Algae in diversified habitat

To say that the algae are of universal occurrence will not be an exaggerated statement because of their presence in nearly all types of habitats. They are found in fresh as well as sea water, on soil, on and within other plants and even animals, on rocks, stones and in desert as well as on permanent snowfields, etc. They are distributed or taken away from their place of occurrence to other parts through some vectors, such as tides, water currents, wind movements, animal movements, ships or aquatic birds, etc. (Atkinson, 1972; Schlichting, 1974). Beetle, an insect with hard shiny wing covers, is actively linked with algal distribution. On 23 species of beetles, 101 different algal genera have been reported by Milliger et al. (1971).

On the basis of their habitat, algae can be categorized as follows:

4.1 AQUATIC ALGAE

The aquatic environment comprises about 70 per cent of the surface of the earth, and here the algae are of great importance as primary producers of elaborated organic materials. In this way, algae play a critical role in the economy of both freshwaters and seas and oceans.

4.1.1 Freshwater Forms

Enormous number of algae occur in waters of low salinity, called *freshwater*. They grow even in as low a salinity as 10 ppm in water surroundings like ponds, tanks, ditches, lakes, puddles, etc. Common freshwater algae are *Zygnema, Spirogyra, Oedogonium, Cladophora, Chara, Nostoc, Oscillatoria, Rivularia,* etc. Many algae grow in brackish water (*Oscillatoria, Anabaena,* etc.). Such waters are unpalatable for drinking, and contain less salt than sea water but more than freshwater.

Most common macroscopic alga reported from freshwater springs is *Batrachospermum* and several diatoms, e.g. *Achnanthes lanceolatus, Denticula tenuis, Fragilaria pinnata* and *Meridion circulare.* Common planktons reported from streams of colder regions include *Pediastrum boryanum, Melosira varians, Synedra ulina, Nitzschia sigmoidea* and *Fragilaria virescens.* Algae found commonly in the flowing waters of the rivers of colder regions include *Bacillaria paradoxa, Cyclotella atomus, C. striata, Nitzschia acicularis* and *Stephanodiscus astreae.* Small ponds or puddles of colder regions contain desmids (e.g. *Cosmarium, Euastrum),* diatoms (e.g. *Pinnularia, Frustulia, Eunotia*) along with species of Volvocales, Chlorococcales, flagellates and blue-green algae (e.g. *Synura, Uroglena, Peridinium, Chroococcus*).

4.1.2 Marine Algae

Algae of the sea water are called *marine algae*. They grow generally in waters where the solutes are usually 30–44 parts per thousand (%0). Marine vegetation occupies only about 2% of the general surface (shorelines and zone of relatively shallow water) of the sea, of which a large part is occupied by the phytoplankton, mainly of the diatoms and dinoflagellates. Some of the common marine algae are *Sargassum, Laminaria, Bangia, Rhodymenia, Padina, Caulerpa, Polysiphonia,* etc.

Phytoplankton of open sea water include species of Desmophyceae (e.g. *Prorocentrum, Phalacroma, Dinophysis*), Dinophyceae (e.g. *Gymnodinium, Peridinium, Ceratium, Gonyaulax*), Bacillariophyceae (e.g. *Thalassiosira, Stephanopyxis, Planktoniella, Chaetoceros, Biddulphia, Fragilaria, Asterionella, Nitzschia*), and rarely Cyanophyceae (e.g. *Trichodesmium*) and Prasinophyceae (e.g. *Halsphaera*).

The *littoral region* is the junction between land and sea, where several large algal groups are confined. The term "littoral" refers to the boundary between land and sea. In this region, the algae are attached to or move over the coastal deposits. Common algae of the "*subtidal zone*" of the littoral region of sea include *Chondrus crispus, Gigartina stellata, Corallina, Laminaria, Rhodymenia palmata, Cutleria multifida, Dictyota dichotoma, Callophyllis lacinata,* etc. Common algae of the sandy beaches of the "*intertidal zone*" of the littoral region include species of *Amphidinium, Gymnodinium, Prorocentrum, Euglena, Navicula, Pleurosigma* and very rarely *Oscillatoria.* On

the fine silty muds of the intertidal zone, the dominant genera belong to several species of *Biddulphia, Navicula Nitzschia* and *Pleurosigma*. In the more silted intertidal zone, several species of *Gyrosigma, Diploneis, Navicula* and *Nitzschia* occur commonly. Sandy shores of the intertidal zone also contain species of *Ulothrix, Rivularia, Lynghya* and *Vaucheria*. Rocky intertidal shores contain rich growth of several species of *Pelvetia, Fucus, Porphyra, Bangia, Ascophyllum, Laminaria* and *Gigartina*. In the *supratidal zone* (high tidal zone) of the littoral region, the sandy beaches are usually highly desiccated and the algal species are rare. Rock substrata found in the supratidal zone have a flora composed of some species of *Prasiola, Hildenbrandia, Porphyra, Blidingia* and gelatinous pustules of some blue-green algae such as *Calothrix scopulorum* and species of *Plectonema, Rivularia, Phormidium* and *Lyngbya*. Rocky pools in the supratidal region tend to be populated by mats of diatoms and Cyanophyceae.

4.2 TERRESTRIAL ALGAE

Algae, found on the soil in the form of a green scum, are called *terrestrial algae*. The soil flora is collectively known as *edaphophytes* (Prescott, 1969). It is further divisible into surface soil flora known as *sapophytes* or *epiterranean*, and under-soil flora called *cryptophytes* or *subterranean*. Some of the algae in the soil even occur up to the depth of 1 m or even more. For such algal members proper moisture, illumination (Starr, 1973) and nutritional requirements are necessary. Shtina (1974) has reported 1410 algal species and forms in the Russian soils. According to Parker (1961, 1971) some of the subterranean algae become partially heterotrophic in darkness.

Some of the common terrestrial algae are *Fritschiella, Chlorella, Vaucheria, Euglena, Chlamydomonas, Lyngbya, Navicula, Caloneis, Pinnularia, Hormidium, Anabaena, Chroococcus, Oscillatoria* and *Phormidium*.

Friedmann *et al.* (1967) and Friedmann and Ocampo (1976) observed many small-sized algae from desert soils. Their water supply is maintained mainly from dew. The desert soil algae have been classified into the following 5 categories by Friedmann and his co-workers:

1. *Endedaphic* : Algae living in the desert soil
2. *Epidaphic* : Algae living on the desert soil surface
3. *Hypolithic* : Algae living on the lower surface of stones on desert soil
4. *Chasmolithic* : Algae living in the rock fissures in desert soil
5. *Endolithic* : Rock penetrating desert algae

6.1 THE RANGE OF MORPHOLOGY

There exists a wide variety of thalli in algae, particularly in vegetative plant body. The different forms show a definite range. On one hand, there are simple plants where the thallus body is microscopic and consists of only one single cell (*Chlamydomonas*, Fig. 6.1A; *Phacus*, *Phacotus*, etc.). All the morphological structures, and cytological, physiological, genetical and other vital and necessary activities, go on regularly in that single cell only. On the other, there are very large (sometimes 60 m or more) and very complex types of plant body in some Chlorophyceae and many Phaeophyceae and Rhodophyceae that it becomes completely a parenchymatous organization (*Ulva*, Fig. 6.1L; *Porphyra, Laminaria, Macrocystis, Nereocystis*, etc.), resembling superficially with that of an angiospermic plant. There are, however, intermediate stages also like colonial (*Volvox, Pandorina,* Fig. 6.1B), palmelloid (*Tetraspora, Palmella,* Fig. 6.1C), dendroid (*Prasinocladus,* Fig. 6.1D), coccoid (*Chlorella*), filamentous (*Spirogyra, Ulothrix, Oedogonium, Cladophora* and *Pithophora*; Fig. 6.1F, G), heterotrichous (*Draparnaldiopsis* and *Fritschiella*), siphoneous (*Vaucheria* and *Botrydium*; Fig. 6.1I), uniaxial (*Batrachospermum,* Fig. 6.1J), multiaxial (*Nemalion, Polysiphonia*, Fig. 6.1K) and a few others. These stages show a definite interrelationship and range, whose comprehensive account is given below.

6.2 UNICELLULAR MOTILE FORMS

Unicellular motile forms are found in all major groups except Phaeophyceae, Rhodophyceae, Bacillariophyceae and Myxophyceae. The distinguishing features are the presence of a unicellular plant body bearing means of motility, i.e. flagella. The most common example is *Chlamydomonas*, in which the biflagellated plant body is surrounded with a definite cell wall, enclosing a cup-shaped chloroplast, one or more pyrenoids, two contractile vacuoles, an eyespot besides other cell organelles and a nucleus (Fig. 6.2).

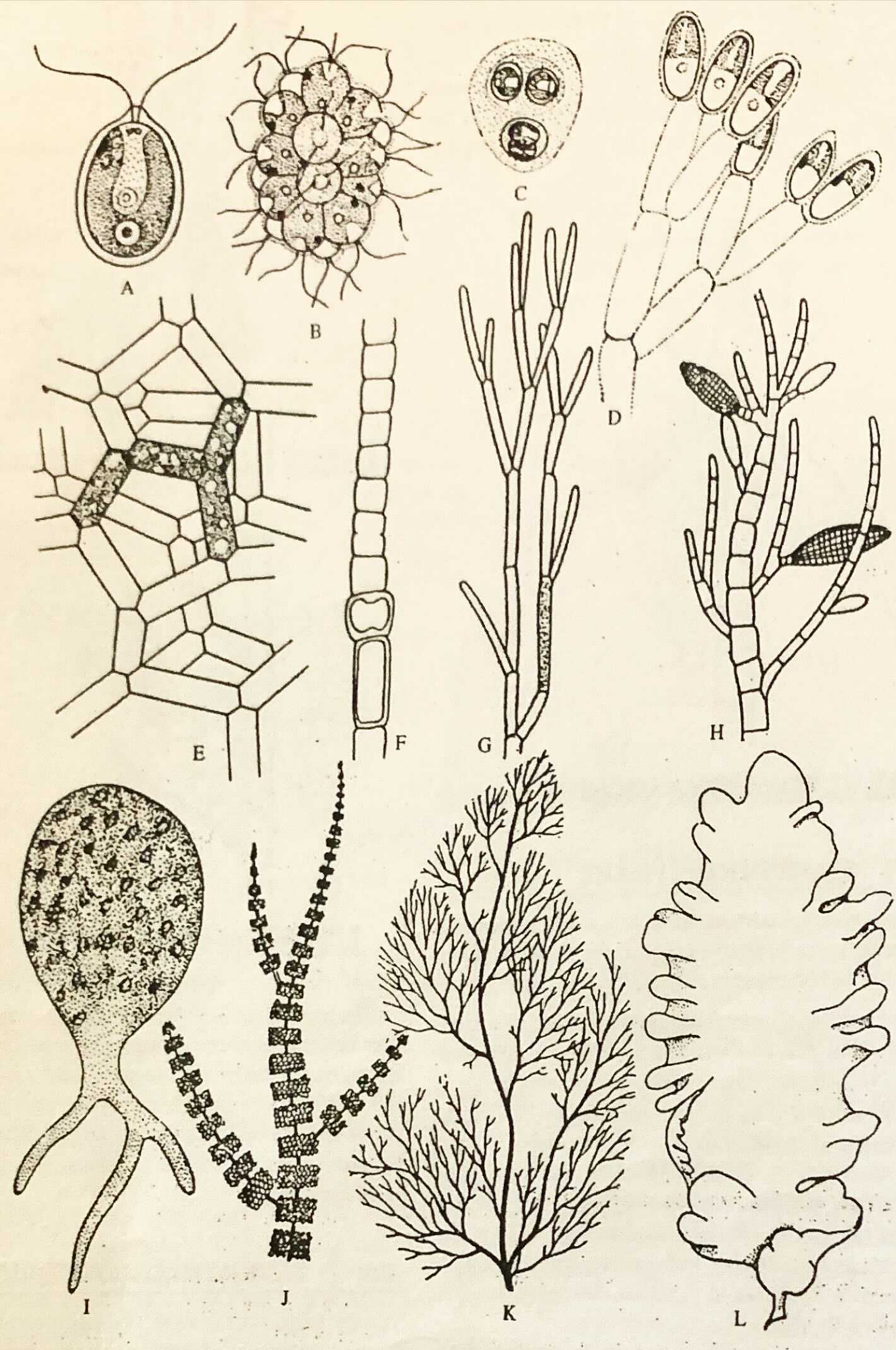
Both the flagella may be equal as in Chlorophyceae or unequal as in Xanthophyceae or Dinophyceae. The number of flagella may be one as in some Chrysophyceae, to four as in some Chlorophyceae.

Unicellular motile algae of Euglenineae are exemplified by *Euglena* (Plate 3E) and *Phacus*; of Cryptophyceae by *Cryptomonas* and *Chroomonas*; of Dinophyceae by *Peridinium* and *Gymnodinium*; of Xanthophyceae by *Heterochloris*; of Chrysophyceae by *Chromulina* and *Chrysococcus*; and of Chlorophyceae by *Chlamydomonas*, *Dunaliella*, *Chlorogonium*, etc.

In *Paraphysomonas vestita* (Chrysophyceae), the monad is a biflagellate cell (Plate 3F), having two heterodynamic flagella. One flagellum bears many hair-like mastigonemes and is called *pleuronematic flagellum*. The other flagellum lacks mastigonemes or any other appendage and is called *acronematic flagellum*. Heterodynamic flagella are those which have independent pattern of beat.

6.3 UNICELLULAR[1] NON-MOTILE FORMS

Unicellular non-motile thalli are found in many algal groups including Chlorophyceae, Chrysophyceae, Cyanophyceae, Xanthophyceae, Bacillariophyceae and Rhodophyceae. They possess unicellular plant body with no flagella. The most common example of this type is *Chlorella*, which possesses microscopic spherical cells, each with a nucleus and cup-shaped chloroplast (Fig. 6.3). 'Fritsch (1935) discussed the unicellular non-motile forms under a separate heading "The *Coccoid Habit*," whereas Round (1973) has discussed such forms under the category "*protococcoidal type*" of unicellular organization.



Different types of algal thalli. A, *Chlamydomonas reinhardtii*; B, *Pandorina morum*; C, *Palmella mucosa*; D, *Prasinocladus lubricus*; E, *Hydrodictyon reticulatum*; F, *Anabaena sp.* G, *Cladophora glomerata*; H, *Ectocarpus*; I, *Botrydium granulatum*; J, *Batrachospermum*; K, *Polysiphonia*; L, *Ulva latissima*. (all based on Firitsch)

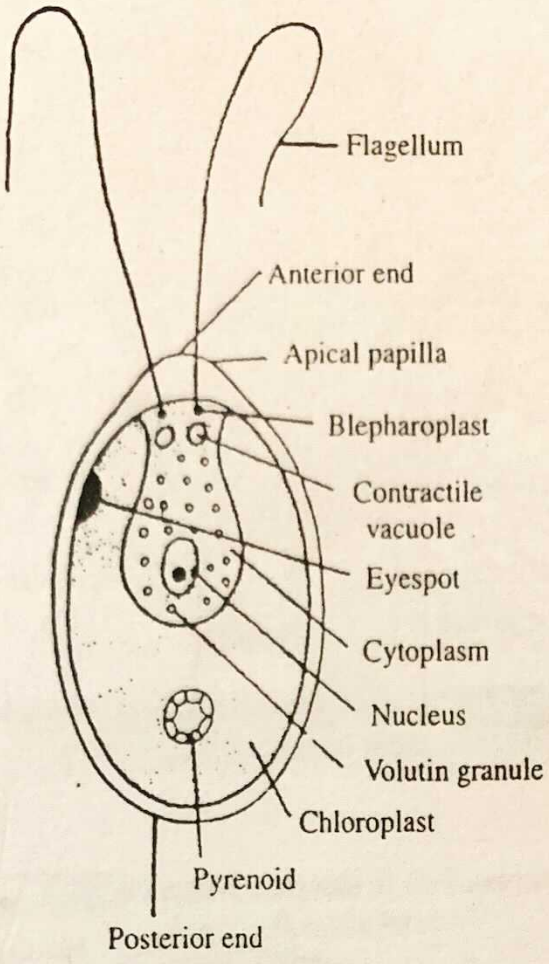


Fig. 6.2 A vegetative cell of *Chlamydomonas*.

forms of this type can better be placed under unicellular non-motile forms to avoid confusion. Pascher (1917) and Fritsch (1935) opined that it is probably legitimate to conclude that all rhizopodial types are the derivatives of flagellate forms.

Some examples of unicellular non-motile forms are *Synechococcus* of Myxophyceae; *Chlorococcum* and *Chlorella* (Fig. 6.3) of Chlorophyceae; *Chrysosphaera* of Chrysophyceae; *Cystodinium* of Dinophyceae; *Porphyridium* of Rhodophyceae; and *Characiopsis* of

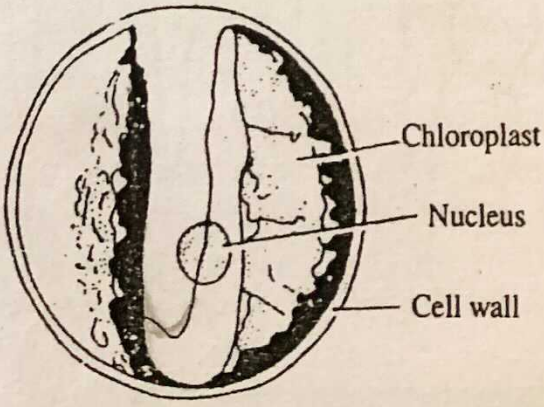


Fig. 6.3 A cell of *Chlorella*.

Xanthophyceae. Round (1973) mentioned some desmids such as *Cosmarium*, *Closterium* and *Micrasterias* (Fig. 5.3A) under protococcoidal forms.

Unicellular non-motile habit must have been developed from unicellular motile forms by withdrawing their flagella.

6.4 MULTICELLULAR FLAGELLATED FORMS OR "COLONIAL FORMS"

These are colonial members of algae whose cells bear the means of motility, i.e. flagella. Innumerable number of cells are present in the colony. A colony with definite number of cells and having a constant shape and size is called *coenobium*. Multicellular motile forms are found in many genera of Chlorophyceae, Chrysophyceae and Dinophyceae. The most common example of such forms is *Volvox* (Fig. 6.4) in which a definite number of cells (500–50,000) are interconnected with each other with the help of protoplasmic connections. The coenobium is hollow and spherical, and contains a single layer of cells arranged on the periphery. All cells are chlamydomonad in structure.

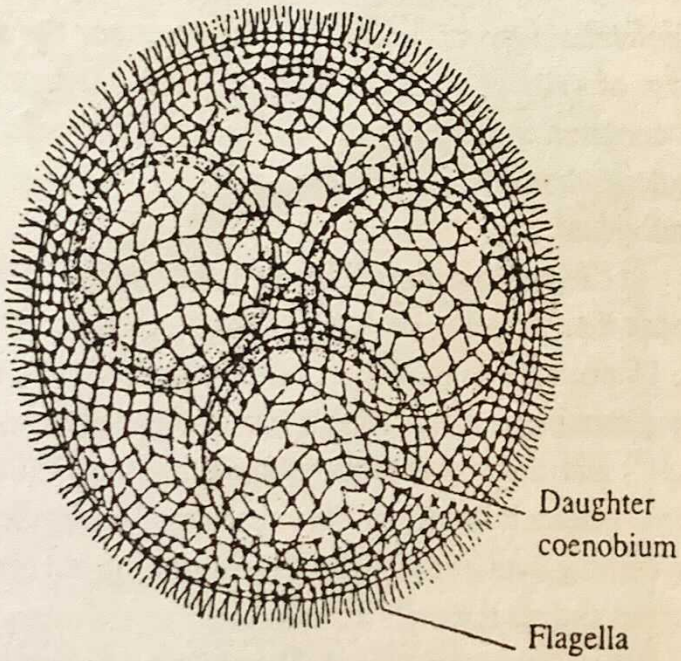


Fig. 6.4 A coenobium of *Volvox aureus*.

Some other examples of "multicellular flagellated" or "colonial forms" are *Ceratium* and *Gonyaulax* of Dinophyceae; *Synura* and *Chlorodesmus* of Chrysophyceae; and *Eudorina*, *Pandorina* (Fig. 6.1 B) and *Gonium* of Chlorophyceae.

The colonial habit must have been developed by the aggregation of many motile unicells.

6.5 MULTICELLULAR NON-FLAGELLATED FORMS OR NON-FLAGELLATED COLONIES

Generally, in this habit the algae bear a definite number of cells and thus represent a coenobium. The cells are non-motile and do not have flagella or any other means of motility. The best-known example of non-flagellated multicellular forms is *Hydrodictyon* (Fig. 6.1 E) in which the cells of the net remain connected in the form of groups of 5 or 6, forming pentagonal or hexagonal structures. This habit is seen mainly in Chlorophyceae, e.g., *Pediastrum* (Fig. 6.5), *Scenedesmus*, *Coelastrum*, etc.

Non-flagellated colonial habit must have been developed by the aggregation of unicellular non-motile cells.

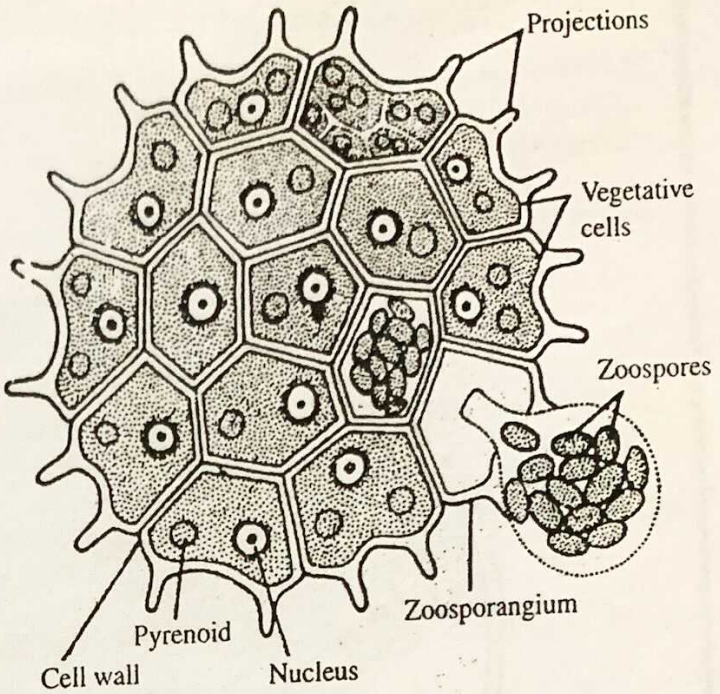


Fig. 6.5 Non-flagellated colony of *Pediastrum*. (after Fritsch)

6.6 PALMELLOID FORMS[3]

These are the colonial members of algae in which "non-motile cells remain embedded in an amorphous gelatinous" or mucilaginous matrix (Bold and Wynne, 1978). In '*palmelloid-forms*' neither the number nor the shape and size of cells is constant. The cells are aggregated within a common mucilaginous envelope. All the cells are quite independent of one another and fulfil all functions of an individual.

In *Chlamydomonas* (Fig. 6.6) and *Chromulina* the cells loose their flagella, undergo successive divisions and form 8, 16 or more cells, which simultaneously get surrounded by a mucilage. They appear like the genus *Palmella* (Fig. 6.1C) and thus represents palmelloid-stage. Therefore, in these genera it is a temporary feature of life-cycle, because on coming over of favourable conditions mucilage gets dissolved and all the cells are set free.

But in *Tetraspora* (Fig. 6.7) and *Palmodictyon* of Chlorophyceae, *Gleochloris* and *Chlorosaccus* of Xanthophyceae, *Phaeocystis* of Chrysophyceae and *Microcystis* of Cyanophyceae, the palmelloid habit is a permanent feature. The mucilage in palmelloid-forms is secreted either by the protoplasts of the cells or it develops by the gelatinization of their membranes.

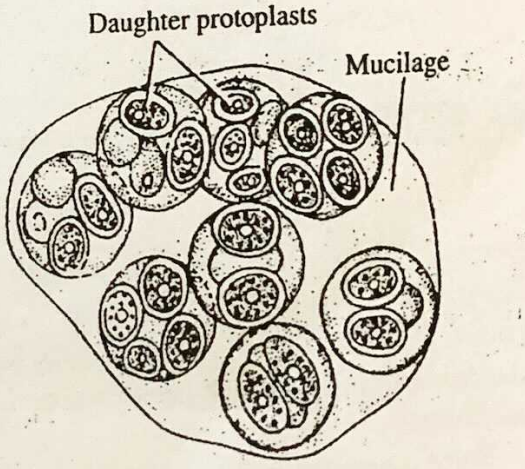


Fig. 6.6 Palmella stage of *Chlamydomonas*.

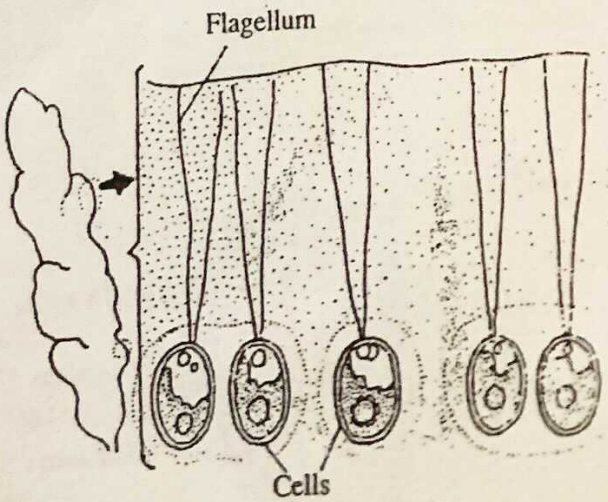


Fig. 6.7 Palmelloid habit of *Tetraspora*. (after Fritsch)

...der the "*tetrasporal*

6.7 DENDROID FORMS

Dendroid actually means tree-like. In *Prasinocladus* (Figs. 6.1D, 6.8), *Ecballocystis*, *Ecballocystopsis*, etc. the plant body appears like a microscopic tree. The mucilage in such cases is restricted only locally, generally at the base of the cells. Therefore, it shows a type of polarity regarding the presence of mucilage.

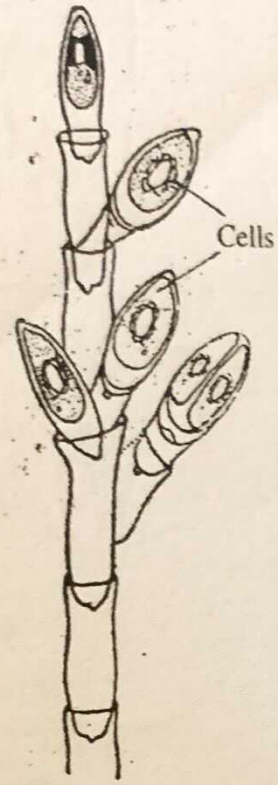


Fig. 6.8 Dendroid habit of *Prasinocladus*. (after Fritsch)

6.8 FILAMENTOUS FORMS

Many cells arranged one upon the other in a definite sequence, or uniseriate row, constitute a *filament*. The filaments may be unbranched and branched in different algal members.

1. *Unbranched filaments* are found in algae like *Spirogyra* (Fig. 6.9, 24.83A), *Zygnema* (Fig. 24.88), *Mougeotia, Ulothrix* (Fig. 24.47), *Oedogonium* (Fig. 24.75 A,B), *Nostoc* (Fig. 23.16), *Oscillatoria* (Fig. 23.11), *Lyngbya* (Fig. 24.75C), *Phormidium* (Fig. 23.20D), *Anabaena* (Fig. 23.20F), *Spirulina* and many other members of Chlorophyceae, Myxophyceae, Xanthophyceae, etc. In *Ulothrix*, *Oedogonium*, etc. the filaments remain attached to the substratum with a basal specialized cell, but in *Zygnema*, *Spirogyra*, etc. they are free-floating.
2. *Branched filaments* are found in *Cladophora* (Figs. 24.61B, 6.1G), *Pithophora*, *Bulbochaete* (Fig. 6.10), *Phaeothamnion* (Chrysophyceae), *Callithamnion* (Rhodophyceae), etc.

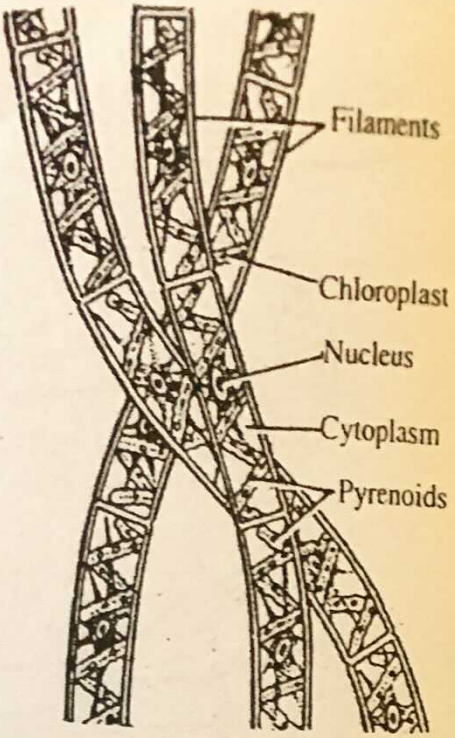


Fig. 6.9 Three unbranched filaments of *Spirogyra*.

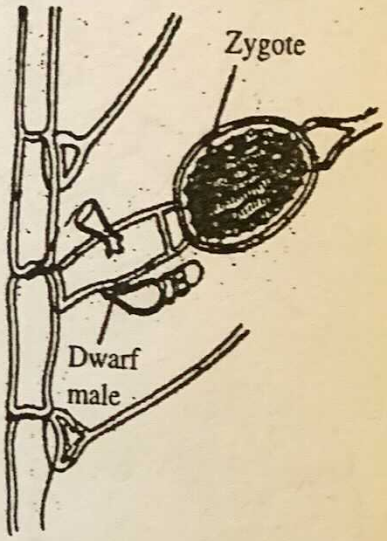


Fig. 6.10 Branched filament of *Bulbochaete*.

The filamentous habit has originated from motile unicellular habit, because every time a motile swarmer comes to rest on some substratum, it secretes a cell wall and divides and redivides to form a *filament*. At the time of the formation of branched filaments, lateral outgrowths develop from numerous cells. These lateral outgrowths undergo transverse septation.

6.9 HETEROTRICHOUS FORMS

'*Hetero*' means different and "*trichous*' denotes trichome or filament. In some algae the plant body is very much evolved and consists of more than one type of filaments, and thus represents the *heterotrichous habit*. It is one of the characteristic feature of order Chaetophorales of Chlorophyceae,

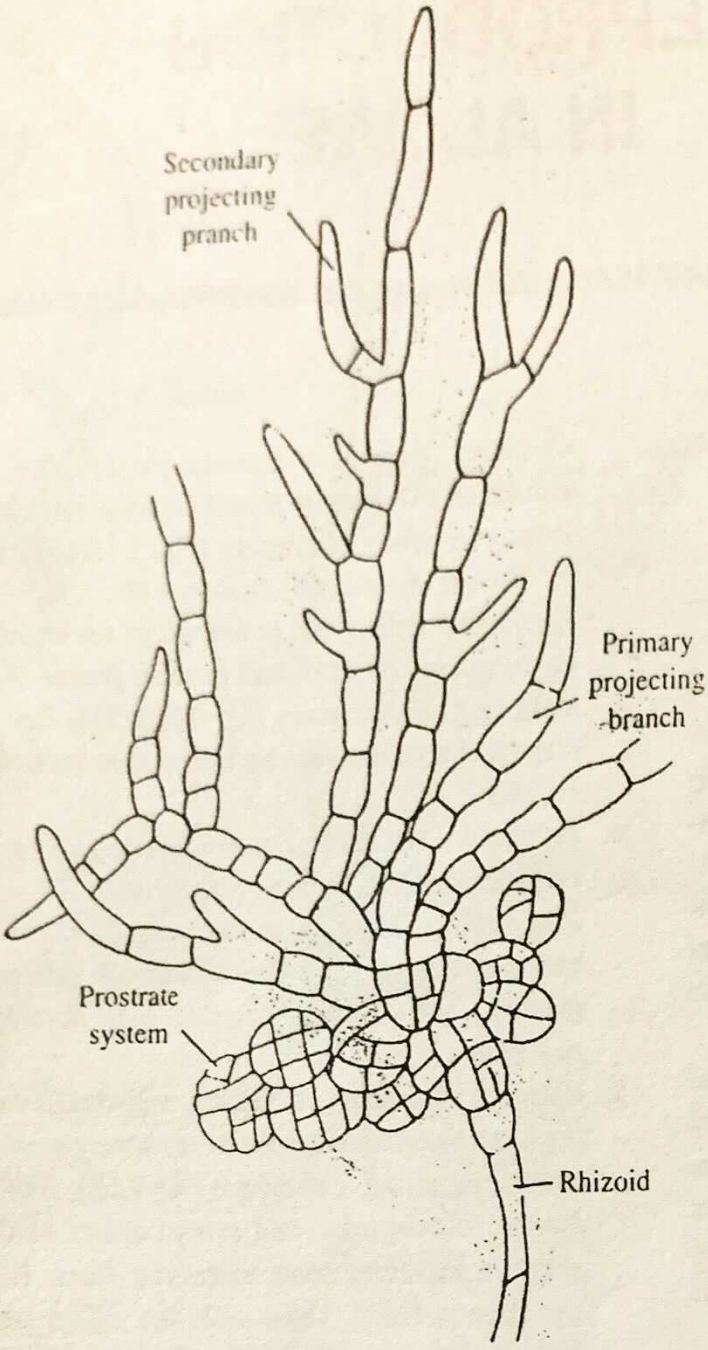


Fig. 6.11 *Fritschiella tuberosa* showing heterotrichous habit.

and some common examples are *Draparnaldia*, *Stigeoclonium*, *Draparnaldiopsis* and *Fritschiella* (Fig. 6.11). It is also found in some Phaeophyceae (*Ectocarpus*, Fig. 6.1H; *Tilopteris*), Rhodophyceae (*Erythrotrichia*), Myxophyceae (Chaemosiphonales) and Dinophyceae (*Dinoclonium*).

Usually, the plant body consists of a prostrate system from which develops an erect system of filaments (also called primary projecting system), which may also divide into many branches representing secondary projecting system and tertiary projecting system.

The heterotrichous habit must have been evolved from the filamentous habit by the specialization of the filaments.

6.10 SIPHONOUS[4] FORMS

In *siphonous forms*, the plant body enlarges considerably without the formation of any septa. Because of the presence of many nuclei, such an organization of plant body is called a coenocyte. A large central siphon-like vacuole is present in the thallus, and thus the name 'siphonous' is given. Such algal thalli are found only in some Chlorophyceae and Xanthophyceae. The best-known example is *Vaucheria* (Fig. 6.12), in which a coenocytic plant body encloses a siphon-like vacuole.

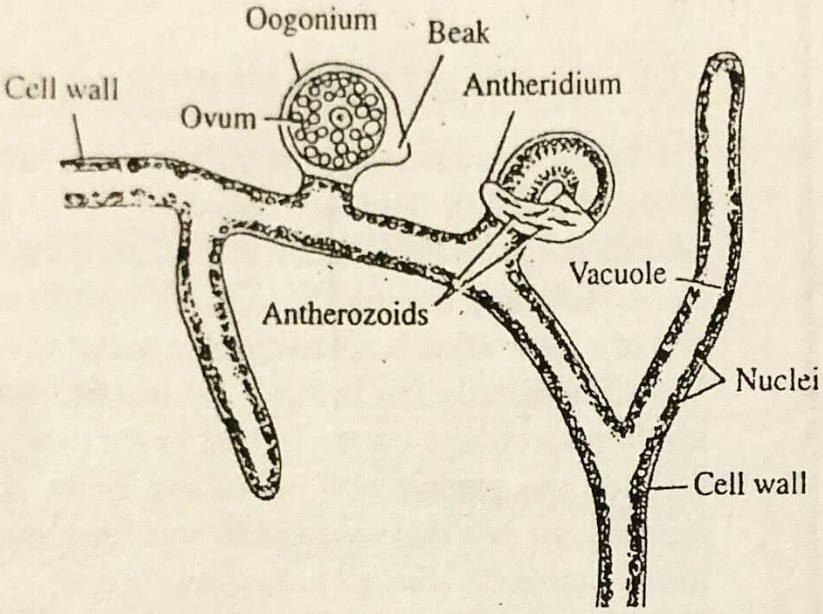


Fig. 6.12 *Vaucheria* showing siphonous habit.

Some other siphonous genera are *Botrydium* (Fig. 6.11), *Valonia*, *Codium*, *Bryopsis*, *Dasycladus*, etc. According to Fritsch (1935), the siphonous forms are "multicellular plants lacking the usual septation".

6.11 UNIAXIAL FORMS

'*Uni*' means one; '*axial*' pertains to axis. In some Rhodophyceae, the plant body is made up of such pseudo-parenchymatous thalli in which there is present one main axis and all others are side branches as in *Batrachospermum* (Figs. 6.1J, 6.13) and *Dumontia*. According to Fritsch (1935), there is present a "close juxtaposition of the branch systems of a single main axial thread" which form the thallus.

Uniaxial form of thalli must have been originated from the filamentous habit during the course of evolution.

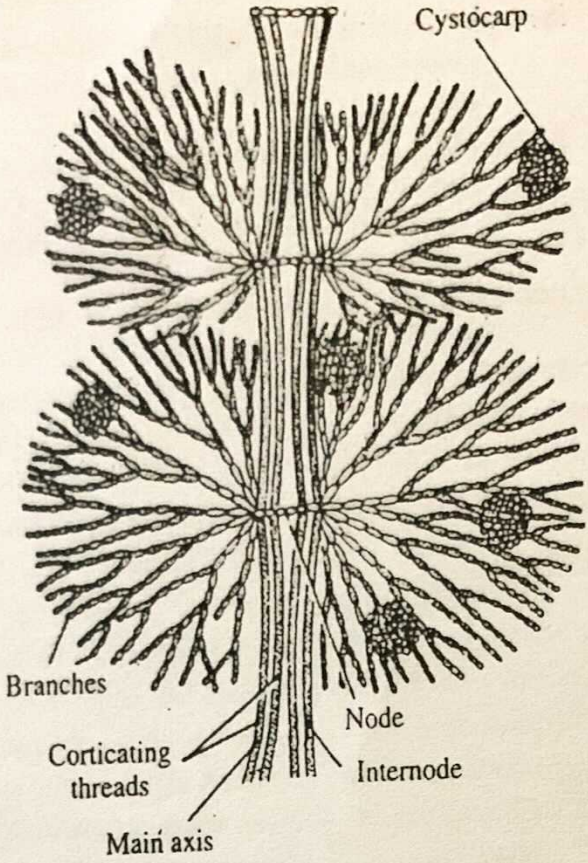


Fig. 6.13 A part of thallus of *Batrachospermum* showing uniaxial habit.

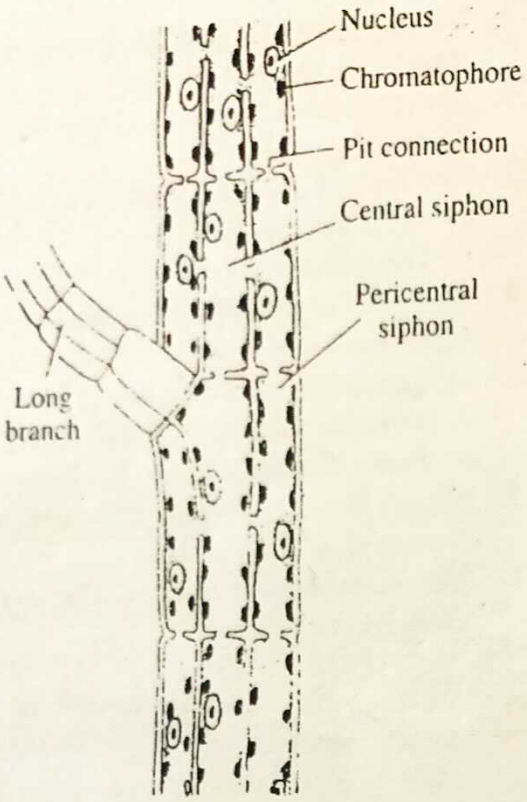
6.12 MULTIAXIAL FORMS

'*Multi*' stands for more than one, and '*axial*' pertains to axis. In some algae, the thallus construction is such that there are present a number of threads in close juxtaposition, giving the appearance of more than one axes. Different filaments of the central and side axes form more or less a compact cortex. The *multiaxial* construction of thallus is seen in *Polysiphonia* (Figs. 6.1K, 6.14), *Nemalion*, *Scinaia*, *Chondrus*, *Codium*, etc.

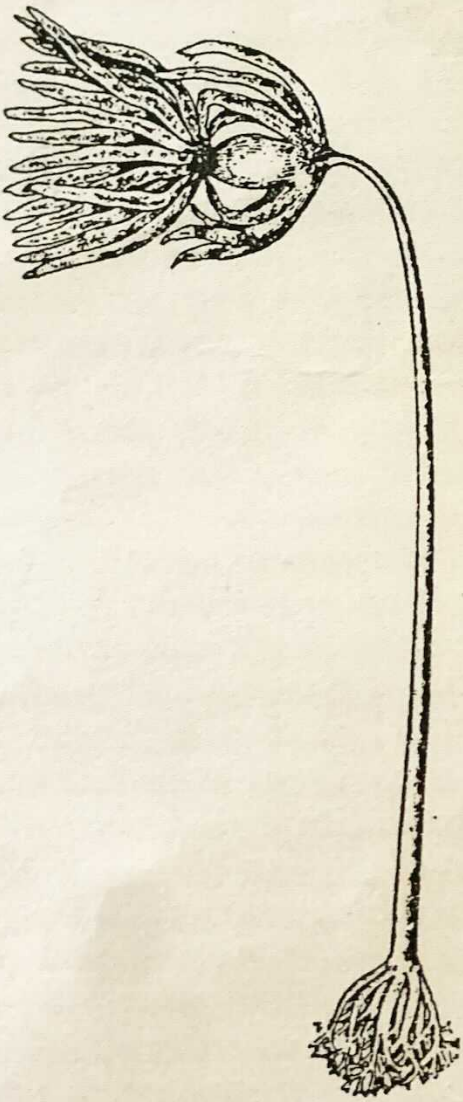
6.13 PARENCHYMATOUS FORMS

Abundant septation of a filament in two or more planes results in the formation of a "parenchymatous" body in some algae. Such plants may ultimately be foliose and fiat (*Ulva*, Figs. 6.1L, 24.56A, B) or tubular (*Enteromorpha*). Some other examples are *Chara* (Fig. 24.105A, B), *Dictyota* (Fig. 31.20A,B), *Porphyra*, *Laminaria* (Fig. 6.15), *Fucus* (Fig. 31.31A), *Sargassum* (Fig. 31.23 A–D), and many other Laminariales, Sphacelariales, Fucales and Dictyotales.

Plant body in some algae (*Macrocystis*) has become so complicated that even sieve-tube-like structures are also developed, similar to that of higher plants.



4 A part of thallus of Polysiphonia showing central and pericentral siphons.



Laminaria cloustoni, a parenchymatous form of alga. (after Fritsch)