973) have used the terms "flimmergeisel" for pleuronematic and "peitschengeissel" for acronematic types.

9.33 ORDER 9. CHARALES[39-43]

9.33.1 Distinguishing Characters

1. The representatives of order Charales (Fritsch, 1935; Iyengar, 1951) are world-wide in their distribution. According to Pal et al. (1962) these are represented in the Indian region by 65 species belonging to 5 genera (*Chara*, *Nitella*, *Lychnothamnus*, *Nitellopsis* and *Tolypella*).
2. They are found in freshwater with sandy or muddy bottoms. Some species occur in brackish water, whereas many grow in waters running over limestone rocks. Many of the Charales become encrusted with calcium carbonate.
3. Plant body is well developed, macroscopic, erect, branched and reaches up to 30 cm or more in length.
4. Plant body is regularly differentiated into nodes and internodes. From the nodes develop many branches of limited growth arranged in the form of whorls.

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[39]The Charales, ranked for the first time as an order by Richard (1815) and followed by Fritsch (1935) and Iyengar (1951), is equivalent to the class Charophyceae (Smith, 1950) or phylum Charophyta (Round, 1973) or division Charophyta (Pal et al., 1962 and Bold and Wynne, 1978, etc.).

[40]Bold and Wynne (1978) have assigned the "divisional" rank to these members. But instead of using the word "Charophycophyta" they have named the division only 'Charophyta'. They have not included the root "*phyco*" in the division because of their "uncertainity that these plants, the stoneworts and brittleworts, are, in fact, algae". So they have shown a doubt about these plants of being even the 'algae'.

[41]According to Grambast (1974), Charophyta occupies an isolated position between green algae and Bryophytes.

[42]"In view of structural complexities and elaboration in the reproductive features", Pal et al. (1962), in a monograph on these members, favoured to place them in an independent division 'Charophyta'.

[43]For details also see Pal et al. (1962), and Wood and Imahori (1964).

5. Besides the branches of limited growth, some branches of unlimited growth also arise from the nodes of the main axis, and therefore the plants appear like that of small aquatic angiosperms.
6. The cells are very long, uninucleate and contain discoid chloroplasts. The size of the cells extends "sometime up to 25 cm" (Pal et al. 1962).
7. Long internodal cells, in most of the species, remain ensheathed with cortex consisting of vertically extending rows of cells. Therefore, the plants show cortication.
8. Sexual reproduction is highly advanced and of oogamous type.
9. Male and female reproductive bodies are well developed, can be seen with the help of the naked eye, and are called globule and nucule, respectively. Globules are globular or rounded structures having many antheridial filaments bearing antherozoids. The nucule is an elongated or conical female body which remains surrounded by many tube cells containing the apical coronary cells. Nucule encloses a single egg.
10. The oospore is a hard nut-like body of various colours (black, brown, yellow or red). It is spherical to narrowly ellipsoid.
11. Germination of oospore is indirect.
12. Formation of the asexual spores is absent.

9.33.2 Classification

Fritsch (1935) considered Charales as an order of class Chlorophyceae, and placed all of them under one family, i.e. Characeae having two sub-families: Nitelleae and Chareae.

Pal et al. (1962) placed them in a separate division Charophyta, divisible further as:

Division CHAROPHYTA
Order CHARALES
Family CHARACEAE
Sub-family NITELLEAE
Genera *Nitella* and *Tolypella*
Sub-family CHAREAE
Genera *Nitellopsis*, *Lychnothamnus*, *Lamprothamnium*, *Chara* and *Protochara*.

However, Bold and Wynne (1978) placed them under division Charophyta having a single class Charophyceae, single order Charales, and single family Characeae.

The life-history of *Chara* has been discussed as a representative form.

9.34 CHARA Linnaeus
(Stonewort)

9.34.1 Systematic Position

According to Fritsch (1935)

Class	—	Chlorophyceae
Order	—	Charales
Family	—	Characeae
Sub-family	—	Chareae
Genus	—	*Chara*

According to Bold and Wynne (1978)

Division	—	Charophyta
Class	—	Charophyceae
Order	—	Charales
Family	—	Characeae
Genus	—	*Chara*

11

Bacillariophyceae[1]

(Diatoms)

11.1 PHYCOLOGICAL POSITION

Pascher (1921) supported the relationship of Bacillariophyceae with Xanthophyceae and Chrysophyceae, and placed all these three classes in a single division Chrysophyta. But Fritsch (1935) did not believe in dividing the algae first into some divisions and then into classes. He treated all diatoms in an independent class Bacillariophyceae. Morris (1968) and Chapman and Chapman (1973) placed all diatoms under one single division Bacillariophyta having only one class Bacillariophyceae, whereas Prescott (1969) ranked Bacillariophyceae as a sub-phylum of phylum Chrysophyta. Round (1973A) upgraded diatoms in the form of a separate phylum Bacillariophyta having two classes Centrobacillariophyceae and Pennatibacillariophyceae, whereas Bold and Wynne (1978) treated Bacillariophyceae as one of the six classes of division Chrysophycophyta.

11.2 DISTINGUISHING CHARACTERS

1. Members of Bacillariophyceae, commonly called diatoms, are found commonly in all kinds of freshwaters, sea waters as well as in air or on the soil and other terrestrial conditions.

   Diatoms are represented by approximately 200 genera (Bold and Wynne, 1978) and 6000 species (Chapman and Chapman, 1973).
2. Plant body is mostly unicellular but some genera occur in colonies.
3. Cells generally possess many discoid or two plate like chromatophores. Some possess stellate chromatophores.
4. Vegetative cells are diploid.
5. Reserve food material is in the form of oil, volutin and chrysolaminarin or chrysose.
6. Photosynthetic pigments are chlorophyll-a, chlorophyll-c, together with xanthophylls such as fucoxanthin, diatoxanthin and diadinoxanthin.
7. The cell wall is silicified and composed of two distinct halves called valves. Two halves are joined by hoop-like structures. They are generally arranged in the manner of a box and lid. The outer half is generally called epitheca and the inner half hypotheca.
8. A single pantonematic flagellum is generally found on the motile stages.
9. Silicified cell wall may contain many spines, bristles or other characteristic secondary structures.

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[1]Instead of describing the details of a few diatoms, a general account of the Bacillariophyceae is given in the present chapter.

For details see Fritsch (1935) and Lewin and Guillard (1963).

10. Motile members show gliding movement.
11. Diatoms produce characteristic spores called auxospores.
12. Vegetative multiplication generally takes place by cell division.
13. Sexual reproduction takes place by fusion, gametes or auxospores.
14. Members are either radially symmetrical or bilaterally symmetrical.

11.3 CLASSIFICATION

Hustedt (1930) divided the diatoms into two orders, i.e. Centrales and Pennales. The same classification has been followed by Fritsch (1935) and most of the other recent workers. A synopsis is mentioned below:

Examples of
CENTRALES —

1. Discoideae, e.g. *Cyclotella* and *Melosira*
2. Solenoideae, e.g. *Corethron*
3. Biddulphioideae, e.g. *Biddulphia* sp.
4. Rutilarioideae, e.g. *Rutilaria*

Examples of
PENNALES — Pinnularia sp., Cymbella sp.

Phaeophyceae
(Brown Algae)

12.1 DISTINGUISHING CHARACTERS

1. Brown algae are represented by about 240 genera (Prescott, 1969) and over 1500 species, of which about 99.7% are marine (Chapman and Chapman, 1973). Only freshwater genera are *Lithoderma*, *Heribaudiella*, *Sphacelaria* and *Pseudobodanella* (Bold and Wynne, 1978).

   Pleurocladia lacustris occurs in both freshwater and marine habitats (Wilce, 1966). A total of 32 genera and 93 species have been reported from India (Misra, 1966).
2. Plant body is highly differentiated and complicated in both external and internal construction. Unicellular, colonial and unbranched filamentous forms are completely absent.
3. Size of the brown algae ranges from simple microscopic epiphytes to very huge members reaching even up to 60 m or more (*Macrocystis*) in length. About *Macrocystis pyrifera*, Prescott (1969) has mentioned that "one unsubstantiated record claims a specimen to have been 212.8 m—the longest plant in the world."
4. Photosynthetic pigments include chlorophyll-a, chlorophyll-c, β-carotene, violaxanthin and fucoxanthin. Occasionally diatoxanthin and diadinoxanthin are also present. Because of fucoxanthin members appear brown in colour.
5. Photosynthetic reserve foods are laminarin and mannitol. Though in some genera sucrose and glycerol are also present.
6. The cell wall is made up of cellulose, fucinic acid and alginic acid.
7. Cells usually contain some whitish granules called fucosan vesicles.
8. Pyrenoids, if present, are of single stalked type.
9. Motile reproductive bodies (zoospores and gametes) have two unequal flagella attached laterally.
10. Motile reproductive bodies are developed either in unilocular or many-chambered plurilocular sporangia.
11. Sexual reproduction ranges from simple isogamy to oogamy through anisogamy.
12. Plants show various types of alternation of generations (Fritsch, 1945; Drew, 1956).

Rhodophyceae

(Red Algae)

13.1 GENERAL CHARACTERS

1. Members of Rhodophyceae, commonly called *red algae*, are represented by approximately 4000 species, about 98% of which are marine (Chapman and Chapman, 1973).
2. Except a few unicellular forms (*Porphyridium*), the great majority of red algae are filamentous (*Goniotrichium*), pseudoparenchymatous (*Dumontia* and *Helminthocladia*) or parenchymatous (*Porphyra*) forms.
3. Though some genera such as *Gigartina* and *Schizymenia* may reach up to 1 m (Smith, 1944) and 2 m (Abbott, 1967), respectively, the red algae do not attain the size as large as brown algae.
4. Red algae are characterised by total absence of flagellated motile stages.
5. The name 'red algae' is given to these plants because of the excess and dominance of red pigments *r*-phycoerythrin and *r*-phycocyanin. Chlorophyll-a is present but chlorophyll-b is absent. The latter is replaced by chlorophyll-d. The chief xanthophyll is taraxanthin.
6. Chief food storage products are in the form of floridean starch, floridoside and mannoglycerate.
7. In addition to the cellulose and pectin, chief characteristic components of the cell walls are polysulphate esters.
8. In most of multicellular genera the vegetative cells are interconnected by cytoplasmic connections or pit connections. These are also called plasmodesmata. The pit connections serve as the passages through which the cytoplasmic materials flow between the adjacent cells. But recent electron microscopic studies have not confirmed it.
9. Sexual reproduction is highly specialized and characteristic. It is of advanced oogamous type.
10. Male sex organs are known as spermatangia. In each spermatangium develops a single, non-flagellated, motionless male gamete, called spermatium.
11. Female sex organs are called carpogonia. Each carpogonium is generally a flask-shaped body, having a long neck-like trichogyne.
12. At the time of fertilization the non-motile male gametes are taken up to the trichogyne with the help of water.
13. Post-fertilization stages are also highly elaborate and characteristic of the red algae. Though there exist many variations, many gonimoblast filaments develop from the fertilized carpogonium in many cases. Tip

cells of these filaments start to function as carposporangia. In each carposporangium develops a carpospore. This entire structure represents the carposporophyte.

14. Higher forms (*Polysiphonia*) also produce tetraspores and tetrasporophyte.
15. Most of the members show biphasic or triphasic life-cycles[1].